South Australia, a great place to do business.

Innovation, Creativity and Technology – three words that define the business culture in South Australia.

We were proud to showcase our simulation technology for the manufacturing, defence, mining and resources industries at the 2015 SimTecT and SimHealth conference.
Message from the SimTecT 2015 Convenor

As the 2015 Conference Convenor I am delighted to extend to you all a very warm welcome on behalf of the Board of Simulation Australasia, Co-Convenors, Panel Advisors and the SimTecT Organising Team.

SimTecT 2015 sees us celebrating the 20th anniversary of Simulation Australasia and achievements of the industry across the past twenty years. What incredible growth across that period! We take pride in seeing how simulation has been cemented as an undeniably pertinent tool for our future development.

SimTecT’s strength lies in its capacity to bring a plurality of interests and perspectives to one location. We trust that you will challenged by our program of speakers representing industry, government policy makers, as well as academic scholars and researchers; that you will take the opportunity to visit our great exhibition showcase to share simulation trends and best practices from all over the world and across domains.

We have a great line up. It is a privilege to welcome our Keynote Speakers Dr Mica Endsley, Phaedra Boinodiris, Professor Mark Sagar and our national, international and local contributors. A special thank you to members of the defence sector for their highly specialised contributions across the entire conference spectrum.

I am confident SimTecT 2015 will inspire and continue to build on the success of last year and look forward to meeting you over the coming days.

Dr Teresa Crea
Convenor, SimTecT 2015

SimTecT 2015 acknowledges the invaluable contributions of Dr Cedric Dumas, Dr Anjum Naweed and Adrian Webb; Panel and Expert Committee Advisers John Illgen, Dr David Crone, Melanie Worrall, Shawn Parr, Matt Schneider, Ben Sullivan, Cameron Knott, Greg Akhurst, Jei Hou, Sanjay Khetia; Cubic (Glyn Davidson), BAE Systems Australia (Woodside AADS Facility), 16th Air Land Regiment (Lt Col Berni White) and Woods Bagot (Liam Hale); All Occasions Group, the Simulation Australasia Board and CEO (John Stewart). Many thanks also to Sarah Verdonk, Michael Monaghan, Bronny Harris, and especially Chloe Wagemaker.

Message from the SimTecT 2015 Paper Committee

Welcome to SimTecT 2015.

This years’ conference has a strong potential to excite your mind and make you discover new challenges and solutions. SimTecT 2015 explores the theme “INTERFACES AND POTENTIALITIES”, with papers addressing a range of simulation challenges through different scientific perspectives. I think you will enjoy the SimTecT program, as well as the many shared sessions with the SimHealth program with guest speakers covering simulation challenges through both conferences.

There is a lot to see and to hear this year, plan your sessions to find which new dimensions can help you to achieve your research and education agenda over the coming years.

I know Adelaide will be again a great place for the simulation community to meet and grow.

Dr Cedric Dumas
Scientific Convenor, SimTecT 2015
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Griffith University

Melanie Worrall
Klevar
Message from the SimHealth 2015 Convenor

On behalf of the Organising Committee I am honoured and delighted to welcome you to SimHealth 2015, the 11th Annual Conference for the Australian Society for Simulation in Healthcare (the Health Specialist Community of Simulation Australasia). Once again the committee have created a rich and varied program, which has only been made possible due the overwhelming number of submissions that were received. Over the next few days we ask our delegates and speakers to reflect, explore and share the theme of this year’s conference “Finding the Balance”.

The city of Adelaide and the Adelaide Convention Centre will provide an incredible backdrop for our local and international speakers to focus on the relationship between simulation and improving patient safety and clinical outcomes. Our Keynote and Invited Speakers including Dr Ken Catchpole, Professor Doris Østergaard, Dr Janice Palaganas, Cathy Smith, to name but a few, will share their experiences through Master Class, Plenary and Panel Sessions.

A new addition to the program this year is SimFringe. Inspired by the concept of a ‘Fringe Festival’, for which Adelaide is internationally known, SimFringe aims to engage Sponsors, Delegates and Exhibitors beyond the traditional conference format, promoting further opportunities for networking. We invite you to participate in our Twitter Photo Competition #simhealth2015, Speed Networking and Fringe 30 Sessions.

As I am sure you will appreciate it takes a team of individuals to bring such an incredible event together. I would like to express my sincere thanks to the conference Organising Committee – Julian Van Dijk, Robert O’Brien, Jessica Stokes-Parish, Cyle Sprick and Sarah Verdonk, and the entire team at Simulation Australasia who have dedicated so much time and energy into bringing together what is sure to be an exceptional event. It has been a privilege to work with you.

To all of our Delegates, Sponsors and Exhibitors, thank you for your continued support, without you this event would not be possible. Finally my challenge to you over the next few days is to meet someone new and find out what they do, who knows what you will discover…

Kirsty Freeman
Convenor SimHealth 2015

Message from the SimHealth 2015 Papers Committee

Welcome to SimHealth 2015. This year’s theme is “Finding the Balance”, an opportunity to reflect and share on how your simulation-based initiatives have investigated the relationship between education and outcomes. We will hear about work that is improving patient safety and clinical outcomes and well as how simulation is improving education pedagogy and the associated results.

We have an impressive list of international and local speakers, increased numbers of interactive, hands on workshops and an incredible collection of research, education and technology innovations to share.

The co-location with SimTect produces a programme with increased opportunities for sharing experiences and perspectives across different industries. I look forward to meeting you at SimHealth 2015 for a wonderful week of ideas and discussion in the beautiful city of Adelaide.

Robert O’Brien
Scientific Convenor, SimHealth 2015
SimHealth 2015 Review Committee

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Centre for Medical and Health Sciences Education

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School of Health Sciences, University of Tasmania

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Julian van Dijk  
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SimTecT
Workshop - Modelling and Simulation

Utilizing Service-Based Approaches for Effective and Efficient Use of Modelling and Simulation

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Description. Modelling & Simulation (M&S) is a widely used toolset within NATO and its Partners across many application domains. Most often associated with military training, M&S is also used for analysis, experimentation, test and evaluation (e.g., in the acquisition process). M&S products are therefore very valuable to NATO and military organizations and it is essential that M&S products, data and processes are conveniently accessible to a large number of users as often as possible. Therefore a new “M&S eco-system” is required where M&S products can be accessed simultaneously and spontaneously by a large number of users for their individual purposes. This environment has to support stand-alone use as well as integration of multiple simulation systems and real systems into a coherent (maybe distributed) simulation environment whenever the need arises. For many reasons, service-based architectures are considered to be very promising for realizing these next generation M&S environments. The combination of M&S with service-based architectures and ideas taken from cloud computing is known as “Modeling & Simulation as a Service” (MSaaS). NATO Modeling and Simulation Group 131 (“Modelling and Simulation as a Service: New concepts and Service Oriented Architectures”) has investigated the idea of “M&S as a Service” as a 1-year Specialist Team. A more detailed investigation of MSaaS and first steps towards possible standardization activities are currently being worked on by task group MSG-136 ("Modelling and Simulation (M&S) as a Service (MSaaS) - Rapid deployment of interoperable and credible simulation environments") which started its 3-year term in November 2014. The workshop will illustrate potential benefits with regards to quality, efficiency, and interoperability that may be achieved by MSaaS. Present current activities within the NATO Modeling and Simulation Group about “M&S as a Service” are presented with the aim aims to initiate exchange and cooperation with the Australasian M&S community. Secondly, the workshop touches on available standards that may be utilized in service-based simulation environments and gaps in the standards landscape that need to be addressed (e.g., by SISO) to realize the full potential of MSaaS.

Format. The format includes invited presentations and open discussions. It is anticipated that the presentations give an introduction into certain specific sub-topics of “M&S as a Service” and enable a subsequent discussion between the workshop participants.

Benefits. Participants are briefed about current NATO MSG activities regarding “M&S as a Service” and will acquire the most up-to-date knowledge about this topic. Initiation of ongoing cooperation activities and intensification of existing relationships is a further objective.
SimTecT

Free Papers

Modelling and Decision Support Systems - Methodologies and Frameworks
A High-Level Tactics Design Methodology and Tool for Simulation Applications

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Abstract. The modelling of human tactical decision-making is important in most military simulation studies. Simulation of tactical decision-making has a bearing on applications such as capability analysis, course of action analysis and training. On the whole, tactics models have been implemented using the simulation platform’s inbuilt scripting language, although some studies have used platform-independent, Artificial Intelligence (AI) languages to model human behaviour. Nevertheless, even the AI-based approaches are at the level of implementation, making it difficult to maintain and modify large libraries of tactics. We present TDF (Tactics Development Framework), a methodology and tool that supports the design and deployment of sophisticated tactical models for simulation studies and simulation-based training applications. TDF represents models at a very high level of abstraction; its diagrammatic representation facilitates model validation by allowing Subject Matter Experts to critique the tactics models. The tool’s ability to propagate designs into implementation helps with model verification. An experimental comparison between TDF and UML is reported. The results of an initial integration with VBS3 are encouraging, and pave the way for a platform-independent, design-level approach to building tactical decision-making models for simulation applications.

INTRODUCTION

Since the earliest days of military simulation, there has been a need to model the behaviour of human entities, such as infantry, fighter pilots and tank commanders. Applications have included capability analysis, hardware acquisition, tactics development, course of action analysis, and training.

Up until the turn of the century, these simulations mostly focused on large, set piece battles in which the simulated combatants faithfully followed doctrine. In more recent times, there has been a shift in focus:

“Today’s military missions have shifted away from force-on-force warfare—fighting nation-states using conventional weapons—toward combating insurgents and terrorist networks in a battlespace in which the attitudes and behaviors of civilian non-combatants may be the primary effects of military actions. These new missions call for agile, independently sensitive forces capable of switching quickly and effectively from conventional combat to humanitarian assistance and able to defuse tense situations without, if possible, the use of force.” p2, (Zacharias et al., 2008)

This has resulted in a need to model non-doctrinal behaviour, e.g. insurgents, as well as more fine-grained and dynamic small unit tactics, for example (Evertsz et al., 2014). In addition, most current simulations of tactical behaviour are scripted using a platform-dependent scripting language, resulting in three major shortcomings:

- The scripting languages are procedural, prescriptive and limited in scope. This results in inflexible and fairly rudimentary behaviour.
- The scripts are difficult to debug or modify, meaning that new behaviours are often implemented from scratch.
- The scripts are tied to the specific simulation platform, making it burdensome to transfer the tactics to other virtual environments.

These factors limit the realism, usability and reusability of current tactical behaviour models. Reuse is also problematic because the models are only represented in terms of the implementation, whether in the form of platform-dependent scripts or even more platform-agnostic, AI-based (Artificial Intelligence) models such as TacAir Soar (Laird et al., 1994) and dMARS (Murray et al., 1995). There is no direct mapping to high-level designs.

This difficulty of reusing and extending tactics has meant that model libraries are small and only cover a small spectrum of scenarios. Our experience, collaborating for 20 years with military tactics-modelling teams, reveals that model reuse is uncommon. When moving to a new simulation platform, one is usually forced to re-implement the required tactics models, even if they have already been written for another platform.

We have been working with defence scientists who have over 15 years of experience in agent-based tactics modelling. They work closely with military SMEs (Subject Matter Experts), and have been using paper-based workflow diagrams and UML to design their models of tactics in the USW (Undersea Warfare) domain. As their code base has grown in size, this approach has not scaled well. Without an appropriate tactics design methodology and tools, it is very difficult to build large tactics libraries, or modify existing ones.
Our research objective is to develop and evaluate a methodology and tool for modelling tactical decision-making for simulation studies and simulation-based training. Ideally, tactics models should be easy to develop and use, and should be independent of the simulation platform. Furthermore, to support model validation, SMEs need to be able to critique the tactics models, and this necessitates representing them at a high level of abstraction, for example in diagrammatic form. To facilitate model verification, this high level, diagrammatic representation should then be systematically propagated into the implementation. In other words, the tool should generate code, rather than requiring programming code to be written manually, with the static design diagrams merely being used as a guide.

To address these requirements, we developed TDF (Tactics Development Framework), a methodology that supports the design, development and deployment of sophisticated tactical behaviour models (Evertsz et al., 2015). This paper follows up on that work by presenting the TDF tool, its application to simulation models of human tactical behaviour, and its integration with VBS3.

TDF is targeted at building behaviour models that go further than routine doctrinal behaviours, or the simple AIs supported by typical simulation environments such as VBS3 or the OneSAF Objective System (Wittman Jr & Surdu, 2005). Military commanders employ sophisticated tactical decision-making that takes account of unexpected changes in the situation. Such dynamic domains require balancing reactivity with proactivity, that is, being goal directed but able to switch focus when a critical situation is recognised, or when a tactical assumption becomes invalid. This mixing of reactivity with proactivity is one of the defining characteristics of agent-based systems (Wooldridge, 2008), and it is poorly supported by most programming paradigms. Consequently, TDF adopts an AOSE (Agent Oriented Software Engineering) approach to the design of tactical decision-making systems.

This paper makes several contributions to the field of modelling tactical decision making:

- the state of the art in AOSE methodologies is extended to facilitate the modelling of tactical decision-making systems by adding missions, a wider range of goal structures, plan diagrams and tactics design patterns;
- the extended methodology is implemented in a new application, the TDF tool, that builds on PDT (Prometheus Design Tool) (Padgham et al., 2008);
- the results of a preliminary evaluation are presented, indicating that TDF significantly enhances the comprehensibility of tactical behaviour models in simulation applications; and
- the early results of an integration of TDF with VBS3 are reported.

**BACKGROUND**

This section provides a brief overview of related work that underpins our approach to tactics modelling.

**The BDI Paradigm**

TDF is based upon the BDI (Beliefs, Desires, Intentions) (Rao & Georgeff, 1995) model of human reasoning. This model derives from work in philosophy on intentional systems and practical reasoning (Dennett 1987), (Bratman 1987), and was developed to support the above-mentioned mix between proactive and reactive behaviour. The BDI paradigm characterises rational agents as having beliefs about the world, desires that they would like to achieve and intentions that they are committed to. This has proven to be an intuitive and powerful computational abstraction for describing, designing and implementing complex, responsive reasoning systems.

The first implementation of the approach, PRS (Georgeff & Ingrand, 1989), focused on real-time fault diagnosis for Space Shuttle missions. The first published application of the BDI paradigm to military simulation was in the air combat domain (Murray et al., 1995).

A BDI agent is an autonomous computational entity that is constantly executing a sense/decide/act loop, not unlike Boyd’s Observe/Orient/Decide/Act (Coram 2002) model of high-level, tactical decision-making. A BDI agent is internally driven, persistently sensing its environment, deciding what to do next and then performing an action if appropriate. A BDI agent continually reassesses its course of action in response to incoming sensory information, and this allows BDI agents to deal with a rapidly changing environment.

BDI architectures vary in detail, but all share the core attributes illustrated in Figure 1. A key element is that these systems have a pre-defined set of plans (Plan Library) that is used to respond to external events from the environment as well as internal events. Internal events are the proactive goals generated within the system.

A typical BDI agent executes a control loop in which it updates its beliefs to reflect the current state of the world, deliberates about what to achieve next, finds a plan for doing so, and executes a step of that plan. Each time around this cycle, it reconsider its options to reflect any changes in the environment, and can change tack if a more pressing need arises.

In the schematic architecture in Figure 1, sensory information from the environment is mapped to events that accumulate in a queue. The BDI Engine takes the next event from the Event Queue and chooses a plan that is applicable in the current context. The chosen plan instance is added to the agent’s intentions. In each cycle, the agent chooses one step of an intention (i.e. instantiated plan) to execute, which may produce an action that is passed to an actuator that effects a change in the environment. This process is executed repeatedly, ensuring that the BDI agent reconsiders its
options so that it can change tack if a more pressing need arises.

![BDI architecture](image)

**AOSE**

AOSE is concerned with how to specify, design, implement, validate and maintain agent-based systems. There are a number of well-established AOSE methodologies, including O-MaSE (DeLoach & Garcia-Ojeda, 2010), Prometheus (Padgham & Winikoff, 2004), and Tropos (Bresciani et al., 2004). A comparative review of O-MaSE, Tropos and Prometheus can be found in (DeLoach et al., 2009). Nevertheless, during our analysis of the requirements for modelling tactical decision-making, we have identified a number of areas for improvement. These relate to high-level tasking (termed ‘missions’); what the tactics achieve (‘goals’); and how they achieve their goals (represented as ‘plan diagrams’).

**Tactics**

The Oxford English Dictionary defines tactics as:

"The art or science of deploying military or naval forces in order of battle, and of performing warlike evolutions and manoeuvres."

Thus, tactics are adversarial in nature. However, we have adopted a less restrictive definition that focuses on their flexibility:

"A tactic is a specification of responsive, goal-directed behavior."

In other words, a tactical decision-making system seeks to achieve its objective in a situation that may require it to adapt and respond to unexpected change.

Responsiveness is key; an effective tactical decision-making system must do more than simply blindly execute a procedure; it must be able to respond in a timely manner to events that interfere with the achievement of its goal, or leverage unexpected opportunities to achieve its goal more effectively.

TDF was initially developed for modelling USW tactics. The USW domain is characterised by a general lack of information about the current situation. A submarine commander’s knowledge of the tactical situation is time consuming to acquire, very limited and is sometimes highly uncertain. This severely impedes the decision-making process – much of a commander’s tactical repertoire is concerned with building situation awareness whilst not being detected. This lack of certainty about the situation makes tactical responsiveness vital, because new information may arise that invalidates the current appreciation of the situation.

**TDF METHODOLOGY**

This section provides a brief overview of the TDF methodology; more detail can be found in (Evertsz et al., 2015).

TDF extends Prometheus with ‘missions’, richer ‘goal structures’, ‘plan diagrams’ and ‘tactics design patterns’.

In keeping with the Prometheus methodology, TDF partitions tactics modelling into 3 main stages:

**System Specification.** Identification of system-level artefacts, namely ‘missions’ (key objectives and their properties), ‘goals’ (hierarchies specifying how to achieve mission objectives), ‘storylines’ (different ways the mission can play out), ‘percepts’ (environmental input), ‘actions’ (to perform on the environment), ‘data’ (to store and access), ‘actors’ (external entities) and ‘roles’ (functional capabilities required of the system).

**Architectural Design.** Specification of the internals of the system, including the different ‘agent’ types (by grouping roles), the interactions between the agents (via ‘protocols’), and ‘messages’ (sent between agents).

**Detailed Design.** Definition of the internals of the agents, i.e. plan diagrams (diagrammatic representation of procedures), internal ‘events’ (to trigger plans), ‘messages’ sent and received, and ‘data’ that is used by the agent.

TDF also encourages the definition of ‘tactics design patterns’; general-purpose tactical solutions that can be customised for related applications.

We now outline the TDF extensions of the Prometheus methodology.

**Missions**

Military simulation studies are usually designed around one or more ‘vignettes’. A military vignette is a general description of a tactical situation. In TDF, a ‘mission’ is more specific than a vignette, and specifies an expected sequence of interactions between the tactical simulation models and their environment. Because tactics are the means of achieving the mission objective, the mission is central to the tactics development process.
A TDF mission specifies a primary objective, secondary objective, a mission statement, operational constraints, risks, opportunities, storylines and data used.

An example mission objective for a UAV (Unmanned Aerial Vehicle) vignette is ‘photograph target’, and a corresponding mission statement might be:

“You are tasked with locating and photographing a convoy. The location of the convoy is roughly known, but you will need to search the area to locate it.”

A state of the world to be maintained for the duration of the mission, for example: “Do not enter any no-fly zones.”

**Goal Structures**

The tactical system is designed to meet its mission objectives, and those objectives result in sub-goals to achieve. These goal/sub-goal relationships are expressed as a goal structure that defines the hierarchy using ‘and’, ‘or’ and ‘concurrent’ connectives.

Generally, AOSE methodologies have not addressed the goal-oriented control structures required to express tactics at a high level of abstraction, and in particular reactive/deliberative considerations, such as the conditions under which a goal should be suspended or resumed. These goal conditions and inter-goal relationships are important to tactical decision-making, and TDF makes such hidden dependencies explicit at the design level, so that the designs are a more accurate reflection of the desired system behaviour, thereby promoting user comprehension and the potential for reuse and sharing.

TDF introduces the notion of a ‘conditional goal’. A conditional goal is used to denote a goal that should only be adopted if certain conditions are true. If the conditions are not met, the goal is skipped. (see [no countermeasures remaining], Figure 2). Effective tactical decision-making is very context-dependent, but contextual information is usually embedded inside the procedures (plans) that implement the tactic. Conditional goals allow such implicit contextual information to be expressed at the goal level during the early stages of the design process.

Plan Diagrams

The goal structures prompt the specification of the various ways that the goals can be achieved, expressed as plan diagrams. A plan diagram is a high-level procedural representation that shows the sequence of steps executed by some part of the tactic. Taken together, the collection of plan diagrams procedurally specifies how the whole tactic does what it does. TDF plans are a level of abstraction above the implementation, and should be viewed as diagrammatic pseudo-code rather than an executable implementation. A TDF plan specifies the general steps of a procedure without getting bogged down in implementation detail.

Plan diagram for UAV engine problem

To illustrate one of these goal control structures, consider the objective of evading an incoming missile (Figure 2). This example shows an application of ‘conditional’ and ‘concurrent’ goals, and the combination of ‘and’ and ‘or’ sub-trees via an ‘anonymous’ node. If there are no countermeasures remaining, the Evasive Maneuvers goal is tried (a conditional goal). Otherwise, countermeasures are used, which involves launching flares and using infrared countermeasures (concurrent goals) to interfere with the missile’s ability to maintain a lock on the UAV. As soon as countermeasures have been deployed, the second branch emanating from the empty circle is tried, i.e. evasive manoeuvres begin.

Without the inclusion of a conditional goal, it would not be apparent that the UAV immediately adopts the Evasive Maneuvers goal if there are no countermeasures available. Without the concurrent inter-goal relation, one could erroneously surmise that the UAV launches flares and then enables its infrared countermeasures. In fact, when there is an incoming missile, it is vital that these two actions are performed as soon as possible, i.e. concurrently.
pursued in their own separate threads, and the plan does not wait for them to succeed. It immediately adopts the goal to reconsider the viability of the current mission in the context of the engine problem.

Note that, because of the underlying BDI model, each plan step is interruptible to the extent that the execution of other (higher priority) plans can be interleaved with this one. So, for example, if an incoming missile is detected and there is a higher priority plan for dealing with that event, this plan will effectively be suspended until the crisis is averted.

We adopted UML activity diagrams as the basis for the representation of plan diagrams in TDF. UML is a widely accepted standard for designing object-oriented software systems. TDF modifies UML where necessary to reflect BDI semantics and PDT notational convention. Despite the similarities in notation between plan diagrams and UML activity diagrams, the underlying semantics have very little in common due to the fundamental differences between the BDI and object oriented paradigms. For example, in BDI, each node either succeeds or fails. If it fails, the invocation of the plan fails and the execution engine will try an alternative way of achieving the goal if one is available.

Tactics Design Patterns

TDF supports reuse and sharing of tactics designs by supporting the development of an extensible library of ‘tactics design patterns’. Tactics design patterns express general-purpose, tactical solutions that can be customised for more specialised applications.

In TDF, goals and plans are grouped in terms of the tactics design patterns they contribute to. This encourages the designer to think in terms of high-level tactics, and promotes design abstraction. Thinking in terms of tactics, rather than low-level procedures, also facilitates merging, reuse and maintenance of tactics sets. For example, if a tactic requires that the UAV remain above a certain cruise altitude, this is defined as an explicit restriction. When considering merging this tactic with one that involves dropping under low cloud, it is obvious that there is a potential conflict. In our experience, this type of conflict is usually not apparent at the implementation level; for example, a descend action might be embedded deep down in the plan/goal graph and might not be noticed when inspecting the top-level plans.

A tactics design pattern comprises the main tactical objective, the triggering event (optional), a problem and solution description, context (situations in which it applies), outcomes (what changes after the tactic completes), information required or updated, goal structures, plan diagrams, and the source of the tactic (i.e. the SMEs or documents it is based upon).

TDF TOOL

TDF is currently a prototype, implemented as an Eclipse-based plugin that extends PDT with graphical tool support for the TDF methodology. The main purpose of the tool is to empower analysts with a mechanism to capture tactical behaviour specifications.
The TDF plugin provides the following extensions to the PDT tool:

- missions;
- additional goal types and control structures;
- plan diagrams; and
- tactics.

The Mission Overview editor (Figure 4) is used for linking missions with tactics and scenarios. The graphical depiction of tactics in the plugin is through a red, head-shaped icon. To maintain consistency with PDT we retain the icons for entities that are shared between PDT and TDF such as percepts, actions, goals, etc.

Extending PDT, the TDF plugin supports the modelling of additional goal types and control structures. Maintenance goals are associated with maintenance conditions that are demarcated by square brackets. In terms of graphical representation, ordered goals are linked with solid lines whereas unordered goals are linked with dashed lines.

In PDT the internals of a plan are specified using informal text. Plan procedures are described as pseudocode but this is optional for designers. The TDF tool presents a more structured approach for specifying the internals of the plan in the form of detailed plan diagrams, as shown in Figure 3. As outlined earlier, the TDF methodology provides a conceptual framework to capture procedural knowledge such as plans in a principled way. The TDF plugin supports the accompanying methodology by providing an effective visualisation of the procedural and contextual knowhow associated with plans.

**Features of the Tool**

The TDF plugin provides type safety, automatic propagation, and code generation. These features play a significant role in ensuring that TDF designs are sound, and that they map to executable code.

**Type safety.** To add an entity to a diagram, a user may either select an existing entity from a list or create a new one. This ensures that the user can only select artefacts of the correct type.

**Automatic propagation.** Relationships between artefacts that span multiple editors are automatically propagated. For example, when a new goal is added to the Analysis Overview, it is automatically propagated to the Goal Overview editor.

**Code generation.** The plugin can generate skeleton code for JACK (Winikoff 2005) and GORITE (Rönnquist 2008). The code generation feature provides a predefined structuring, in the form of JAVA packages, to the system. This facilitates and enforces good software engineering practices. In addition, the code generation is built to allow an iterative design and coding approach by preserving user code edits that occur outside of the demarcated TDF-generated portions.

Overall, providing the TDF tool as an Eclipse plugin integrates the design and development of tactics within a unified environment. One of the future directions for the tool is to extend the code generation abilities to cover agent-oriented programming languages other than JACK and GORITE. This will encourage different communities to adopt the TDF methodology for designing tactical decision-making systems.

**EVALUATION OF TDF**

The objective of the evaluation is to test the prediction that, relative to UML, TDF improves the level of comprehension of a tactical decision-making system’s design. The underlying assumption is that a tactics design that is easier to understand will facilitate reuse and sharing between developers.

**Method**

A photoreconnaissance scenario, was used to evaluate how well the designs were understood by the participants.

**Participants**

The participants comprised 10 computer science students, all familiar with UML. They were not compensated for their involvement in the evaluation.

**Experimental Design**

The participants were randomly assigned to the two experimental conditions (TDF and UML) in equal numbers using a between-subjects design.

**Procedure**

In order to minimise the need to learn the mechanics of the TDF and UML tools, the tactics designs were presented as a collection of static diagrams. The same experimenter ran all sessions. Both groups were encouraged to ask questions about any notation they were unsure of. The participants were given unlimited time to browse the designs and could ask questions related to syntax but not the behavioural implications of the tactics.

A 15-item multiple choice questionnaire was completed immediately after perusing the designs. The questionnaire tested their understanding of the UAV's behaviour in specific situations addressed by the tactics design. The subjects could consult the design at any time while completing the questionnaire. Time taken to complete the questionnaire was recorded.

**Results**

As predicted (H1: $\mu_1 > \mu_2$) the mean number of questions answered correctly was higher for the TDF group: TDF$\mu_1 = 82.4\%$, UML$\mu_2 = 66.4\%$. A one-tailed, independent t-test rejects the null hypothesis, H0: $\mu_1 = \mu_2$, $p < 0.025$.

There was no significant difference in the time taken to complete the questionnaire between the two groups: $\mu_1 = 13.4$, $\mu_2 = 13.6$ (minutes).
Analysis

The experimental evaluation indicates that TDF’s approach to tactics representation is more readily understood than equivalent UML versions. The effect is surprisingly large, given that the designs were deliberately simplified so as not to disadvantage UML. BDI models inherently provide an implicit and abstracted representation of interruptible behaviour. In contrast, potential interruptions must be explicitly represented in UML activity diagrams. If there are more than a few such interruptions, the activity diagram can quickly become very complex. Limiting the number of potential interruptions to just two reduced this TDF/BDI advantage, and this occurred in only one activity diagram. It seems likely that the TDF/BDI advantage would have been even greater had the design included a more extensive mix of reactive/deliberative behaviour, as represented by TDF maintenance goals.

TDF maintenance goals further simplify the design of reactive/deliberative tactics. A maintenance goal comprises a maintenance condition that specifies a particular state of the world that the agent must maintain, for example, ensuring that there is enough fuel to return to base. If the maintenance condition becomes untrue, then a goal is adopted to bring the world back into compliance, for example, by refuelling. Maintenance goals can be succinctly expressed in TDF, but are not straightforward to specify in UML because it does not embody the concept of maintenance goals.

INTEGRATION OF TDF WITH VBS3

Used by defence forces around the world, Virtual Battlespace (VBS) is the leading military 3D, photorealistic virtual environment. Like other virtual environments that focus on visual realism, its inbuilt models of human behaviour are fairly rudimentary, and its scripting language is not well suited to the task of implementing dynamic and flexible tactics. With this shortcoming in mind, we have integrated TDF with VBS3 to allow the incorporation of richer models of human tactical decision making. TDF is a tactics design framework, and so does not integrate directly with VBS3. Figure 5, illustrates the components of our framework that facilitate the integration with VBS3.

TDF’s JACK code generation capability enables interfacing to the TDF/SIM infrastructure. This infrastructure comprises:

- TDF/VBS plugin, that communicates with VBS3; and
- TDF/VBS Director, that interfaces with the JACK agent(s) as shown in Figure 5.

Percepts are received from, and commands are sent to, VBS3 using ASI (Application Scripting Interface), which provides access to VBS3’s scripting language. Percepts are generated by VBS3 at the frame rate of the simulation (of the order of 50-100 frames per second). The TDF/SIM infrastructure reduces the perceptual load on the agents by filtering out any percept whose value has not changed since the previous frame.

Example Scenario

An infantry L-ambush scenario provides a good demonstration of the combined capability of TDF and VBS3. In an L-ambush (Figure 6), the ambushers position themselves behind cover.

The most effective course of action for the ambushees depends upon a number of factors, including ambusher proximity, availability of cover, and whether the ambushees are all in the “kill zone”. These contextual variables are represented in TDF as conditional goals, and ultimately form the context conditions of the associated plans. In contrast to scripts, the tactical alternatives are clearly represented at a high level of abstraction in TDF. Figure 7, illustrates an example goal overview diagram for countering an L-ambush.
The goal overview shows that there are three alternative ways of countering an L-ambush, with the choice depending upon the relative strength of the ambushed/ambushers. If the ambushed are outgunned, they retreat; if they are stronger than the ambushers, they return fire; otherwise, if equally matched, they retreat while providing covering fire to each other.

**Summary of TDF/VBS3 Integration**

The lack of a design-level tactics-modelling methodology and tool has hindered the development of tactics libraries, because they are cumbersome to build and are tied to a single simulation platform. We believe that TDF represents a novel and important development in the quest to provide tactics libraries that can be used across different simulation platforms. However, support by simulation platforms for external control needs to improve. Writing scripts to generate high-level percepts can be difficult and time consuming, and could be avoided if the simulation platform provided a greater variety of percepts through its API. There can also be delays in the platform’s response to incoming commands, which in the case of VBS3 may be due to its underlying pathfinding process. This negatively impacts performance, and is particularly noticeable in training applications.

**DISCUSSION**

This paper introduced a novel methodology and tool for modelling military tactics. TDF extends a state-of-the-art agent design methodology with artefacts required for tactics modelling.

The original motivation for the development of TDF came from a team of analysts who have been using UML to model USW tactics over a period of many years. This approach did not scale to larger tactics libraries, and sharing and reuse across developers was problematic. Indeed, our experience of modelling military tactics over the last 20 years suggests that model reuse causes difficulties, particularly when sharing across team members. It is not unusual for a developer to prefer to implement a new tactical model from scratch, rather than try to understand and reuse another’s model.

TDF extends Prometheus with missions, a wider range of goal structures, plan diagrams and tactics design patterns. These extensions are intended to make tactics designs easier to understand and share. The provision of conditional goals is key to the design and maintenance of tactics because tactics typically mix deliberative and reactive modes of reasoning. Annotating goals with the conditions under which they are adopted, maintained, dropped or resumed is a key feature of TDF that makes the tactics easier to understand, reuse and modify.

Ease of comprehension was evaluated in the context of a UAV photoreconnaissance scenario. The results of the evaluation indicate that TDF designs are easier to understand than corresponding UML versions. This effect was significant, despite the fact that the designs were deliberately simplified to reduce the inherent advantage that TDF has with regard to activities that can be interrupted by environmental events.

**The Way Forward**

Currently, TDF is mainly a descriptive design tool, although it can also generate skeleton JACK and GORITE code. There is considerable scope for extending TDF with automated analysis tools that help the designer identify problems and classify tactics design patterns. The following two enhancements to TDF would be fairly straightforward and would provide immediate benefits:

- **Completeness Checking.** In BDI systems, the goal structure is implicitly represented by plans. The mapping of goals to plans in TDF could be automatically checked to ensure that the goal structures are reflected by the set of plan diagrams, highlighting goals that have no procedural embodiment as plans. This could be implemented via some form of abstract interpretation (Cousot & Cousot, 1977) of the goal/plan graphs to derive the implicit goal structure.

- **Tactics Ontology.** An editible ontology for tactics would enhance tactics reuse. Reasoners in modern ontology editors allow set membership to be automatically determined via class properties. With an appropriate ontology, tactics design patterns could be automatically classified based on their properties, for example, automatically identifying tactics that involve “lethal force”. Furthermore, an environmental ontology would allow greater independence from the particular simulation platform by defining the percepts, actions, and the types of object available in the simulation environment. This will further help insulate the tactics models from the details of particular simulation platforms.

TDF could also move further in the direction of formalisation of its various design artefacts. For example, the outcomes property of tactics design patterns could be changed from a natural language description to a formal, logical expression that defines how the world changes during and after the execution of the tactic. This would provide an opportunity for automated detection of conflicts, for example in the USW domain, a tactic with the outcome of surfacing would conflict with a mission that has the restriction that the submarine remain submerged at all times. However, caution should be exercised when moving in the direction of formalisation. Our experience with users suggests that, for many developers, the inclusion of such formal elements in the design is a burden. There is a delicate trade off between using natural language descriptions of property values vs. formal expressions. This could be overcome by allowing the expression of both formal and informal property values. The user could use formal expressions if automated design analysis is required, falling back on natural language descriptions if automated analysis is not required or if formalisation would significantly slow down the design process.
TDF’s high-level diagrammatic view provides an opportunity for SMEs to critique the tactics models; an important part of validation. We are currently extending TDF to provide knowledge elicitation support to the tactics modeller.

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REFERENCES
Validating Airframe Simulation Model of R22 Helicopter by Using Crashworthiness Standards

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Abstract. This article is one of a series of ones in a project which investigates helicopter crashworthiness by using stochastic simulation. The authors developed a stochastic simulation framework to build up Meta Models among flight parameters, structural factors and injuries responses. Coming to the second phase, the study manages to use stochastic algorithm to conduct structure analysis on helicopter crashworthiness. A requirement of validated airframe model has a sharp conflict with the lack of the data in real crash tests of helicopter.

This paper aims to validate the R22 helicopter airframe simulation model based on the crashworthiness standards of FAR 27 and MIL-STD-1290. A long term purpose is to build a numerical model for investigation of stochastic simulation into helicopter crashworthiness. Hughes-Liu beam element is used to build the simplified airframe model. FAR part 27 presents an adaptable sink rate at the impact moment in a drop test established for the criteria of designing landing gear for crashworthiness. MIL-STD-1290 introduces a standardized system that reflects the correlation between the lower downward speed determined by the test with landing gear collapsed and higher downward speed used for causing injury of occupants in the drop test. A dynamic validation is used to demonstrate that the sensitivity responses of the numerical model conform to a widely acceptable theory relating the impact velocity and the maximum deceleration.

An airframe simulation model of R22 helicopter has been successfully developed and validated in terms of stochastic simulation of helicopter crashworthiness. A scheme whereby landing gear drop test, injured drop test and sensitivity validation can validate the simulation model of rotorcraft in a reasonably acceptable level. The numerical results of the simulation have been proved by the regulations of MIL-S-1290 and FAR 27 and monographs of Elband human tolerance which are reviewed and integrated into a validation scheme.

INTRODUCTION

In order to investigate helicopter crashworthiness by using stochastic simulation, the authors developed a stochastic simulation framework into building up Meta Models among flight parameters, structural factors and injuries responses. This article is a sequel of the same authors’ article, which makes analysis on helicopter accidents caused by engine failure using the algorithm of Monte-Carlo simulation [1]. The next phase is to use stochastic algorithm associated with simulation to establish the relationship between the sink rate at the impact moment and the deceleration imposing onto the occupant body. Hughes-Liu Beam element is used to build a simplified airframe model in this phase so as to reduce the time consuming of running simulation.

One key challenge of building an acceptable airframe simulation model is validation. Unfortunately, the appropriate data of crash tests is inaccessible so that the traditional validation method by comparing simulation results with actual data is not suitable for this study. We appeal to the design criterions in the published regulations, though most of existing criteria pertaining on the rotorcraft are within the military domain. However, existing criterions of rotorcraft design were identified conflicting requirements [2].

One of crashworthiness requirements defined for military rotorcraft is MIL-STD-1290A which was cancelled in the mid-1990s but reinstated, without revision, in 2006 [3]. The MIL-STD-1290A presents crashworthy design in detail and defines a set of crash scenarios being survivable in the pre-design phase of an aircraft. Their performance in crash conditions has made a significant progress on the previous generation helicopters [4]. It contains a system of requirements for components design of rotorcraft such as landing gear and seat box system test, longitudinal crash, vertical crash, latitudinal crash, and roll over crash, and so on. It states that the landing gear must have capability of dissipating kinetic energy of the entire aircraft when it crashes with vertical velocity of 20 feet/sec, and with the vertical impact velocity being 42 feet/sec. Besides MIL-STD-1290A, current crashworthiness requirements [5] also have this statement. Since it is in term of the military rotorcrafts, the requirement may not be appropriate to the current prevalent light helicopter like R22. The human injury is evaluated by the human tolerance which illustrates by uniform deceleration and duration of the deceleration [6].

Another crashworthiness standard of rotorcraft is Federal Aviation Regulation (FAR). Federal Aviation Regulations (FARs) part 27 utilizes crash load to require a rotorcraft to be designed so that the design can meet the requirement of protecting occupants from injury. The landing gear is the first sub-system that generally hits the impact surface. Typically, FAR part 27 presents the drop tests for designs of landing gear and other reserve energy devices. The tests are conducted by providing drop height, rotor lift or effective mass, and requirements of test results.

Validation of a model is defined as a specific purpose or a set of objectives and its validity determined for that
The objective of this whole project of investigating helicopter crashworthiness is to build a system model under a certain scenario that describes the relationships of key factors of the system by sensitivity analysis. Validation for sensitivity conducted on the airframe simulation model is based on a hypothesis of a relationship between impact velocity and maximum load force response. This is widely accepted but implicit in many fields [7]. It can be reasonably assumed that a higher impact velocity can cause an increment in the deceleration response.

This paper is to validate the R22 helicopter airframe simulation model by crashworthiness standards of FAR 27 and MIL-STD-1290 so that the structure simulation model can be adapted for stochastic simulation on helicopter crashworthiness. A simplified airframe of helicopter structure is built using Hughes-Liu beam elements. FAR part 27 presents drop test that establishes the criteria of designing landing gear by an adaptable sink rate at the impact moment. Since the requirements of FAR 27 for landing gear is same as the requirements of drop test with lower downward speed in MIL-STD-1290, the higher speed in the vertical impact test causing injurious load at the seat position can be verified. The sensitivity validation is conducted by using the two velocities generated from the two crashworthiness standards and a well-accepted hypothetical theory of impact velocity and deceleration peak. Therefore, the validation scheme contains landing gear drop tests with the lower downward speed that does not lead to a potential injury, potential injury inducing drop tests for the higher downward speed, and sensitivity validation with several values between the two standard speeds. (Figure 1)

CRASHWORTHINESS STANDARDS

This section is to review crashworthiness standards to make a scheme for validation of helicopter airframe model. FAR 27 and MIL-STD-1290 both describe every aspect of a design for crashworthiness and define a set of survivable crash scenarios in phase of prior to an aircraft designing. The crash scenario defined in FAR 27 has a certain height where helicopters free drop; the requirement is the landing gear is capable of withstanding being collapsed or subfloor non-contacting with the ground. Similarly, MIL-STD-1290 also defines the requirement of non-collapsed landing gear but with 20 feet/sec at the impact moment (Figure 2). MIL-STD-1290 also required the deceleration response in the seat position without causing injury of occupants. Human tolerance (Elband Human Tolerance Data) has to be taken into account as an evaluation of deceleration for human injury.

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Rotor lift, where considered in a manner similar to effective mass method;

The landing gear must withstand this test without collapsing.

The effective mass mentioned in the drop test procedure can be described: using an effective mass to replace the original mass of the craft to describe the rotor lift on the wing and Design Gross Weight (DGW) on the helicopter mass. The effective can be derived from:

$$W_e = W \times \frac{h + (1 - L)d}{h + d}$$

Where:

- $W_e$: the effective weight to be used in the drop test (kg);
- $W$: the maximum weight of the rotorcraft used in this paper is maximum takeoff weight of R22 helicopter (kg);
- $d$: deflection of the vertical component of the axle travels relative to the drop mass;
- $h$: specified free drop height (m);
- $L$: ratio of assumed rotor lift to the rotorcraft weight (m).

### Table 1: Parameters of the Drop Test

<table>
<thead>
<tr>
<th>Free Drop Height (b)</th>
<th>Max Weight (W)</th>
<th>Ratio of Lift to Craft weight (L)</th>
<th>Deflection (d)</th>
<th>Effective mass (W_e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.495m</td>
<td>635kg</td>
<td>0.67</td>
<td>0.36m</td>
<td>456.9kg</td>
</tr>
</tbody>
</table>

Table 1 depicts the key parameters used in the test for R22 Helicopter. This paper takes into consideration of the worst case in crash scenarios of the helicopter. By the given parameters, sink rate at impact moment can be derived. By the effective mass, the deceleration of the helicopter in drop test can be calculated by:

$$a = \frac{W_e}{W} \times g$$

$$h_a = \frac{1}{2} at^2$$

$$v = at$$

Where:

- $a$: deceleration of the helicopter (m/s²)
- $h_a$: vertical component of the helicopter axle travel
- $v$: sink rate of the helicopter at the impact moment
- $t$: time consumption of dropping test

The sink rate based on the given values of the parameters is 3.35m/s or 11ft/sec. It means that the landing gear is not collapsed or the bottom of the cabin does not contact the ground when $v$ is less than 3.35m/s or 11ft/sec. Because the sink rate at the impact moment is from such test conditions as drop height and effective mass which are the inherent property parameters of helicopter itself, the result should be more rational.

### MIL-S-1290

MIL-S-1290 also defines analogous criterions to FAR part 27 for design of the landing gear. But the difference is it presents crash vertical velocity prior to the impact of craft with the ground. MIL-S-1290 provides various tests for crashworthiness design of the whole aircraft system, such as longitudinal crash, vertical crash, latitudinal crash, and roll over crash, and for key components such as landing gear and seat box system. In this paper, we select criteria of landing gear drop test and vertical drop test with lower (20ft/sec) and higher vertical impact speed (42ft/sec).

For requirements of the test for designing skid landing gear, it has to be capable of sustaining the decelerating aircraft impacting onto level and rigid surface from an impact vertical velocity of 20ft/s. In the test, the landing gear is allowed to be deformed or damaged, but fuselage not to contact the ground. A simultaneous fuselage angular alignment is also defined for roll and pitch from +15° to -5° (figure 3). To maximize the capability of absorbing impact energy, the landing gear is desired to continue to protect the cabin and occupants after fuselage has contacted with the ground [4].

![Figure 3: Roll and pitch attitudes envelope [3]](image-url)

Criterion of vertical impact test is to demonstrate the protection capability of the whole aircraft system with a rotor lift assumed equal to 1 DGW (Design Gross Weight) and an orientation (attitudes) combining pitch and roll angle as defined in Figure 3. The vertical impact test is distinguished from landing gear drop test only for the crash velocity in MIL-S-1290 but drop height in FAR 27. In vertical impact of MIL-S-1290, the aircraft has to withstand sink rate of 42ft/sec impacting on a rigid horizontal surface without allowing:
the height of the cockpit reduced by more than 15%.

The occupants suffering from an injurious accelerative loading.

When the vertical impact velocity is higher than 42 feet/sec, the structure of the aircraft has to be capable of maintaining an appropriate space for the survival.

Table 2: Criteria in the MIL-S-1290

<table>
<thead>
<tr>
<th>Test</th>
<th>Impact condition</th>
<th>Limitation/ evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landing Gear Drop Test</td>
<td>20 ft./sec</td>
<td>Fuselage non-contacting with ground</td>
</tr>
<tr>
<td>Vertical Injured impact</td>
<td>42ft./sec</td>
<td>&lt;15% deformation of the cabin height</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Injurious loading (Figure 4 within 0.1s)</td>
</tr>
<tr>
<td></td>
<td>&gt;42ft./sec</td>
<td>No catastrophic ceiling collapse</td>
</tr>
</tbody>
</table>

Comparing criterion in the MIL-S-1290 with in FAR 27 reviewed, the requirement of drop test in FAR 27 is same with the landing gear drop test in MIL-S-1290: fuselage without contact with ground. The impact downward velocity derived from FAR 27 is 3.35 m/s or 11 feet/sec. The 20 feet/sec in landing gear drop test of MIL-S-1290 is not that rational for light R22 helicopter. But by the lower downward speed of 11 feet/sec, then the higher downward speed should be proportional to the lower downward as that ratio in the original standard in MIL-S-1290 (20 feet/sec to 42 feet/sec). Thus, the higher downward speed is developed into 7.35m/s or 24ft/sec.

Human Tolerance

Current human tolerance criteria are based on the Elband human tolerance data, in which human injury is evaluated by uniform magnitude of vertical deceleration and the duration of the deceleration. The whole coordination system of the deceleration against duration is divided into three regions (Figure 4). The bottom left shadow and lower section means the safety area, while the top shadow part is the severe injurious area and the section between them is the moderate injury area. The difference of the human injury is determined by the deceleration occupants are suffering and the duration of the deceleration. For example, an occupant under an deceleration of 10g within 0.05s is uninjured. As to the helicopter vertical crash, the uniform deceleration at the seat position is mostly within 0.1s.

VALIDATION OF THE AIRFRAME MODEL

This section is to validate the simulation airframe model which is referred to dimensions of R22 Helicopter structure. The simulation model is made of Hughes-Liu beam elements. Validation has three phases, the lower speed validation in the landing gear drop test, the higher speed validation in the injurious load drop test, and the sensitivity validation in the drop tests. In the sensitivity validation, several interval values between the lower and higher speed are applied into the drop test. Referring to the requirement in MIL-S-1290, there are 11 initial conditions with different combinations of selected pitch angle and roll angle of the craft prior to the impact.

Airframe Simulation Model

Since the purpose of the paper is to conduct stochastic simulation on helicopter structural crashworthiness, a simplified simulation model is used for analysis of the impact energy transference among the landing gear, the cabin and the seat box system (figure 5).

The helicopter structure is reconstructed by the numerical model composed of Hughes-Liu beam elements in the code LsDyna. That is because beam element has absolute advantage in time consuming but maintaining the quality of the simulation. This advantage determines that the model with beam element is acceptable of the whole project of stochastic simulation which will run simulation model numerical times. The structure is composed of landing gear, fuselage and seat box which are the significant components in crash scenario.

The major material for the metal landing gear is Aluminum 7075. The skid gear was modeled using circular cross-section beam elements of varying thickness. Concentrated masses were used in the model to represent the ballast weights at certain position, such as seat position and engine point.
Non-Collapsed Landing Gear Drop Test

MIL-S-1290 and FAR 27 define a similar criterion of drop test that does not allow the helicopter landing gear to be collapsed or the subfloor to impact with ground. To evaluate the contact between subfloor and the ground, a Touch down Ratio is introduced as follow:

\[ R = 1 - \frac{H_c}{H_o} \]

Where:
- \( R \) = Touch down Ratio
- \( H_c \) = Current height of the point at the bottom of the cabin
- \( H_o \) = Original height of the bottom point

When the ratio arrives at 1 or more than 1, it means the subfloor crashes the ground or the landing gear collapsed. The impact sink rate is 3.35m/s according to the section 3.1 and the attitude of the craft is according to the figure 6 with different pitch and roll angle. We selected 11 cases with different combination of pitch angle and roll angle besides the baseline.

![Figure 5: Simulation Airframe model with Hughes-Liu beam elements](image)

Injured Drop Test

The sink rate causing injury in the drop test is inaccessible for R22 Helicopter in the given regulations. MIL-S-1290 provides an injured sink rate that is apparently not accurate to the light rotorcraft of R22. This paper derives the injurious sink rate by the correlation between the lower sink rate in the landing gear non-collapsed test and the higher sink rate in the injured impact test. The non-collapsed sink rate is 3.35m/s, so the injurious vertical velocity should be 7.35m/s.

![Figure 6: Impact condition with combination of pitch angle and roll angle](image)

Figure 7 illustrates touch down ratio in the drop test according to various cases of different pitch and roll angles. The ratio increment in the first 0.25s and arrive at the peak before they decline a little. The pulse of baseline (pitch 0 degree and roll 0 degree) has an earlier peak than other curves, since other helicopter model when crashing with the ground has an adjustment until the craft axle line is perpendicular to the ground. Figure 7 can demonstrate that the landing gear is not collapsed in all the selected case. Therefore, the simulation airframe model meets the requirement of landing gear drop test.

![Figure 8: Touch down ratio in the Landing Gear Drop Test](image)

Figure 8 shows the deceleration in the seat position in injured impact test by the combinations of pitch and roll angle. The maximum of deceleration is less than 100m/s\(^2\), and the peak of over 60m/s\(^2\) has been taking less than 0.05s. Referring to the Elmand Human Tolerance Data, the deceleration of less than 100m/s\(^2\) cannot make injury of occupants when the duration of uniform deceleration is less than 0.1s. It also can be seen from the figure 8 that all the curves have two major crests, the first of which should be caused by the clash between landing gear and the ground and the second should be by the crash of subfloor onto the ground. Therefore, the airframe model with sink rate of 7.35m/s at impact moment cannot make injury on occupants.
The criterion of MIL-S-1290 requires less than 15% deformation of the space of cabin. To evaluate the deformation of the cabin in the test, there is a ratio introduced into the analysis, called deformation ratio:

\[ R_c = \frac{H_{cc}}{H_{co}} \]

Where:
- \( R_c \) = the ratio of cabin deformation
- \( H_{cc} \) = the current height of the cabin
- \( H_{co} \) = the original height of the cabin

This ratio is to describe the percentage of deformation of the cabin. Figure 9 illustrates the deformation percentage (ratio) of the cabin according to different combination of pitch and roll angle. After 0.2 s of the time history, the deformation ratio of each attitude case maintains a constant that is less than 0.06 (6%). Therefore, the simulation model meets the requirement of the criteria of less than 15% deformation for the cabin space.

Sensitivity Validation

Sensitivity validation is conducted by demonstrating a hypothetical theory that the increasing impact vertical velocity can cause the worse injury or the higher maximum of the deceleration in the seat position. This assumption is shown in the figure 10. We selected 2 interval values between the sink rates at the impact moment we derived in landing gear drop test and injured drop test. The 2 interval values and the two sink rates from the drop tests are the 4 impact sink rates of the drop test for sensitivity validation. There are four regions determined by different impact sink rate and maximum of the deceleration (in the seat position). When impact sink rate is less than 3.35 m/s or greater than 7.35 m/s, the landing gear can be considered not to be collapsed or the occupant can be relatively possible of suffering severe injury. 4.7 m/s and 6.05 m/s are the interval values between the first two sink rates, and divide the interval area into 3 sections: moderate injury zone 1, 2, and 3.

If the impact sink rate between its lower and greater sink rates can make the maximum of the seat position deceleration within those made by the lower and greater sink rates, it can justify the correlation between impact sink rate and the maximum of deceleration.

There are 4 cases in the drop test; each case has different vertical velocity at the impact moment of the helicopter. For each case, there are 11 manners according to pitch and roll angle. The maximum of the deceleration in the seat position will be record for evaluation.

Discussion

The validation of the airframe model of R22 helicopter is made by three manners. Landing gear drop test validates the performance of skid landing gear, providing design standard in a lower impact downward speed. The downward speed is also a base of deriving higher downward speed and interval sink rate. Injured drop test use the higher sink rate at the impact instant calibrating the limitation of the occupant’s injury in
drop test. The validation of sensitivity is to obtain a dynamic robustness of the reconstructed helicopter simulation model. The three manners of validation can restrict the simulation better for the next phase of stochastic simulation.

CONCLUSION
An airframe simulation model of R22 helicopter has been successfully developed and validated for a project of stochastic simulation into helicopter crashworthiness. A validation system is established by integrating landing gear drop test, injured drop test and sensitivity validation. This method can make an acceptably sensible validation on the simulation model of rotorcraft under a condition of lack in real test data.

The numerical results of the simulation have been proved by the regulations of MIL-S-1290 and FAR 27 and monographs of Elband human tolerance which are reviewed and integrated into a validation system. The downward speed leading to collapse of landing gear in the regulation test is obtained, so does the speed causing the injury of occupants.

REFERENCE


Prioritisation of Helicopter Trajectories in Maritime Surveillance and Identification Missions

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Abstract. In maritime surveillance and identification missions with a helicopter and several vessels of varying types, it is important to prioritise the identification of vessels that look suspicious as quickly as possible. This not only minimises the helicopter flight time but also enhances airborne maritime surveillance, particularly against smuggling, which is difficult to notice [1]. In this work, we consider a fictitious littoral scenario involving smugglers and present trajectory optimisation criteria to improve the effectiveness of suspect vessel identification. The key objective is to create a priority list of the boats to be identified by using radar and electro-optical sensor information collected by the helicopter. A previously reported rules-based approach [1] considers boat speeds, manoeuvres and headings for detecting anomalous vessel behaviour. Here, we further develop a weighted decision algorithm to prioritise the identification of suspect vessels, which also includes the boat distances from a known smuggler vessel. A simulation model utilising this algorithm is created to measure the effectiveness of various airborne identification strategies that can be used for cognitive modelling of helicopter crews, as well as training purposes.

· INTRODUCTION

In helicopter-based maritime surveillance and identification missions over a littoral region, the effectiveness of a mission is measured by how quickly suspect vessels are identified by a helicopter. The task of determining the order in which the detected vessels are to be identified by a helicopter can be formulated as a helicopter trajectory optimisation problem. This paper is the first in a series of planned papers that present methods for solving helicopter trajectory optimisation problems in the littoral environment and where a single known smuggler vessel and multiple suspect, neutral and friendly vessels exist.

The smuggling scenario presented here is an extension of the one used by Nilsson et al. [1]. The scenario considers a known smuggler ship, transiting a littoral strait. The smuggler is tracked by the helicopter while its accomplices need to be detected and identified before they rendezvous with the known smuggler. These accomplices are henceforth referred to as suspect vessels. It is assumed that the helicopter is the only means to effect the detection and identification of suspect vessels.

The key data used for trajectory optimisation are radar tracks of the vessels and electro-optical (EO) sensors that help classify whether a vessel should be investigated further. The noise in radar track estimates necessitates the development of statistical detection techniques, provided tracking statistics can be modelled sufficiently accurately. The EO sensor gives accurate identification results if the helicopter is close to a vessel. The classification and subsequent prioritisation of suspect vessels for further identification by the helicopter is carried out based on radar range, speed and heading estimates available to the helicopter crew. It is possible to weight these estimates to cater for different operational objectives.

PROBLEM DEFINITION

The following problem considers a hypothetical vessel identification mission by the helicopter. The aims of the mission are to:

1. have the helicopter correctly identify as many suspect vessels as possible; and
2. have the helicopter correctly identify suspect vessels as far away from the smuggler as possible.

A prioritised track list contains the list of all vessels classified as suspect and that will be further investigated by the helicopter. The aim is for the helicopter to ensure adequate early identification of suspect vessels by continuously updating this list. This is expected to minimise the probability of a suspect vessel reaching the smuggler unidentified.

Illustration of a hypothetical maritime surveillance and identification scenario.
Scenario Description
Consider a known smuggler cruising with a constant velocity $v = 18$ knots through a strait of length 22 n mile and width 81 n mile (see Fig. 1). The other boats in the strait are classified into four categories: (i) suspect small boats, requiring identification, (ii) small fishing boats that are not suspect (neutral), (iii) large merchant ships that are not suspect (neutral), and (iv) large cruise ships that are not suspect (neutral). In Fig. 1, the helicopter crew would benefit from knowing, ahead of time, which vessels are suspect so that these are investigated and identified accordingly. The helicopter crew’s task is to first detect and then identify the vessels that may be suspect.

Identification Strategy
A helicopter is tasked with flying in the rectangular strait area to identify as many of the suspect vessels as possible. The identification (using EO) and detection (using both radar and EO) of all boats is done by the sensing systems on the helicopter. It is assumed that if the helicopter arrives near a boat, a visual inspection will give accurate vessel identification. A simplified 3-DOF helicopter model will be used to simulate the helicopter flights.

Search Optimisation
It is important to prioritise the identification of vessels in a way which ensures that: (i) all of the suspect vessels are identified, thereby minimising the number of neutral vessels identified by the helicopter; and (ii) the airborne identification of all the suspect vessels occurs as far away from the smuggler as possible.

A suspect vessel must be identified by the helicopter crews prior to reaching the smuggler. Otherwise, an illegal activity is likely to take place without sufficient surveillance.

The helicopter is to prioritise vessels to identify with the objective of suspect vessels being identified first. The helicopter crew will prioritise vessels to identify using a distance metric and a rules-based approach [1] that may improve situational awareness in maritime surveillance and identification missions.

All of this information is obtained from radar track estimates of the detected vessels (position and velocity vector). Identification is done by EO sensors on board the helicopter. A variable time interval which depends on the distance to each vessel and the time taken to visually inspect each vessel using EO is needed to assess whether a vessel requires crew attention before moving to other vessels on the priority list.

MODELLING OF RADAR TRACK ESTIMATES
The radar tracks of vessels are modelled assuming constant velocity motion with slowly time-varying dynamics. The noisy position vector measurements are processed by a recursive least squares (RLS) algorithm [2].

At each measurement time instant $t_k = kT$, $k = 0,1,2, \ldots$, the position vector of a vessel is

$$\mathbf{p}_{k+1} = \mathbf{p}_0 + t_k \mathbf{v}_0$$

where $\mathbf{p}_0$ and $\mathbf{v}_0$ are the initial position and velocity vector of the vessel, respectively. The radar collects a noisy version of the position vectors

$$\hat{\mathbf{p}}_k = \mathbf{p}_k + n_k$$

where $n_k$ is the additive white Gaussian noise with zero mean and range-dependent variance:

$$n_k \sim \mathcal{N}(0, \sigma_k^2).$$

Here $\sigma_k^2 = \| \mathbf{p}_k - \mathbf{s}_k \|^2 \sigma_0^2$ with $\mathbf{s}_k$ denoting the helicopter position (projected to the flat earth surface) at time $t_k$ and $\sigma_0^2$ the reference noise variance.

Using the RLS algorithm, the vessel position and velocity are estimated from the $\hat{\mathbf{p}}_k$ as follows [3]:

$$\mathbf{M}_k = [\mathbf{I}_2, t_k \mathbf{I}_2]$$

$$\Phi_k = \mathbf{M}_k^T \mathbf{M}_k + \lambda \Phi_{k-1}$$

$$\varphi_k = \mathbf{M}_k^T \hat{\mathbf{p}}_k + \lambda \varphi_{k-1}$$

$$\begin{bmatrix} \hat{\mathbf{p}}_0 \\ \hat{\varphi}_k \end{bmatrix} = \Phi_k^{-1} \varphi_k$$

$$\hat{\mathbf{p}}_k = \mathbf{M}_k \begin{bmatrix} \hat{\mathbf{p}}_0 \\ \hat{\varphi}_k \end{bmatrix}$$

where $0 < \lambda < 1$ is the RLS exponential forgetting factor and $\mathbf{I}_2$ is the $2 \times 2$ identity matrix. The RLS position and velocity estimates of the vessel, $\hat{\mathbf{p}}_k$ and $\hat{\varphi}_k$, are given by the last two equations above.

PRIORITISATION OF VESSELS
The estimated vessel distance from the smuggler, the estimated vessel speed and heading affect how the helicopter crew will prioritise vessels in the helicopter maritime surveillance and identification mission. Earlier work by Nilsson et al. [1] suggests that the prioritisation of which vessel to identify is guided by considering behavioural observations such as vessel course and speed changes. Intuitively, the method developed here also considers a distance metric that is measured relative to the smuggler vessel. Fig. 2 depicts these estimates to motivate their use in constructing a metric for vessel prioritisation.

In this example, it is assumed that the farther away a vessel is from the smuggler (large $d_k$), the lower priority it will be given for identification purposes. For simplicity, all stationary vessels are not a high priority.
If a vessel is heading away from the smuggler, it is considered to be a low priority vessel. Unidentified vessels in the vicinity of the smuggler or heading straight towards it are considered high-priority as they could reach the smuggler without surveillance. Based on this, we propose the following metric for vessel prioritisation:

\[
J_k = d_k \left( w_1 f(\hat{\theta}_k) + w_2 \frac{1}{\|\hat{\theta}_k\|^2} + w_3 \frac{1}{\|\hat{\theta}_k - \hat{\theta}_{k-1}\|} \right)
\]

where \( w_1 + w_2 + w_3 = 1 \) and \( w_i \geq 0 \). The functional \( f(\hat{\theta}_k) \) measures how much the vessel heading deviates from the smuggler position:

\[
f(\hat{\theta}_k) = |\hat{\theta}_k - \zeta (r_k - \hat{p}_k)|
\]

where \( \zeta \) denotes the heading angle. The vessels are prioritised according to \( J_k \), using the relationship that the smaller \( J_k \), the higher priority a vessel gets. The effect of individual terms in the metric can be adjusted by means of weight coefficients \( w_i \).

**SIMULATION MODEL**

In the simulations, two vessel sizes are considered; namely, small boats and large ships. The vessel identification operation is only concerned with small boats, some of which may be suspect while the others are not. The smuggler is a large boat that cruises with a constant speed of 18 knots following a straight line in the middle of the strait of length 81 n mile and width 22 n mile (the search region). The helicopter flies at a constant speed of 146 knots (maximum range 450 n mile). The total number of vessels in the search region is set to 20. The number of small boats is randomly selected using a probability of 60%. Of the small boats, the probability that some will be suspect is 50%. Small boats are either cruising with a constant speed of 25 knots, stationary, or are manoeuvring towards the smuggler after being stationary for a random time interval. Any vessel identified as suspect is stopped while an airborne identification operation takes place. This is indicated as a downward slope in the speed estimates (see Figs. 3–6). The merchant vessels all cruise with a constant speed of 23 knots. The initial positions of vessels are randomly determined within the search region. The initial headings of neutral vessels are uniformly distributed in a small interval around zero degrees to ensure they do not hit the northern or southern boundaries of the search region.

The reference noise for radar position measurements is \( \sigma_0 = 0.001 \). The RLS exponential forgetting factor is \( \lambda = 0.99 \). The developed identification simulation model consists of a simulation model for the smuggler and other vessels which calls the RLS tracker to generate radar readings and the priority list function.
to optimise the helicopter flight trajectory. Once all of the small boats within the search region are identified, the mission and the simulation end.

Simulated identification scenarios for different weights are shown in Figs. 3–6. We seek to minimise the time spent by the helicopter crews searching for and identifying suspect vessels. Clearly, it is assumed that the sooner all suspect vessels are identified, the shorter the helicopter’s mission will be. These simulations not only show the effectiveness of the developed prioritisation metric, but also illustrate the effect of weights that are applied to heading, speed and acceleration measurements in reducing the helicopter’s mission time.

In the simulations, there are five suspect boats that are successfully identified. Among all weight combinations considered, the total helicopter flight time from the start of the mission to the end is minimised when only the decision rule as a distance-speed product is considered as prioritisation metric (i.e., $w_1 = 0, w_2 = 1, w_3 = 0$). Therefore, for this example, it would be prudent to prioritise for further identification only those vessels that have the greatest closing velocity towards the smuggler.

CONCLUSIONS

The paper has presented a simulation study for helicopter trajectory optimisation in maritime surveillance and identification operations. It was shown through simulation examples that the judicious use of radar and EO data can help prioritise subsequent identification of detected boats. Future work will apply this method to analyse different scenarios using Monte Carlo techniques and 6-DOF modelling of helicopter flight manoeuvres [4] while exploring the effectiveness of different weight combinations across a range of suspect and neutral vessel positions.

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Planning Modelling and Simulation for Major Defence Projects

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Abstract. Guidance for the development of modelling and simulation (M&S) plans for major capability projects has been available for several years through the Defence Simulation Manual (SIMMAN). This paper reports on the first formal and resourced application of SIMMAN guidance to two major projects. The Australian Defence Simulation and Training Centre (ADSTC) commissioned this work in consultation with Capability Development Group (CDG) and ADSTC personnel. The process of applying SIMMAN guidance, key issues encountered and the nature of the resulting M&S Plans are discussed as well as considerations for future M&S planning.

ABBREVIATIONS USED
ADSTC: Australian Defence Simulation and Training Centre
AEW&C: Airborne Early Warning and Control
CDG: Capability Development Group
CGRB: Capability Gateway Review Board
DCIC: Defence Capability and Investment Committee
DCP: Defence Capability Plan
KMS: Knowledge Management System
M&S: Modelling and Simulation
MSCRB: Modelling and Simulation Certification Review Board
PDS: Project Document Suite
PMP: Project Management Plan
PO: Project Office
SIMMAN: Defence Simulation Manual

INTRODUCTION

All Defence Capability Projects have the requirement to consider Modelling and Simulation (M&S). This requirement has been articulated in the 19 Dec 2012 Defence Capability and Investment Committee (DCIC) direction: “DCIC directs that every project considers simulation as a fundamental requirements element” and “every project that required simulation would provide funding consideration for simulation prior to first pass consideration”.

This paper examines the first formal and resourced application of M&S planning guidance to two major projects. A review of this guidance was undertaken in conjunction with this M&S planning process and the resulting implications for future guidance are also discussed. A summary of abbreviations used is provided at the end of this paper.

M&S PLANNING GUIDANCE

The DCIC direction for consideration of simulation as a fundamental requirements element has resulted in the development of the Capability Development Group (CDG) Product Development Suite (PDS), 6.10-07 Defence Modelling and Simulation Assessment Certificate (Department of Defence, 2014). The M&S certification process includes three stages: initial assessment – M&S Considerations Document, M&S Plan prior to Capability Gateway Review Board (CGRB) First pass, and M&S Plan update prior to CGRB Second pass (refer to Figure 1). The process provides an assessment of how project decisions and plans, with respect to M&S, comply with Defence Simulation Manual (SIMMAN) (Department of Defence, 2013). The Certificate is provided by the Modelling and Simulation Certification Review Board (MSCRB), managed by the Australian Defence Simulation and Training Centre (ADSTC), in response to submission of the M&S Plan by the project. The Plan should be prepared according to general guidance provided in the Project Document Suite (PDS) Guide Section 5.01.

An M&S Plan template has been developed by the ADSTC for inclusion in the PDS Guide for projects to
use. This template aims to provide Project Managers with an effective tool to guide them through the M&S planning process; it questions the potential for M&S to benefit key capability development and in-service phases and provides example applications.

**CHALLENGES TO EFFECTIVE M&S PLANNING**

Effective guidance for M&S planning in relation to a Major Acquisition Project faces challenges ranging from resourcing the work required, through identification of an appropriate level of technical detail, to educating and motivating project staff who have many competing demands for their attention. Addressing these challenges requires the M&S planning process to be:

- manageable by a Project Office (PO) without internal planning process to be:
- valid in terms of the SIMMAN and related M&S policy and procedures;

- and purely used as a means to pass through project gates.

- lack of current simulation guidance that would be useful to the CDG desk officer undertaking M&S planning (from considerations through to development of a complete plan);
- lack of a mature ADSTC Knowledge Management System (KMS) that allows CDG desk officers to readily identify potentially useful models, tools and techniques; and
- a lack of experience and practice of embedding M&S planning as part of the broader project planning and management so that products do not become orphaned and purely used as a means to pass through project gates.

- reliable such that different Project Offices have a common understanding of the development process and can apply it to their specific circumstances;
- motivational in relation to effective and efficient use of M&S; and
- informative and educational in relation to the development, use and governance of M&S in Defence.

The current circumstances of M&S guidance in Defence that complicate resolution of the challenges faced include:

- SIMMAN, of which only Chapter 1 has been released, does not detail the M&S application consideration for Defence Capability Plan (DCP) projects according to the current M&S PDS documents requirement. Current SIMMAN supporting documents are primarily based on a new process specifically intended for training applications of simulation;

- The current M&S PDS documents requirement. Current Defence Capability Plan (DCP) projects do not detail the M&S application consideration for Defence Capability Plan (DCP) projects according to the current M&S PDS documents requirement. Current SIMMAN supporting documents are primarily based on a new process specifically intended for training applications of simulation;

- much diligent and detailed work has been undertaken by Defence over the past 10 to 20 years to address the challenges described above; a further challenge now is to build on this. In particular, the CDG PDS now includes the following M&S planning products, with reference to M&S certification in the CDG Project Management Plan (PMP):

**M&S PLANNING PRODUCTS**

Much diligent and detailed work has been undertaken by Defence over the past 10 to 20 years to address the challenges described above; a further challenge now is to build on this. In particular, the CDG PDS now includes the following M&S planning products, with reference to M&S certification in the CDG Project Management Plan (PMP):

**M&S Considerations Document.** An initial and high-level assessment of the potential for application of M&S to all phases of a capability development project.
M&S Plan. A detailed report of specific plans and justifications for M&S which is updated for consideration at key project milestones such as First Pass and Second Pass Capability Gateway Reviews.

M&S Certificate. Formal acknowledgement by Defence M&S authorities and stakeholders of the M&S planning that has occurred, detailing risks and whether further work is required.

The M&S planning piloting and review study currently underway is developing M&S Plans for two Capability Development Projects selected on the basis of representing quite different stages of completion and quite different contexts of actual systems.

For each of these projects, M&S planning products are required to consider the Requirements, Acquisition, In-Service and Disposal phases in the life-cycle of a Defence capability. Within these phases, the need for M&S and associated costs and risks are being examined in relation to models, techniques and tools for:

- decision support for concept demonstration, capability development and acquisition;
- training and mission rehearsal; and
- decision support for routine business and operations planning.

The analysis of M&S models, techniques and tools will aim to improve methods to define the M&S need, detail minimum requirements and constraints, describe expected benefits, indicate M&S limitations, define required levels of fidelity, identify data requirements, describe system performance requirements, describe personnel implications, describe facilities implications, outline confidence building and acceptance measures, describe interoperability requirements, provide a timeline, outline related opportunities and risks, estimate ROM costs, assess investment benefit and value-for-money and outline further studies required.

PILOT PROJECTS

SEA 1179 Ph 2 – Patrol Boat Replacement is in very early stages of the capability development process. M&S planning is likely to focus on broad needs, especially those related to decision support for concept demonstration, capability development and acquisition.

AIR 5077 Ph 5A – AEW&C Interoperability Compliance Upgrade is far more advanced with capability requirements determined. The WEDGETAIL capability itself is well established and this upgrade has the benefits of existing M&S capabilities. Nonetheless, the M&S Plan needs to consider impacts of the upgrade for existing WEDGETAIL M&S and implications for interoperability with other M&S systems.

While piloting of M&S planning guidance as described in this paper has been applied to the two selected projects, the resulting M&S Plans are necessarily constrained by factors such as project maturity and availability of detailed information. Nonetheless, the applicability of the current planning template has been tested and a number of suggested improvements recommended.

LESSONS LEARNED AND FUTURE POTENTIAL

A key issue during piloting has been alignment of the planning process to existing policy. Ensuring alignment is likely to require significant rationalisation of the legacy guides that relate to application of M&S to the various phases of the capability life cycle. The challenge is to ensure that this rationalisation activity is undertaken with care to ensure the relevant intellectual capital in M&S, which has been developed over the last decade or so, is retained where appropriate.

The initial action of producing an M&S Considerations Document very early in the life of a project appears to be well worthwhile. This helps document M&S used in concept development during the Needs Phase so that further use, say during options analysis, can be assessed. This early assessment of potential applications of M&S also provides a basis for more detailed analysis leading to a formal M&S Plan as a project approaches the Acquisition Phase. Indeed, early investment in the M&S Considerations Document arguably returns a substantial benefit to the subsequent M&S Plan.

Current M&S planning guidance does not address the use of M&S during the initial Needs Phase; however, existing practices of concept development and workforce planning appear to utilise M&S well. This seems to be a result of M&S in this initial phase being considered as ‘business as usual’ with tools and expertise well-embedded within relevant agencies.

The first iteration of an M&S Plan appears to be crucial to ensuring coordination, funding and resources for later M&S development and application. While technical details, such as data formats, are important these might best await M&S development activities with planning focusing on qualitative issues that underpin effective project management. Especially for projects that have substantial M&S applications, technical details can be documented in later iterations of the M&S Plan once they are determined through developmental activities.

The Directorate of Simulation Services within ADSTC functions as an enabler of simulation for collective training and experimentation. This Directorate is likely to have increasing importance in M&S planning for capability projects as collective training through simulation grows and capabilities need to be included in Joint synthetic environments. To this end, capability projects might need to assess their relevance to JP 3035 which aims to establish the long term Joint training environment and services. All consultation with DSS and JP3035 would be through the ADSTC Standards and Certification Officer.

The Directorate of Simulation Governance, also a part of ADSTC, is responsible for simulation governance across Defence, including planning guidance. While not resourced to conduct M&S planning for capability projects, this Directorate has a clear stake in the...
process and facilitates certification of M&S Plans. While M&S planning is being established as a routine process for capability projects, this Directorate is providing advice and will require additional resources to support the transition.

Individual Service M&S offices/officers also play a key role in M&S planning. These bodies provide access to Service-specific M&S expertise and experience and can coordinate the needs of a project with existing resources and services. They also maintain situational awareness of and interrelationships between Defence Capability Projects of which their respective Service Chiefs are Capability Managers. Inclusion of these bodies within M&S planning guidance will help to avoid reliance on a project manager having personal knowledge of, and fortunate points-of-contact within, these bodies.

CONCLUSION
At the time of preparation of this paper development of M&S Plans for the two selected major projects and review of the M&S planning process was still underway. With this understanding, some initial comment can be made from what has been reported in this paper.

Challenges to effective M&S planning can generally be addressed through:
- making the process manageable by Project Managers (e.g. providing access to resources and expertise to undertake the required work);
- releasing the rest of the SIMMAN chapters and providing regular updates of SIMMAN and the supporting documentation;
- making the benefits of M&S planning clear; and
- educating the users of M&S planning guidance.

Specific near-term actions to improve M&S planning guidance include:
- alignment of all guidance that affects M&S planning such that contradictions and inconsistencies are resolved;
- implementation of a mature M&S policy and planning guidance;
- development of an ADSTC KMS providing ready access to information regarding pertinent models, tools and techniques; and
- establishment of M&S Plans as valued tools that are worthy of updating as a project evolves.

REFERENCES
SimTecT

Workshop - Human Dimensions in Simulation

"The Safe Container": Creating Minimum Safety Standards In Australasian Simulation

Dr Cameron Knott¹; Dr Elysebeth Leigh²; Sanjay Khetia³; Marc Lyons⁴
¹Austin Health, Victoria; ²FutureSearch; ³QinetiQ Training; ⁴Building Leadership Simulation Centre

Presenter Details.

- Inter-industrial members of the Simulation Australasia ‘Human Dimensions in Simulation’ Committee
- Inter-industrial members of the Simulation Australasia Standards Committee

Overview.

Session structure:

- A 90-minute participative open-forum workshop to develop themes around for a minimum safety standard in Australasian simulation
- Synchronous participation:
  - via direct audience participation with cross-industry expert simulation panel
  - via social media platform (“tweet-wall”) in room
- Distributed and asynchronous participation via social media platform

Expected Outcomes.

Session objectives

- To discuss inter-industrial risks simulation poses to institutions, faculty, learners and third-parties (such as clients, customers and patients)
- To discuss common concepts for mitigating and preventing the potential risks in a simulation program and industrial safety programs.
- To consider creation of a standardised taxonomy for simulation terminology to enable minimum simulation safety standards and a simulation registry in Australasia
Detailed Description.

Proposed workshop structure:

- Process: based on first phase of developing international standards organization best practice: [http://www.iso.org](http://www.iso.org)
- Session leaders will provide a brief overview of key terms involved in simulation topic e.g. standards, safety, and debriefing.
- What would an evidence-informed safe simulation program look like?
- What can go wrong?
- Where can simulation go wrong?
  - Organisational level, Simulation level (Preparation, Simulation session, Debrief, Afterwards), Faculty, learner or third party
- Collaborative participatory inquisitive process designed to draw out various perceptions of simulation risk in each industry
- Collaborative discussion to consider where this risks may fall in a ‘risk-matrix’ for simulation safety standards
- Out of this structured discussion will emerge essential information about:
  - the variety of contexts
  - ways that each key term is considered and applied in different settings
  - range of skills and knowledge required of learning facilitators/directors
- Develop proposal for initial elements for a Delphi process for “Minimum safety standards in simulation” from session and its associated social media platform

Expected Outcomes.

Evaluation via use of conference application or via use of social media platform affiliated to #safecontainer hashtag, pre-registered on Symplur.

Timeline.

90 minute workshop:

- 15 minute introduction
- 45 minutes discussing risk at various levels of organisation and simulation program
- 15 minutes summation of ideas expressed
- 15 minutes closure of session, with evaluation via conference app and social media, with invitation to engage in next phase of development of standards
United States Pacific Command (USPACOM) LVC Training
Focused at the Strategic and Operational Level

Major Matthew Mackey, M&S Branch Chief, PWC; Michael Fagundes, M&S Strategic Planner; Terri Eubanks, Joint Training Specialist

Abstract. The United States Pacific Command (USPACOM) is one of six geographic combatant commands defined by the Department of Defense’s Unified Command Plan (UCP). As a geographic combatant command, USPACOM is in charge of using and integrating United States Army, Navy, Air Force and Marine Corps forces within the USPACOM area of responsibility (AOR) to achieve U.S. national security objectives while protecting national interests. The USPACOM AOR covers more of the globe of any of the other geographic combatant commands and shares borders with all of the other five geographic combatant commands. The commander of US Pacific Command reports to the President of the United States through the Secretary of Defense and is supported by multiple component and sub-unified commands including: U.S. Forces Korea, U.S. Forces Japan, U.S. Pacific Fleet, U.S. Marine Forces Pacific, U.S. Pacific Air Forces and U.S. Army Pacific. [1]

Accordingly, the USPACOM Joint Exercise Program (JEP) and associated training events and activities are unilateral, bilateral, and multinational. In order to execute the JEP and achieve all of the desired joint training goals and objectives, the challenges of distance, culture, language, and data sensitivity levels must be overcome, while managing fiscal resources and the joint force operational tempo.

In the Pacific, the lead joint training provider in support of the USPACOM Commander (CDR) is the Pacific Warfighting Center (PWC), located on Ford Island, Oahu, Hawaii. The PWC provides training venues with synthetic environments, training aides, and technology solutions to prepare USPACOM Headquarters (HQs), Components, Sub Unified Commands, Partners, and other organizations to achieve and sustain mission readiness. Based upon training audience requirements, the PWC is able to design live, virtual, and constructive (LVC) solutions to achieve the desired effect for realistic training, focused at the strategic and operational levels.

1. Introduction
We operate in a resource constrained environment with threats that range from natural disasters to conflict to terrorism to cyber. Governments must be prepared to protect their citizens and maintain a safe and stable society. Within the United States Department of Defense (DoD), there are multiple organizations that work together to resolve regional, national, and global challenges and problem sets. How are they able to successfully execute their missions? How do they maintain mission readiness?

In the Pacific, the lead joint training provider in support of the Commander (CDR), United States Pacific Command (USPACOM), is the Pacific Warfighting Center (PWC), located on Ford Island, Oahu, Hawaii. The PWC provides training venues with synthetic environments, training aides, and technology solutions to prepare USPACOM Headquarters (HQs), Components, Sub Unified Commands, Partners, and other organizations to achieve and sustain mission readiness. Based upon training audience requirements, the PWC is able to leverage live, virtual, and constructive (LVC) tools to achieve the desired effect for realistic training, focused at the strategic and operational levels. Before continuing with the LVC tools and training environment solutions, one must first understand USPACOM.

2. Background
USPACOM is one of six geographic combatant commands defined by the Department of Defense’s Unified Command Plan (UCP). As a geographic combatant command, USPACOM is in charge of using and integrating United States Army, Navy, Air Force and Marine Corps forces within the USPACOM area of responsibility (AOR) to achieve U.S. national security objectives while protecting national interests. The USPACOM AOR covers more of the globe than any of the other geographic combatant commands and shares borders with all of the other five geographic combatant commands. The commander of US Pacific Command reports to the President of the United States through the Secretary of Defense and is supported by multiple component and sub-unified commands including: U.S. Forces Korea, U.S. Forces Japan, U.S. Pacific Fleet, U.S. Marine Forces Pacific, U.S. Pacific Air Forces and U.S. Army Pacific.

There are few regions as culturally, socially,
In concert with other U.S. government agencies, USPACOM protects and defends the territory of the United States, its people, and its interests. With allies and partners, USPACOM is committed to enhancing stability in the Asia-Pacific region by promoting security cooperation, encouraging peaceful development, responding to contingencies, deterring aggression, and, when necessary, fighting to win. This approach is based on partnership, presence, and military readiness. [1]

Accordingly, the USPACOM Joint Exercise Program (JEP) and associated training events and activities are unilateral, bilateral, and multinational. In order to execute the JEP and achieve all of the desired joint training goals and objectives, the challenges of distance, culture, language, and data sensitivity levels must be overcome, while managing fiscal resources and the joint force operational tempo. These factors lead the PWC organization to leverage technology solutions and LVC tools to deliver the Joint Training Environment (JTE) to train the USPACOM CDR and staff, Joint or Combined Task Force CDRs and staffs, Component CDRs and staffs, and Sub-Unified CDRs and staffs. Many exercises include partner nations and are executed with bilateral and multi-national agreements, environments, processes, and procedures.

3. Discussion
The JTE enables all forces to conduct realistic training and attain force readiness to accomplish their missions and assigned tasks. The network component allows for training to occur at home station, training sites and operational HQs, and to deployed locations in the field. Leveraging LVC capabilities allows for a focused scenario and circumstances for the training audience, which can be an individual in a simulator, a unit in the field, a combatant commander and his battle staff, or a national level event that includes the entire DoD, including the President’s office.

Figure 1: Joint Training Environment (JTE)

There are many computer models, simulation federations, and other tools that are used to create a realistic synthetic environment. This environment enables organizations, teams, and individuals to perform their roles and assigned tasks at optimal levels, without moving thousands of soldiers, equipment, vehicles, and other assets into the field. These capabilities are integrated in a single consistent coherent environment to enable multi-echelon training.

Live = Real people in real training areas using simulation instrumentation kits
Virtual = Real people in a synthetic environment operating a simulator
Constructive Simulation = Synthetic people in synthetic environments – with outcomes determined by the simulation

At the operational level, a Command Post Exercise (CPX) environment effectively provides realistic training to a Commander, staff, and multiple supporting organizations. For USPACOM, these activities are designed to stress a training audience at the headquarters (with supporting organizations) and Joint or Combined Task Force levels. Focus areas and themes for this type of training include Humanitarian Assistance / Disaster Recovery (HA/DR); Non-combatant Evacuation Operations (NEO); interoperability; maritime domain awareness / security; command and control; information operations / cyber; logistics; interagency coordination; and information sharing, to name a few. Constructive simulations and scripted events injected to the training audience through an exercise control organization are the CPX drivers. This is illustrated within Figure 2, located below.
The focus here is on the staff’s ability to respond to situations through information sharing and collaborative decision making.

The Pacific Warfighting Center, USPACOM’s joint training solutions provider, is tasked with building a synthetic environment for all scenarios, including the use of LVC solutions. The current development focus is on combining the right mix of people, processes, and technology resulting in cost effective capabilities to drive a realistic joint operational environment. LVC solutions are continuously updated and evolving to address training gaps, multiple scenarios, and more efficient ways to conduct training events. Each training event establishes tasks and objectives to accomplish, identifies which organizations will participate, and changes based upon commander’s guidance, priorities, and mission readiness needs. The PWC remains diligent in evaluating exercises and identifying the best LVC solution based upon requirements, schedules, and available resources.

4. Conclusions
This paper provides the framework for the Joint Training Environment (JTE) and the Strategic and Operational focused Simulated Training Environment to encourage general modelling and simulation (M&S) community members to have detailed discussions with training provider subject matter experts (SMEs) to enhance training programs and associated events and activities across multiple venues and levels.

LVC tools and solutions provided by government and industry require continuous improvements and enhancements to meet the multiple scenario, architecture, and training requirements ranging from small to large scale at one or more locations across geographies. This partnership enables best practices, technology innovation, and subject matter expertise to be aligned across identified problem sets, training gaps, and domains.

There is much discussion across the M&S community concerning the costs and benefits of an integrated live, virtual, and constructive environment established for a joint training event. Identifying the primary training audience and their objectives; defining what expertise is required to participate as a training aide; and managing the scenario and resources to achieve safety and effectiveness are critical parameters for success. This is an area to further research and analyze.

References.
Simulation Supporting Army Digitization Experiments and Operational Integration

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Abstract. The application of Concept Development & Experimentation (CD&E) cycles for the development and acquisition of new C2 and C4ISTAR systems, combat platforms and equipment under a DOTLMPFI (Doctrine, Organization, Training, Leadership, Material, Personnel, Facilities, Interoperability) approach is a quite well known and worldwide well accepted in the Defense. It is also widely recognized that the availability of a Unit with capabilities to test and experiment new proto-types or pre-series systems, platforms and equipment is a good way to execute on-field testing and experimentation activities supporting Verification, Validation and Acquisition (VV&A) processes. Italian Army Chief of Staff established the Unit for Digitization Experimentation (USD) to execute digitized C2 and C4ISTAR systems and platforms operational integration sessions.

The role of simulation supporting CD&E cycles within the availability of a distributed battle labs organization is also well known due to the versatile and cost-effective solutions nowadays available. Live, Virtual and Constructive simulation-based training systems could also be effectively used to support fielded test and experiments providing a more effective operational scenario and fulfilling gaps existing due to the lack of availability of special assets. In addition providing test and experiment planning and execution tools.

The author has developed a capability model to design a generic Army Unit for Experimentation and Transformation (UET). Applying this model under a DOTLMPFI approach is possible to define simulation-based training and experimentation capabilities required by a generic UET to support experimentation and transformation processes. UET units, like the Italian Army USD, could benefit in particular from latest cost-effective Live and Virtual immersive simulation-based training solutions to support C2 and C4ISTAR experimentation campaign.

In conclusion a Unit for Experimentation and Transformation (UET) could benefit from a large simulation-based training and experimentation support to be more cost-effective and efficient under the DOTLMPFI approach. Furthermore integrating Test Bed Battle Labs and Simulation-Based Training facilities and developing ad-hoc interoperable simulation-based capabilities to test, experiment, verify and validate prototypes and pre-series systems within a close to real operational scenario provided by the simulation.

ITALIAN ARMY UNIT FOR DIGITIZATION EXPERIMENTATION (USD)

The Italian Army Chief of Staff established a Unit for Digitization Experimentation in order to test new generation of C2/C4ISTAR systems and prototypes supporting the army digitization and transformation processes to develop new operational capabilities.

All of these systems have been being developed within the Italian Army “Forza NEC” program. The Italian Army 31° Tank Regiment was the chosen unit and was transformed into the Unit for Digitization Experimentation (USD). It was assigned the mission to experiment the Future Soldier System, Forza NEC Operational Capabilities.

Future Solder System.
the new generation of Command Post C2 system (SIACCON 2), C2 and navigation systems for combat platforms and tactical vehicles (SICCONA and BFSA) belonging to light, medium and heavy infantry, to recce and heavy cavalry and to main battle tanks.

SIACCON 2 – Digitalized Command Post.

Furthermore the increase in effectiveness of operational capabilities.

Fielded Operational Integration Sessions (SIO) are required to test and experiment the level of integration between different prototypes and pre-series platforms across operational nodes (from T0 sensors to T6 Brigade Command Post). SIO’s are planned, organized and executed periodically, usually four times a year, to verify systems and platforms effectiveness and functionality. Each session lasts 2-3 weeks.

USD’s Operational Integration Sessions

Interoperability Layers

The USD’s personnel is also trained and qualified in live fire exercises operating these systems as they become available and mature, up to platoon level. Main USD tasks are:

- testing the platform looking for possible bugs, and
- supporting the development of new TTP’s and eventually doctrine driving further systems evolution

The use of simulation to support USD’s test and experimentation activities is actually limited and simulation is used to provide constructive entity level capabilities to the USD digitized Command Post. This capability is needed to provide additional stimulation to the C2 system SIACCON 2 within the USD digitized Command Post.

As widely recognized, fielded test and experimentation activities are expensive in terms of usage of resources, vehicles and platforms and these activities. Simulation, and in particular Virtual Immersive Simulation and Network Simulators may support USD’s early operational integration phases in a cost effective manner. Furthermore looking at reducing the number of fielded operational integration sessions, implementing non-fielded Simulation-Based Operational Integration Sessions.

UNIT FOR EXPERIMENTATION AND TRANSFORMATION (UET)

The author has developed a generic capabilities model to support the development of a Unit for Experimentation and Transformation (UET) under a
DOTLMPFI approach. The model takes into consideration three main capabilities should be developed when establishing UET:
Simulation-Based Training
Test Bed Battle Labs
Experimentation Campaign

UET capabilities model

To be adherent to a DOTLMPFI approach the Organizational aspect is crucial. Regarding the other relevant aspects taking into consideration Army Doctrine, Leadership and Facilities maybe more than a UET should be established “re-organizing” what is already in place.

Regarding Interoperability it is necessary that the simulation-based training capability should be integrated and make it interoperable with the test bed and battle lab simulation-based experimentation capability.

Italian Army UET capabilities

Italian Army USD test and experimentation capabilities could be improved implementing and integrating Virtual Immersive Simulation technology and Live instrumented simulation technology to provide new cost-effective training and experimentation solutions.

According to the UET capabilities model, integrating the ITB Battle Labs solutions with the SIAT LVC simulation-based training technology it could be possible to support USD’s operational integration and experimentation activities in a very cost–effective manner through the development of:

Cost-effective vehicle platform simulators integrated with real, emulated or simulated C2 systems
Interaction between real and simulated platforms, special assets (UAV, UGV,...) and fielded units to provide the complete operational scenario needed to conduct comprehensive experiments and stress test sessions
Virtual Training for operators
Support to planning, testing and verification of exercises/experiments sessions before conducting them on field (risk reduction)

The following pictures show the concept to provide cost effective simulation solutions to test and to train Future Soldiers C4ISTAR component and the C2 component (SICCONA and BFSA) installed on combat platforms and tactical vehicles.

CONCLUSIONS

Applying to the Italian Army USD the capabilities model developed by the author, USD could benefit from a simulation-based approach to support operational integration and experimentation activities.

In fact it is more cost-effective to test, experiment, verify and validate prototypes and pre-series systems combining Test Bed (ITB) simulation and analysis tools capabilities, LVC Simulation-Based Training systems (SIAT) and USD’s real platforms. Integration between CD&E facilities (ITB) and simulation-based training facilities (SIAT) produces a better programs ROI and improved effectiveness during Operational Integration sessions. LVC Simulation-Based Training technology should support operational integration sessions in order to reduce Training and Experimentation costs and environmental impact.

Finally it is very important to underline that digitization and transformation processes under a DOTLMPFI approach require a well defined and integrated organizational structure.

REFERENCES


Procedural Voxel Algorithm for Real-time Simulation

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Abstract. Today a set of detectors such as LiDAR (Light Identification Detection and Ranging) [1] can generate 3D scenes from the cloud of volumetric pixels (voxels). Voxels are stored in volumetric database and presented by Sparse Voxel Octrees (SVO). This technology provides the full information about voxels including the geospatial coordinates in space from digital elevation model (DEM), RGB colour from satellite imagery, and the level of transparency. Current software programs generate the database using regular or irregular mesh network. This methodology doesn’t allow identifying the type of each objects’ material in 3D scene which in turn makes the process of simulator database generation more complicated and time-consuming. Here, a novel algorithm is introduced that can automatically generate the material ID of each voxel in database and use it for enhanced capabilities in real-time simulation process. This algorithm is based on analysis of raster imagery and coordinates of each voxel to discern the material type. The render of final 3D scene shows the results of algorithm’s material recognition.

INTRODUCTION

Polygonal and mesh modelling have been the standard in three-dimensional modelling for over twenty years. This type of three-dimensional modelling is based on regular triangulated networks (RTN) and triangulated irregular networks (TIN) [2]. A TIN is a vector-based representation of the physical land surface, made up of irregularly distributed nodes and lines with three-dimensional coordinates that are arranged in a network of no overlapping triangles (Figure 1):

**Figure 1:** triangulated irregular networks (TIN).

RTN is a computationally efficient means of capturing all posts in an elevation raster, but it takes more triangles then TIN (Figure 2):

**Figure 2:** regular triangulated networks (RTN).

PROBLEM DEFINITION

The above methods have a major drawback for inclusion of additional objects into the 3D scene after generating the landscape. Each new object to be inserted requires to be cut from the landscape (Figure 3). However, if the edges of each polygon do not exactly match the edges of the tiles adjacent to it, visual artefacts are visible between the polygons [3]. These artefacts look like cracks or gaps in the terrain skin.

**Figure 3:** Runway and airport 3D models as an example of insert.

Also, the problem of inserts in 3D scene arises in material ID generation. Material ID generation allows the simulators to use such options as EO (electro-optical), IR (infra-red and NVG (night vision goggles) sensors. Each new object that is recognized as new material (soil, water, grass, concrete, runway, etc.) should be derived from the general database by Boolean operation. This methodology significantly received a lot of artefacts around each new object or insert.
The voxel-based rendering technique meets the task requirements. This type of rendering has recently received significant attention due to its potential in the context of efficiently rendering massively large and highly detailed scenes [5].

![Figure 5: Voxel 3D engine visualization.](image)

**METHODOLOGY**

In this paper, we introduce the procedural algorithm of colour recognition by RGB channels.

```
Georeferenced Satellite Image
  ↓
RGB analysis by threshold filter
  ↓
Surface material classification
  ↓
Assignment of new colors according the type of sensor
  ↓
Generating the Material Database
  ↓
Rendering process
```

**Figure 6: ID material classification algorithm.**

This methodology is able to recognize different types of material from Material Dataset (MD) and assign the material ID number for each of recognized voxel. MD

![Figure 4: Examples of sensor views in simulators.](image)

A – TV guided missile; B – Night vision; C – Radar.

Today, the high quality of precise positioning instruments and inertial navigation systems, light detecting and ranging (LiDAR) information has turned out to be a highly accurate means of collecting elevation and imagery data over a wide geographic area [4]. The raw data from LiDAR is cloud of points (voxels) that could be presented by voxel-based rendering engine without mesh triangulation and polygonal presentation. Several voxel-based rendering systems have recently been proposed, for example, the raycasting framework of Gobbetti, the GigaVoxels system of Crassin, and the Efficient Sparse Voxel Octrees of Laine and Karras [7]. All these methods mainly focus on efficient rendering and could be implemented in real-time simulators and sensors views.
is associated with the satellite images to display the objects using the cognitive colours of the materials. The cognitive colours in MD are displayed as a list of different colours with a spread around the main RGB values:

<table>
<thead>
<tr>
<th>Material</th>
<th>RGB channel min.</th>
<th>RGB channel max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>20;18;93</td>
<td>108;165;242</td>
</tr>
<tr>
<td>Vegetation</td>
<td>21;90;24</td>
<td>35;162;41</td>
</tr>
<tr>
<td>Soil</td>
<td>83;71;42</td>
<td>131;109;55</td>
</tr>
<tr>
<td>Concrete</td>
<td>104;104;104</td>
<td>200;200;200</td>
</tr>
<tr>
<td>Asphalt</td>
<td>20;20;20</td>
<td>72;72;72</td>
</tr>
<tr>
<td>Sand</td>
<td>190;165;28</td>
<td>248;227;103</td>
</tr>
<tr>
<td>Grass</td>
<td>23;155;85</td>
<td>27;183;100</td>
</tr>
<tr>
<td>Wet asphalt</td>
<td>8;8;8</td>
<td>19;19;19</td>
</tr>
<tr>
<td>Wet lawn</td>
<td>109;162;40</td>
<td>125;186;47</td>
</tr>
<tr>
<td>Dry lawn</td>
<td>166;188;80</td>
<td>188;212;91</td>
</tr>
<tr>
<td>Clay</td>
<td>104;112;56</td>
<td>116;129;64</td>
</tr>
<tr>
<td>Dirt</td>
<td>104;108;86</td>
<td>127;135;105</td>
</tr>
<tr>
<td>Metal</td>
<td>214;215;208</td>
<td>224;226;217</td>
</tr>
<tr>
<td>Ice</td>
<td>235;243;242</td>
<td>252;255;255</td>
</tr>
<tr>
<td>Snow</td>
<td>250;253;253</td>
<td>255;255;255</td>
</tr>
</tbody>
</table>

Table 1: Materials in RGB channel

The quality of image recognition depends on satellite image resolution and features of the environment. Higher precision requires manual specification of the areas that include certain types of materials. Recognized 2D pixels save the data with materials’ ID and geolocation and are then projected as voxels onto a three-dimensional surface (terrain skin) according its geolocation (latitude and longitude).

Figure 8 shows the RGB analysis of a satellite image that includes materials such as vegetation, concrete, soil, sand, and water.

Figure 7: Satellite image before material ID recognition.

Figure 8: Satellite image after material ID recognition.

Figure 9: 3D scene before projection onto a terrain.

Figure 10: 3D scene after projection onto a terrain.

Figure 10 shows the result of the voxelization algorithm after projecting the recognized satellite image by RGB colours. The final scene has 365K voxels at a frame rate of 650 Hz. This is the same result as polygonal rendering with high-resolution surface displacement [6]. However, the voxel scene can be optimized, and frame rate will increase. A huge number of voxels in one scene dramatically increase the rendering time.

CONCLUSION

The proposed methodology allows generating new material ID of objects directly from 3D scene with high precision and presents all objects of the database without any artefacts in terrain skin. This advantage will significantly increase the performance of rendering the huge 3D scenes without limitations in material ID quantity of objects and inserts. Also, the voxel presentation of material ID can be used in future not only in rendering of night vision goggles or IR sensors, but as physically realistic model of 3D environment, for example: dynamic landscape, interactive environment, destructible objects, etc. In the future, the authors suggest using material ID generation not only by RGB channels in 2D satellite
images, but also on the geometric arrangement of voxels in 3D scene of simulator.

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Tactical Level Integrated Live Virtual And Constructive (LVC) Simulation

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Abstract. The Integrated LVC Capability allows training to be conducted in a live ground environment with constructive air platforms and virtual screen interfaces. This capability increases realism and pressure on the trainee as he follows air platform procedures (e.g.: nine-line brief), because he/she is operating in a live ground environment. However this training benefit is achieved at a considerable cost saving, because live air platforms are not required.

WHAT IS THE INTEGRATED LVC CAPABILITY?

Working with the Australian Army Land Simulation Centre, Cubic has developed an integrated LVC capability that facilitates training in a live ground environment, using a virtual Unmanned Aerial Vehicle (UAV) screen displays and constructive airframes. This system has been particularly useful in the training of:

Joint Tactical Air Controllers (JTAC) in the delivery of simulated munitions in the execution of close air support (CAS) missions. Tactical commanders in the use of UAV in tactical decision-making. Tactical HQ staff in the use of UAV in tactical decision-making.

This integrated LVC capability comprises three software applications:
CATS Metrix™, Meta VR Virtual Reality Scene Generator (VRSG)™, and Virtual Battlespace (VBS)™.

At the core of the capability is CATS Metrix – this is essentially a command and control software application that provides an electronic map-based common operating picture (COP), which tracks instrumented soldiers (live entities) as they move across the exercise area. Integrated with CATS Metrix is VRSG, which displays CATS Metrix live entities on a virtual 3D UAV screen. A commander or JTAC, viewing such a screen on a tablet, would be presented with a full motion video image of live entities almost identical to a UAV view, as they move across the live exercise area in near-real time. The third application, VBS is used to introduce constructive effects and constructive entities onto the VRSG screen, which increase the level of complexity and realism for the training audience. CATS Metrix can also be used to generate constructive effects.

For example, a JTAC can direct a constructive aircraft from CATS Metrix to engage live opposing force entities in the field; if the JTAC follows correct procedures, the constructive engagement will occur and the result against the opposing force in the field is immediate and tangible – i.e: the alarms on their instrumentation will go off registering them as either killed or wounded. Additionally, on the virtual UAV (VRSG) screen, additional constructive explosive effects are imported from VBS to increase the level of realism on the screen.

This integrated capability is particularly effective because it allows soldiers training in the field, in a live environment, to use constructive air platforms to achieve a visible and realistic effect on opposing force live entities, in the field. This level of realism increases confidence in the simulation system, as well as boosting the training effect. This is because JTACs and tactical commanders are required to act against live entities.

WHY IS IT SIGNIFICANT?

This integrated LVC capability provides realistic training in the employment of high-value assets such as UAV and offensive air support aircraft at a fraction of the cost. It achieves this by realistically replicating the effect of air platforms in a live ground environment.

The result is a training system that is highly effective, but does not carry the cost of employment of live airframes.

The system does not seek to replicate live training with actual air platforms, but rather complements such live training. For example, by conducting LVC JTAC training, prior to live training involving real airframes, ensures that JTACs are well prepared to maximize the effect of the latter (more expensive) training.

HOW DOES IT SUPPORT TRAINING?

JTAC identifies OPFOR target personnel. JTAC places call for support to roleplayer CAS pilot. JTAC directs roleplayer UAV pilot to maintain “eyes on” the target. Simulated FMV stream is sent down to JTAC tablet from ECC; JTAC monitors OPFOR movement using virtual UAV and direct line of sight. JTAC uses correct procedures (voice comms with roleplayer pilot) to execute an airstrike on OPFOR personnel. ECC executes a constructive airstrike in CATS Metrix – “destroy” command sent to OPFOR via FREC link. Alarms go off on the live OPFOR/effect displayed on JTAC tablet. Mission complete.
THE CHALLENGE

The key challenge was to ensure the fidelity of live entity movement, as it is represented on the VRSG (i.e.: virtual UAV HUD) screen. An early problem was that movement of live entities was either:

“Jumpy”, as entities jumped from one location to the next – i.e., there was no smooth realistic movement track of live entities; or

(if a predictive dead reckoning algorithm was used), live entity movement was smoother, however the entity “jumped” back to its correct new position when the CATS Metrix system updated with the next correct position.

Neither of these options were acceptable to the end user, because live entity movement was not represented realistically.

THE SOLUTION

A small time delay was imposed, so that the CATS Metrix system could update with 2x actual positions, before it initiated a new movement track on the VRSG screen. The result was that a dead reckoning algorithm could then be used to predict the movement track between two actual positions (taken at short intervals). This resulted in a smoother, more realistic movement track, however the downside was the small delay between the actual entity live movement on the ground and, the representation of that same movement on the VRSG (simulated UAV) screen. However on balance, end users found this delay acceptable, given that:

CAS targets are stationary or very slow moving; and

There is inherent delay in the execution of CAS missions anyway – and so the small imposed delay was absorbed into the general delay inherent in the mission procedures and munition time of flight.

Nevertheless, Cubic continues to examine ways by which this delay can be minimized, thus creating increased realism.

CONCLUSION

The integrated LVC capability developed by Cubic in conjunction with Land Simulation Centre has been well received by end users and demonstrates how simulation can be used to deliver highly effective training at reduced cost.
SimHealth

Free Papers - Research IPL/Debriefing

The Expert Practice of Video Assisted Debriefing: An Australian Qualitative Study

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Aims. This research has an exploratory purpose and aims to qualitatively describe the use of Video assisted debriefing (VAD) as reported by expert simulation educators across Australia.

Background. Debriefing is a significant component of simulation-based education. VAD refers to the use of audiovisual capture and review to support participants’ learning after simulations. With technological advances, VAD is increasingly accessible. However, there are challenges associated with optimal use. We sought expert debriefers’ views on their practices of VAD.

Methods. Expert debriefers who work with manikin-based immersive simulation were peer nominated by simulation education experts. Twenty-four debriefers participated in semi-structured interviews. VAD inductively emerged as a significant category from transcripts. All extracts pertaining to VAD were extracted and analyzed using thematic and content analysis.

Result. Thematic analysis explored: 1) how and when expert debriefers use video in debriefing 2) impact of audiovisual systems 3) educational approaches to VAD and 4) debriefers balancing benefits and challenges using VAD.

Use of VAD
All 24 respondents had used VAD but reported current infrequent to consistent practice. In general, debriefers thought VAD was valuable although their use depended on a number of factors: the familiarity and reliability of the recording equipment; the scenario type and learning objectives; the number of learners in the scenario; the learners’ level of experience; the simulation location; and the group dynamics. The respondents agreed that VAD was to be used as a “supporting tool”.

Audiovisual systems
Debriefers noted that a usable audiovisual system was one where it was easy to annotate and playback clips. Without these features, the debriefers were less likely to use VAD. On the other hand, access to an advanced audiovisual system did not necessarily promote the use of VAD.

Educational approaches
Respondents emphasized the importance of verbally framing each clip, noting what and/or why the learners will be viewing.

VAD was commonly used to enhance learning by showing what actually happened rather than talking about what was thought to have happened. VAD was particularly helpful in providing objective perceptions of time, space and use of equipment.

There was overall agreement, that VAD was used to progress an educational agenda, such as a trigger for discussion or to refocus learners on learning objectives. Debriefers also stressed the need to ensure the use of video was not “punitive” or “shaming”.

Balancing benefits and challenges
Overall, the choice to use VAD was a matter of balancing the benefits and challenges. These varied according to the debriefers’ experience, audiovisual systems and educational styles, as well the specific considerations of learning objectives and learner characteristics.

Discussion. Overall, this study indicates that this group of 24 experts was remarkably similar in their approaches to VAD to support learning after immersive manikin-based simulations. While there were variations in when and how video was used, respondents agreed that video is primarily an educational tool when debriefing across all contexts, disciplines and levels of learner experience. Specific educational techniques included: introducing the educational purpose of viewing a clip; letting the learners observe and reflect on their performances; providing examples of
good practice; and integrating the clip into the debrief by using it as a launching pad for discussion. Challenges using VAD included the reliance on a mediating audiovisual system and the risks of being punitive and of harming the learners, although others felt that the video presented a more ‘neutral’ way of conveying feedback than from themselves. Many respondents articulated the value of the video’s objectivity, although clearly the facilitator’s capacity to select and frame excerpts does not make the video wholly neutral, even if it is not critical in stance. The judicious but confined use of video was commonly reported, with the sense that decisions about what and how much to use developed with VAD expertise; this finding corresponds to the Gore et al survey of nursing simulation practices1 and other recent expert comment2.

The notion that VAD is a ‘tool’ rather than a necessary component of a debrief implies that the skill of the debriefer is more important. It is implicit that the presence or absence of video can be managed along with the other available tools for the debriefer. This aligns with the current research which does not show specific benefit for use of VAD3–10.

In a recent review Cheng et al found that there is limited evidence suggesting that VAD yields outcomes similar to those of non-VAD7. In other words, while video may be beneficial, it is not necessary.

Conclusions. Overall this study indicates that expert debriefers share a belief that video is an adjunct to debriefing. VAD use is variable from almost always to very rarely used. Analysis suggests optimal use of VAD in a single debrief is at most a few short clips, with learners oriented to the educational purpose of the particular extracts.

References.


Learning Through Simulation To Immerse Students In Interprofessional Practice

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Aims. Learning through simulation is an effective method to provide students with an authentic experience to develop specific skills and attributes. In 2014, a pilot of a series of Interprofessional workshops was conducted with 814 students. The curriculum module was designed as a four-hour interactive simulation workshop. The size of the student cohort warranted a complex strategy to accommodate the student load; over 40 workshops and 14 facilitators.

The research aimed to evaluate the effectiveness of the learning activities to assist students to achieve the learning outcomes associated with the desired Interprofessional capabilities.

Background. The importance of Interprofessional practice (IPP) capability in health practitioners has been recognised for 2 decades internationally. In Australia, the World Health Organisation’s 2010 report unequivocally established the evidential benefits of Interprofessional learning and practice.

Following a substantial competitive grant process this University was awarded funds to develop an Interprofessional education program across 10 health disciplines culminating in an IPP experience in a purpose built clinic. The curriculum transitions students through 3 modules; classes, simulation and practice. This paper presents the results of an evaluation of the simulation module, known as Immerse.

Methods. Students from the 10 participating disciplines, n=814, were allocated to one of 40 workshop events scheduled over an 8 week period. Each workshop group had students from at least 5 disciplines. The workshop included team based activities based on TeamStepps™ and an introduction to simulation. Two immersive simulation scenarios were then conducted with a debrief after each.

A mixed method approach congruent with an overall evaluation plan for the program was developed and approved by the Human Research Ethics Committee. A purpose designed survey instrument was developed for students and staff. Additionally a student focus group and staff interviews were conducted. 267 students completed the survey and descriptive analysis of the survey data was undertaken. Focus group and interview data was thematically analysed by two evaluators.

Result. Students felt they learned something about Interprofessional practice that was new to them. They agreed that the learning activities had helped them achieve the learning outcomes. Many had little idea of what interprofessional education was and why it was important to them and felt more time introducing this prior to the workshop would be beneficial. Students were also very positive about the opportunities to meet and work with students from other health disciplines.

Students didn’t feel the simulation helped them learn how to manage conflict in an Interprofessional team. Although feedback from staff interviews suggests students challenged one another effectively and constructively. The focus group commentary showed students learned more about other health professionals than they learned about their own professional identity.

Staff said that the lesson plan was well structured but they felt ‘time poor’ and had to keep a reign on the workshop to ensure outcomes were met in a timely fashion. TeamStepps™ was considered a useful strategy to include and there was strong agreement that TeamStepps™ should be expanded in the IPEP curriculum generally.

Discussion. Health care provision is complex and rapidly changing. Health disciplines learn largely in isolation of one another despite the common core values and overlap of knowledge and skills (Engum & Jeffries, 2012). Learning in silos can foster misunderstanding and hamper teamwork and communication (McNair, 2005). The Institute of medicine has advocated Interprofessional education as a means to prepare healthcare practitioners for the complexities of real world practice. Preventable medical error, resulting in death is reported as 98,000 patients
annually in the United States and is attributable in part to communication lapses (Institute of Medicine, 2000). Interprofessional teamwork is recommended as a core concept in addressing healthcare error and poor health care outcomes (Engum & Jeffries, 2012).

This program module educating graduates to be responsive and adaptable professionals, aims to break down disciplinary silos and actively engage students learning with from and about each other. Simulation of Interprofessional practice is part of an iterative and scaffolded process to develop interprofessional capabilities. The Interprofessional capabilities that drive the curriculum include Interprofessional teamwork, Interprofessional communication, navigating Interprofessional conflict, professional roles and identities and critical reflection on Interprofessional practice.

It would be useful to understand what students already know about team conflict and its management so as to assist them in meeting this learning objective. It may also be necessary to discuss with students during the session how they met this learning objective more explicitly; for example by highlighting where team members managed conflicting views constructively, supported other team members or eased tensions amongst the group.

**Conclusions.** While logistic resources are intensive this pilot program and evaluation demonstrate the effectiveness of a large scale interprofessional immersive simulation program. Students from 10 disciplines were able to participate together and learn about Interprofessional practice.

**References.**


Innovative Interprofessional Learning for Undergraduate Paramedics, Nurses and Midwives: Simulating Birth in the Emergency Department

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Aims. In this pilot study we aimed to test an innovative interprofessional simulation to improve undergraduate paramedic, nursing and midwifery students’ clinical skills and self-efficacy when managing births in unplanned locations.

Background. The rate of Birth Before Arrival (BBAs) is an increasing problem in Victoria1 with close to one baby born each day in an unplanned environment. Compared to births in planned locations, outcomes for mother and baby after a BBA, including those occurring in the Emergency Department (ED), are worse due to a lack of crucial, but simple, management2-4. Demonstrated improvement of the management of obstetric emergencies by qualified staff has been recorded after in-hospital obstetric emergency interprofessional learning (IPL) simulation5. However, whilst midwives have expertise in the management of birthing women, paramedics5 and nurses7 have less knowledge in this area and often lack confidence. Interprofessional learning (IPL) is gaining momentum in undergraduate health professional education8. As well as developing and refining clinical skills, IPL amongst undergraduate health professionals has developed students’ perceived self-efficacy, increased their understanding of the roles of other professions9 and reinforced a sense of their own9,10.

Methods. Permission for the study was granted by the Monash University Human Ethics Research Committee. We developed a scenario of a woman in late second stage labour (actor fitted with a Mama Natalie birthing simulator (Laerdal®) who was being transported by paramedics to an outer metropolitan hospital. The woman’s condition necessitated student paramedics divert to the Emergency Department, where initially only student nurses are in attendance to assist. A student midwife arrived within 5 minutes of the normal birth. Students were required to work together collaboratively to manage the immediate care of both mother and baby. The simulations were videotaped and audiotaped debriefing was conducted after each simulation.

Participants were recruited from the final year of the Bachelor of Nursing, Bachelor of Emergency Health (Paramedic), and Bachelor of Midwifery. The study design is a mixed-method collecting data using video, audio-tape and repeated measures self-report questionnaires. This paper presents the questionnaire data from pre-simulation, one and 3 month follow-up. The questionnaires comprised a previously validated 16-item, 10 point scale Self-Efficacy Beliefs in Interprofessional Learning (SEBIL)11, and 15 purpose developed multiple choice questions to measure students’ clinical skills knowledge pre-simulation and at one and four months post-simulation. Immediately following the brief post-simulation the students completed an 18-item, 5-point Likert scale Satisfaction with Simulation Experience Survey (SSES)12 to measure students’ perceptions of the quality of their simulation preparation, support, feedback and fidelity. Possible SSES scores range from 18-180, with higher scores indicating greater satisfaction with the simulation-based learning. IBM SPSS version 21 was used for data analysis. Data analysis included descriptive statistics, repeated pair samples t-test and chi-square for the clinical knowledge questions. The level of statistical significance was set at $\alpha=0.05$. 

**Results.** A total of 24 students, 8 males and 15 females with a median age of 22 years from three different health professional programs (10 double degree nursing/paramedic, 10 nursing, 4 midwifery) participated in 5 simulations. Results (Table 1) showed a significant difference between both the self-efficacy sub-scales (Interprofessional Interaction and Interprofessional Team Evaluation and Feedback) on the SEBEL measure before simulation and after one month, maintained at three months p<0.0001. Overall students’ were satisfied with their simulation experience, with the three subscales scoring highly for clinical learning, reasoning, debrief and reflection. The purpose-developed multiple choice question questions revealed no significant difference in clinical knowledge.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Range</th>
<th>Pre-Sim M (SD)</th>
<th>After Sim M(SD)</th>
<th>1 Month M (SD)</th>
<th>3 Month M(SD)</th>
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<tbody>
<tr>
<td><strong>Self-Efficacy</strong></td>
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<tr>
<td>Sub scales</td>
<td></td>
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<tr>
<td>IP Interaction</td>
<td>4.88-8.63</td>
<td>7.4 (0.85)</td>
<td>8.4 (0.65)#</td>
<td>8.5 (0.76)</td>
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<tr>
<td>IP Team Evaluation &amp; Feedback</td>
<td>4.13-8.50</td>
<td>6.7 (1.0)</td>
<td>7.9 (0.9)#</td>
<td>8.1 (0.9)</td>
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<td><strong>Clinical Knowledge MCQs</strong></td>
<td>6-14</td>
<td>11.0 (3.23)</td>
<td>10.3 (2.24)</td>
<td>10.5 (2.38)</td>
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<tr>
<td><strong>Satisfaction with Simulation</strong></td>
<td></td>
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<tr>
<td>Experience Subscales</td>
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<tr>
<td>Debrief &amp; Reflection</td>
<td>4.2-5.0</td>
<td>4.7 (0.31)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Clinical Reasoning</td>
<td>3.8-5.0</td>
<td>4.3 (0.36)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Clinical Learning</td>
<td>4.3-5.0</td>
<td>4.8 (0.30)</td>
<td>-</td>
<td>-</td>
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</table>

*Students who completed initial survey findings  
# Significant at p<0.0001

**Table 1:** Results of Self-Efficacy Beliefs in Interprofessional Learning, Clinical Knowledge & Satisfaction with Simulation Experience N=24*.

**Discussion.** The emergency birthing scenario was written by the multidisciplinary research team and piloted five times with a small group of paramedic, nursing and midwifery students. Whilst the MCQ questions did not demonstrate improvement of students’ clinical knowledge post simulation, the results for the self-efficacy measure suggest that participation in the simulation enhanced students’ perceptions of their ability and capacity to work within an interprofessional team. Students displayed high levels of satisfaction with simulation. As this study was performed on one campus of one university with a small sample size of self-selected students, it cannot be generalized to a broader population. However, piloting this scenario has allowed the research team to refine and develop the simulation further.

**Conclusions.** The pilot simulation was well received by students and it improved their perceived self-efficacy for interprofessional teamwork, role recognition and communication. However, the simulation did not demonstrate an improvement in students’ clinical knowledge as measured by the MCQs, highlighting the need for further research into the effectiveness of simulation in improving clinical knowledge. Additionally further research is required to evaluate whether a larger, non-selected group of students, would score similar results on the self-efficacy and satisfaction with the simulation scales.

**Conflict of Interest Declaration.** None of the authors have a financial interest/arrangement or direct affiliation with Laerdal Medical.
References.

SP FX: Making Simulations Come Alive On A Budget

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Presenter Details. Sarah is the Education Coordinator for the GGT UDRH Simulation Project and delivers workshops on the recruitment and training of simulated patients, and using moulage to enhance the delivery of scenario-based activities.

She is a Registered Nurse with postgraduate qualifications in Emergency Nursing and is currently undertaking the Masters in Clinical Education.

Sarah also facilitates skills and scenario based simulation workshops for health professionals and students in regional SA and south west Victoria. She is passionate about supporting rural education and in developing new and innovative ways to make learning experiences as engaging as possible.

Overview. This workshop is targeted at health professionals who are involved in the delivery of scenario-based training using simulated patients (SPs). It aims to improve the quality of ‘in situ’ training offered to health professional students by providing facilitators with the skills and confidence to deliver training workshops that are more engaging through the use of ‘moulage’.

Expected Outcomes. Through this ‘hands on’ workshop, participants will be able to practice quick and inexpensive ways to apply simulated injuries to SPs recreating sounds, smells and looks using every day ‘off the shelf’ products. They will be walked through a step-by-step guide on how to fabricate wounds, bruising and burns using tried and tested recipes that can be applied safely and effectively without extensive time and expensive resources.

Learning Outcomes:
1. Understand the theoretical principles for using moulage in simulation.
2. Demonstrate the ability to effectively create realistic wounds, bruising and burns to simulated patients.
3. Identify safe and hygienic moulage practices.

Detailed Description. An overview of the theory and concept of moulage will be provided and WHS considerations covered.

Tables will be stocked with home-made ‘skin’ ‘blood’ and ‘scab’ and other required resources. Participants will practice demonstrated moulage techniques whilst facilitators provide guidance and feedback. A booklet will be provided containing step-by-step instructions on how to apply simulated burns, bruising and lacerations using effective low cost ‘off the shelf’ products.

Evaluation. Upon completion of this workshop participants will be able to demonstrate the application of these low-cost moulage techniques to enhance a simulated learning event.

Timeline.
10 minutes: Introduction and PowerPoint Presentation
30 minutes: Bruising and laceration step-by-step guide and practice
5 minutes: Clean up
30 minutes: Burns step-by-step guide and practice
5 minutes: Clean up
10 minutes: Discussion and evaluation
How Real Can It Be? Using A Low Resource High Fidelity Birth Suit To Simulate Postpartum Haemorrhage

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Presenter Details.

Bree Bulle is a Consultant Midwife with the Maternity Services Education Program (MSEP) based at the Royal Women's Hospital Melbourne and has been integral to the development of a mobile process to support the MSEP program. Bree has a keen interest in the development of low resource, clinically focused tools to facilitate high fidelity simulation and in using simulation as a conduit for practice improvement in maternity care.

Overview.

The aim of this workshop will be to demonstrate key aspects of the simulation process for postpartum haemorrhage (PPH) using a life like birth suit. The birth suit is worn by a simulated patient actress. This process supports a flexible, realistic, mobile approach to simulating postpartum haemorrhage in limited resource settings. The workshop will involve skills sharing and resources including demonstrations of various simulation tools specifically developed to complement the suit and enhance fidelity.

Expected Outcomes.

Use low resource clinically based tools to facilitate a high fidelity simulated PPH within a clinical or non-clinical setting e.g.; an ambulance.

Prioritize the immediate clinical and pharmacological management for PPH using a Key Event Tool (KET). This tool has been developed by MSEP to highlight clinical care, education and training, risk management and National Safety Standards relevant to managing PPH.

Practice setting up the birth suit and various tools used with the suit e.g.; a blood pump, life sized uterus, placenta, estimated blood loss workstation and develop reusable simulated blood clots.

Detailed Description.

The Maternity Services Education Program (MSEP) has facilitated multidisciplinary maternity education for the past ten years in regional and rural Victoria. Each program is tailored to the site’s needs, facilitated over one and a half days and includes simulated maternity emergencies together with extensive quality improvement activities. The program is accessible as it is facilitatted on site, and is affordable as it uses innovative resources that are cost effective and life like. Simulated learning environments (SLEs) have been identified by stakeholders as a mechanism to increase clinical training capacity and efficiency. MSEP use this methodology for teaching procedural skills, clinical management, teamwork, decision making and communication skills. At a national level, Health Workforce Australia (HWA) strongly encourages the uptake of SLEs in Australia (HWA 2010) across a broad range of health professions. MSEP have a strong history of collaboration in workshop delivery, including programs facilitated with Ambulance Victoria. The aim of this workshop will be to demonstrate key aspects of the simulation process for postpartum haemorrhage (PPH) using a life like birth suit. The birth suit is worn by a simulated patient actress. This process supports a flexible, realistic, mobile approach to simulating postpartum haemorrhage in limited resource settings. The workshop will involve skills sharing and resources refined over a ten year process; including demonstrations of various simulation tools specifically developed to complement the suit, enhance fidelity and support an efficient cost effective approach to simulating PPH Activities: This clinically focused, practical and engaging workshop will focus on the birth suit simulation experience used by MSEP and allow for hands on practice and skill sharing. A short didactic session will be followed by a series of practical workshops to demonstrate the suit in action. Resources developed to support the transfer of learning to clinical practice will be showcased. Participants will view the process in action and discuss specific tools and resources to utilise in their own setting.
Method.

The workshop will be facilitated over 90 minutes and include practical demonstrations, tools and resources. Clinically experienced facilitators will structure the workshop to allow for questions and answers to support shared learning among disciplines. While the focus of this workshop will be on simulating massive obstetric haemorrhage, the workshop will be invaluable for any clinicians embarking upon implementing a mobile simulation program in a low resource setting.

Evaluation.

Pre and post workshop surveys will detail the usefulness of the workshop to improve individual levels of knowledge, confidence and competence to simulate postpartum haemorrhage in a clinical or non-clinical setting. Qualitative data will focus on specific resources demonstrated to enhance new learning and their practical application to simulated learning environments.

Timeline.

Introduction and plan for the workshop, pre-evaluation survey - 10 minutes

Orientation and hands on practice with the birth suit and tools and resources developed to enhance fidelity - 50 minutes

Simulation examples and video footage of the suit in action - 15 minutes

Questions and answers, skills sharing - 10 minutes

Post workshop survey evaluation - 5 minutes
Sketching Isbar: A Contemporary Approach To Teaching Communication In Healthcare

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Aim of the Education Program.

Western Health created a visually engaging 3-minute animation to disseminate knowledge and understanding about communication techniques and the use of ISBAR as part of a funded Project STRIPE 3 (Simulation TRaining for InterProfessional Education) in 2013/2014. STRIPE 3 targets undergraduate and new graduates from Nursing and Physiotherapy and the focus is on the deteriorating patient in an acute health care setting. The program consists of two simulation scenarios where patient deterioration occurs and escalation is required. Communication and the use of ISBAR are key objectives of the scenarios. The program is of 3.6 hours duration.

Participants attend a presentation outlining the importance of good communication and ISBAR in the context of the deteriorating patient prior to participating in a simulation scenario. Initially the presentation was in a PowerPoint format, but teaching communication skills is not always easy and engaging learners can be challenging. Learners today are often ‘tech savvy’, easily distracted or simply overwhelmed with new information therefore we decided to adopt a different approach to presenting ISBAR by developing a short animation. (Link to YouTube to view animation) https://www.youtube.com/watch?v=h0Ol6CiJAZw

Methods Adopted.

The animation was developed with an external company and a script of 350-400 words was written by a subject matter expert, using Spark Line methodology, a technique developed by Nancy Duarte. This involves creating a memorable story involves describing a current state or the way things are to the audience, which may not be great. Then future state is described which is so much better and can lead to positive change. The focus of the animation was on why escalation can be difficult, how poor communication can lead to adverse patient outcomes, the ISBAR tool, its ease of use, and some practical tips on its application and using ISBAR can help improve communication overall and ultimately improve patient safety.

Evaluation Data from the Program.

The major outcome of this project was the creation of a teaching tool that is short, covers a lot of content to engage learners in a visual and entertaining way, and delivers an important message about communication and patient safety. The animation has been very well received to date and evaluation of its use in the STRIPE 3 program is currently being undertaken.

Conclusions and Recommendations for Future Use and Development.

Using alternative methodologies to teach communication and ISBAR can result in visually engaging ways to help learner understand important concepts. The ISBAR animation is freely available to all as the Commonwealth of Australia funded the STRIPE 3 project in 2013/2014, and other health care networks in Australia and overseas have already expressed an interest in using the animation. More formal evaluation of the use of this method is required to determine how effective it really is in teaching ISBAR.
Using Simulation to Develop Communication Skills: Difficult End-of-Life Conversations with Patients

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Aim of the Education Program. Health professionals find conversations with patients and families about the transition from curative to palliative care difficult¹, with many avoiding such conversations². Teaching the skill of talking about end-of-life issues with patients or clients presents challenges including: providing a safe, realistic forum for practice prior to real world use; the availability of good role models in clinical practice; and opportunity to seek and respond to feedback when learning these skills³,⁴. The curriculum incorporate online video case studies⁵, academic readings and classroom discussions but lacked an experiential dimension. Introducing a simulation experience would allow students to link theory to practice⁵ and practice in a safe environment⁷. This pilot study aims to evaluate a newly developed exemplar video and role play simulation to assist students to develop skills in conducting difficult conversations about end-of-life issues.

Methods Adopted. Approval was granted by the University Human Ethics Research Committee. Students were recruited from a convenience sample of post-graduate and graduate entry Master of Nursing Practice. Pre-simulation, students completed readings, a preparatory lecture, on-line case study and knowledge self-test. The intervention comprised:

1. Viewing the 15 minute purpose developed scripted video of an interview between a health professional and patient who had received news they had incurable cancer.
2. Two students participated in two role-play simulations with an actor, whilst the remainder observed via video link. All students participated in the debriefing.

Post-simulation students appraised the communication skills demonstrated in the exemplar video using the Involve –Skill Assessment Tool (SAT)³ and a free response section. The 20 item, Simulation Design Scale (SDS)⁷ was used to measure students’ perceptions of the preparation, support, problem solving, feedback and fidelity of the simulation. IBM’s SPSS version 21 was used to analyse the data.

Evaluation Data from the Program. This paper presents preliminary data from the Simulation Design Scale. Of the 43 students who participated in the study, 42 returned questionnaires; the majority were graduate entry, Master of Nursing Practice students with 0 – 5 years (79%) health experience. The coefficient alpha for the overall scale was .93. Summary scores from the SDS (Table1) indicate the majority of students were satisfied with the simulation experience.

<table>
<thead>
<tr>
<th>Components</th>
<th>n (%)*</th>
<th>M (SD)</th>
<th>Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives &amp; Information -5 items</td>
<td>40 (95)</td>
<td>19.25 (3.81)</td>
<td>.86</td>
</tr>
<tr>
<td>Support - 4 items</td>
<td>33 (76)</td>
<td>16.45 (2.75)</td>
<td>.89</td>
</tr>
<tr>
<td>Problem Solving - 4 items</td>
<td>36 (86)</td>
<td>15.64 (2.99)</td>
<td>.88</td>
</tr>
<tr>
<td>Feedback/Guided reflection - 4 items</td>
<td>37 (88)</td>
<td>17.59 (2.77)</td>
<td>.86</td>
</tr>
<tr>
<td>Fidelity items - 2 items</td>
<td>39 (93)</td>
<td>8.92 (1.42)</td>
<td>.86</td>
</tr>
<tr>
<td>Total SDS score – 20 items</td>
<td>27 (64)</td>
<td>85.33 (8.39)</td>
<td>.93</td>
</tr>
</tbody>
</table>

*some students did not complete all items, or scored items as not applicable

Table 1: Simulation Design Scale Student Satisfaction and Coefficient Alpha Scores for Subscales.
Conclusions and Recommendations for Future Use and Development. We developed an exemplar video and role-play simulation to teach skills in talking about end-of-life issues. Preliminary data shows students felt well prepared for the learning activity, and most felt well supported. Results confirm the Simulation Design Scale has a high degree of internal reliability. The majority of students either agreed or strongly agreed that the exemplar video and simulation were positive learning experiences. Preliminary data analysis indicates students valued the combined video and role-play simulation. The questionnaire requires minor modification in layout to improve the item response rate. The alpha scores show a high level of internal consistency for the SDS. Data collection is ongoing.

Disclaimer. The authors have no conflict of interest to declare

References

Development Of Disaster Training System Using Information And Communication Technology

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Aims. We developed a disaster training system of triage and treatment using information technology for mass casualty. The system consists of a computer server, personal digital assistant (PDA) displays, exclusive designed software with victim database. Using victim data on a PDA display provided by computer server, trainees perform a virtual triage and selection of initial treatment for virtual victims in a virtual disaster field.

Background. Disaster training is an essential element for supporting disaster responses of the social system and reducing damage to society. Usually, large-scale disaster trainings have become common. The unprecedented complex disaster of the Great East Japan Earthquake with a huge tsunami and the melt down of Fukushima Dai-ichi Nuclear Plant has dramatically heightened the need for more sophisticated disaster training in Japan.

Methods. We developed a virtual disaster training system consisting of a computer server with field data and patient data, personal digital assistant (PDA) displays, exclusive designed software. Viewing patient data, delivered via Wi-Fi server on iPad, trainees perform a virtual triage and selection initial treatment of virtual victims in a virtual disaster field. To realize virtual training system, we designed the structure of the system and detailed scenarios with a time factor. We launched the first version of the virtual desktop infrastructure (VDI) in April 2012 after a pilot study had been performed using a prototype over approximately 7 months, beginning in December 2011.

Result. The computer server provides information on training fields such as localization, positioning and transportation. In this virtual training field, selected victim data is delivered from the server computer to iPad. Trainees perform virtual triage and treat the virtual patient on iPad. Also, they can request transportation. The trainer evaluates the virtual management performed by the trainees on a server computer. Our system enables us to train in several types of mass casualty incident (MCI). Furthermore, various aspect of MCI training such as commander training can be given. After the unprecedented complex disaster of the Great East Japan Earthquake with a huge tsunami and the melt down of Fukushima Dai-ichi Nuclear Plant, the requirements of disaster training have become more diverse to manage complex disasters. Our system was accepted one of Fukushima restoration project and presented at Medica 2013, the world's largest medical fair in Düsseldorf, Germany.

Discussion. Triage is the process of determining the treatment priority of patients based on the severity of their condition at disaster. This concept enables us to treat patients efficiently when resources are insufficient for everyone to be treated immediately. Triage may result in determining the order and priority of emergency treatment, the order and priority of emergency transport, or the transport destination for the patient. Triage may also used for patients arriving at the emergency department. In the case of a complex disaster, triage should be performed repeatedly and recorded on each form. In Japan, the triage system is mainly used by health professionals such as emergency medical technicians (EMT) and medical doctors. Our system is consisted of a laptop computer as server, Wi-Fi system and iPads. The system realized smart disaster training system for various situations.

Conclusions. We developed a disaster training system using information and communication technology. The system consists of a laptop computer as server, Wi-Fi system and iPads, exclusively designed software and a patient database. Furthermore, we designed original chronological scenarios of standardized cases.
References.


A Tale About ISBAR And Communication

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Aim of Education Program.
‘Mr Everyday Goes To Work’ is a visual story about communication that has a literal and a symbolic meaning. It was developed at Western Health as part of a Commonwealth of Australia funded project called STRIPE 3 (Simulation TRaining for InterProfessional Education) in 2014.

The focus of the STRIPE 3 Project is an interprofessional approach to the deteriorating patient using simulation, where escalation of care is required. Key objectives of the scenarios are good communication using ISBAR. The program is targeted at final year undergraduates and new graduates from Nursing and Physiotherapy. Participants attend a presentation prior to the simulation, outlining the importance of good communication in the context of the deteriorating patient.

Junior health care professionals are often overwhelmed with competing needs and large amounts of new information when they begin working in acute health care environment, so getting their attention on an important topic can sometimes be challenging. Communication skills are not always easy to teach, therefore an innovative approach on teaching the topic of ISBAR using story telling was desired to engage learners in a more interactive way.

Methods Adopted.
External facilitators hosted a workshop for a group of relevant internal stakeholders from the hospital. The main focus for the group was how to use a visual story telling to deliver an important message about patient safety and the importance of good communication in the context of the deteriorating patient. An initial presentation about the purpose of the workshop and the STRIPE 3 program was used as a springboard for a facilitated discussion and ideas generation. Sub-topics were teased out and issues that needed to be addressed around escalation of care discussed. Initial draft picture stories were then generated in small groups and then presented to the whole group. A vote was taken on the story which best represented the key factors that the group wanted to include. The story ‘Mr Everyday Goes To Work’ was then drafted by an external party and reviewed by stakeholders prior to being completed.

The literal meaning of the story is about Mr Everyday and all the problems he faces on his journey to work. The story tells how poor listening and ineffective communication skills and lack of situational awareness affect his decision-making and outcomes. Parallels to acute healthcare environments are then drawn from the story, to highlight key points and discuss how ineffective communication can lead to delays in action or adverse outcomes, especially in the context of the deteriorating patient. Strategies for effective communication are then introduced and discussed, reinforcing the need for a structured method such as ISBAR to improve communication skills and increase confidence, and contribute positively to improving patient safety.

Evaluation Data from the Program.
‘Mr Everyday Goes To Work’ is intended to be used as part of the graduate STRIPE 3 program and evaluation of its use will be commenced in March 2015.

Conclusions and Recommendations for Future Use and Development.
Story telling is a powerful method of communicating an important message and can be an engaging way to teach key principles, which are not always easy to learn in a conventional way. ‘Mr Everyday Goes To Work’ is an eye catching contemporary resource, which is freely available for use. More evidence will be required as to the benefits of teaching junior health care professionals communication using this method.
In-Situ Simulation To Explore Systemic Issues That Impede Adherence To The Massive Transfusion Protocol

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Aim of the Education Program.

Massive transfusion of an exsanguinating patient is a complex undertaking. Massive transfusion protocols have been in use in order to streamline patient management. The massive transfusion protocol (MTP) at Nambour General Hospital was revised in 2014 based on findings of an audit. The audit identified deficiencies in compliance to the MTP, communication and timing of activation & deactivation.

Aligning to the SCHHS Practice Development philosophy provided the educational platform to facilitate an in-situ simulation scenario across 3 clinical speciality areas including the blood bank was planned to explore systemic issues that could impede adherence to the massive transfusion protocol. Practice development is "a continuous process of improvement toward increased patient effectiveness in patient centred care. This is brought about by helping healthcare teams to develop their skills and to transform the culture and context of care. It is enabled and supported by facilitators committed to systematic, rigorous, continuous processes of emancipatory change that reflects the perspectives of service users and service providers." (McCormack, Manley & Wilson, 2008)

Methods Adopted.

A practice development values based decision making model (SCHHS Nursing and Midwifery Practice Development Service Profile 2014-2015) was applied to the competing priorities for clinical education. A hierarchal approach to determining operational imperative (clinical risk, best practice and workforce development) overlayed with highest order values (relationships, transparency, accountability and equity) were used to make collaborative decisions to facilitate this simulated event across 3 clinical speciality areas and the blood bank with support from the Simulation Pocket Center.

The simulation exercise involved staff from the emergency department (ED), operating theatre (OT), intensive care unit (ICU) and blood bank. Simulation was conducted in patient treatment areas using a high-fidelity manikin and real equipment, drugs (excepted controlled drugs) and simulated blood and blood products.

The scenario was the presentation a trauma patient to the ED with hypovolaemic shock secondary to bleeding from pelvic fracture. A scenario template was shared with each clinical area with branch points created to incorporate various responses from participants. A deterioration was planned in each clinical area which would trigger further transfusion. Each clinical area including the blood bank had a designated simulation facilitator and debriefer.

Debriefing was conducted in each of the clinical areas and the blood bank at the conclusion of the simulation in each area. At the conclusion of all debriefing sessions, simulation faculty met to discuss systemic issues based on which recommendations were made.
Evaluation Data from the Program.

The in-situ simulation exercise was able to bring out several systemic issues which could be remedied easily. Feedback from faculty and participants suggest that the simulation exercise was realistic, provided an opportunity to review systems, and was educationally beneficial.

Participant evaluations using a 5 point Likert scale suggest the following:

100% of the participants Strongly Agree or Agree that the simulation improved the participants understanding of the Massive Blood Transfusion Protocol

100% of the participants Strongly Agree or Agree the simulation enabled them to improve/refine skills/knowledge

100% of the participants Strongly Agree or Agree the simulation was realistic

100% of the participants Strongly Agree or Agree the simulation and debrief provided and opportunity to review systems within the clinical area

96% of the participants Strongly Agree or Agree the simulation enabled them to improve/refine communication and teamwork skills

Conclusions and Recommendations for Future Use and Development.

In conclusion the benefits gained from conducting this in-situ simulation across 3 speciality areas and the blood bank to explore systemic issues has resulted in recommendations to improve patient safety, improve teamwork and communication and provide education to multidisciplinary teams. We intend to conduct similar simulation exercises twice a year to ensure recommendations are embedded into clinical practice.

References.

1. Annette Faithfull-Byrne "SCHHS Nursing and Midwifery Practice Development Service Profile 2014-2015"
Defining The Role Of The Scribe In Ward Based Critical Events Through Simulation.

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Aim of the Education Program.
The role of the scribe in ward based critical events is often one which is forgotten or relegated to junior nursing staff as an afterthought once the event is underway, risking gaps in essential documentation. On the Surgical Ward (SW) at the Children’s Hospital Westmead (CHW), it was identified through in situ simulations that the role of the scribe was one that was most feared and avoided during a critical event, due to unfamiliarity of the role’s responsibilities. Current focus of patient resuscitation programs includes teamwork, communication, and cardiopulmonary resuscitation skills, with little to no reference on the role of the scribe. Limited critical events on paediatric surgical wards and a paucity of evidence for training and education programs, ward based nurses have limited opportunity to practice this skill in training or real life events(1,2).

Feedback from nursing staff on SW indicated that due to the ‘hands on’ nature of the yearly resuscitation accreditation program, they felt confident in managing the airway and circulation aspects of the deteriorating child. Therefore it was decided that formal explanation of the scribe document as well as ‘hands on’ practice would help to equip nurses on SW to confidently undertake the role of the scribe. The aim of the program is to provide SW nurses with the knowledge and skills to be able to scribe accurately during a critical event within the context of the simulated learning environment.

Methods Adopted.
A 4 hour course was developed, incorporating a theoretical component of the role of the scribe, documentation on the scribe document, and the intricacies of communication within the scribe role. All participants were given an opportunity to practice the role of the scribe in a simulated scenario. The GoPro ® camera was utilised for its point of view capabilities. Worn on the head of the scribe, it enabled participants to review footage from the simulated event and provide feedback during debrief.

As the element of practicing skills is crucial in cementing newfound knowledge, the participants required opportunities to further consolidate their skills in scribing during a critical event. In situ simulated scenarios in the ward environment were developed to highlight the role of the scribe. Course participants were targeted to step into the role of the scribe during these simulations in order to demonstrate the role to other SW nursing staff. Those not able to attend the study day benefit from being able to observe those experienced in the scribe role and scenario debrief was structured to highlight aspects of the scribe role.

Evaluation Data from the Program.
Feedback from the study day was overwhelmingly positive. All participants agreed that the simulated scenario as well as utilization of the GoPro® video feedback enhanced their knowledge and skill.

Evaluations indicated that the in situ scenarios were beneficial to the course participants, who were able to consolidate their skills in the scribe role, indicating the ability to practice every 6 months would enhance this further.

The participants have been actively taking up the role of scribe in ward based critical events

Conclusions and Recommendations for Future Use and Development.
The future of this program would be to review other aspects of ward based critical events and identify other educational needs. During the in situ simulations, it has been identified that medication preparation and administration during critical events is an area to further explore for SW nursing staff. Adding this component to the study day and increasing the capacity of participants creates a more robust education programs for the nursing roles during a ward based critical event.

References.
Dealing With Ambiguity And Uncertainty In Simulated Crisis Management

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Aims.

To compare how 2 different groups deal with ambiguity and uncertainty in a simulated crisis.

Background.

"A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they are mutually accountable." (1)

In managing a medical crisis there is limited time for disparate people who may or may not know each other, or their skills and competencies, to form a cohesive team. We have run two programs, one which focuses on clinicians the other on multidisciplinary teams consisting of consultant anaesthetists, trainee anaesthetists, theatre nurses and recovery nurses.

One of the most interesting observations throughout our programs is the effect of ambiguity and lack of role clarity and how different groups, i.e. clinicians and nurses cope.

Methods.

In the first program a trauma patient undergoing an exploratory laparotomy unexpectedly develops bronchospasm, tachycardia and becomes hypotensive and eventually goes into cardiac arrest. The attending anaesthetist has just taken over from a colleague who has been called away in the middle of the case.

The second program is composed of up to 5 Advanced Cardiac Life Support (ACLS) scenarios, run over an afternoon for multidisciplinary teams consisting of 2 consultant anaesthetists, 2 anaesthetic trainees, an anaesthetic nurse and a recovery nurse.

All scenarios are scrutinized by an independent observer.

In both programs, all simulations are followed by a debrief. At the end of the sessions participants are asked to provide feedback and information via a questionnaire.

Results.

In the first program, approximately 85% of consultants reported high levels of discomfort while trying to come to a definitive diagnosis. Clinicians reported that they felt less discomfort when the patient went into cardiac arrest because they had a well-defined condition to treat with a recognised treatment algorithm.

In the second program we observed that in some sessions there seemed to be teams within the larger team, usually, team of anaesthetic consultants, separate team of anaesthetic trainees and more rarely, the nursing team. However, in most sessions to date, we have observed that nurses work independently of each other and the other teams until a direct request was made by one of the clinicians.

Analysis of nurses’ responses in the questionnaire show that over 90% rate role clarity highly. In over 50% our sessions, when there are high levels of ambiguity and lack of role definition, the nurses cope by automatically reverting to tasks that bring them back into their comfort zones, i.e. “the nursing role”.

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Discussion.

Ambiguity leads to uncertainty and both cause discomfort. In both programs, we purposely created ambiguity and uncertainty to test knowledge and application of technical skills and observe the effect on multidisciplinary teams.

In the first program, clinicians were relieved that the mannequin arrested because they "now knew what they had to deal with". Ambiguity was decreased because they no longer had to work through several possible causes of the patient’s deterioration and the risk of loss of face, due to an incorrect diagnosis, was decreased.

In the second program, nursing staff who were not assigned a task, reverted to their “nursing role” e.g. scribing and drawing up drugs that had not been requested. This brought them back into their comfort zone. Appearing busy reduced the risk of being asked to do something with which they were not familiar.

Conclusions.

Our observations suggest that simulation based training of multidisciplinary teams could also be used to teach yet another dimension of dealing with medical crises, i.e. how to cope with and use ambiguity and uncertainty constructively.

References.

Ambulance Victoria Virtual Paramedic

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Abstract. The Virtual Paramedic (VP) provides Ambulance Victoria (AV) paramedics and other pre-hospital partners with the opportunity to rehearse their response to major incidents within an immersive, experiential, learning environment. The VP has achieved dramatically improved exposure of AV paramedics to their major role in major incident response, and at a greatly reduced cost. This paper provides information from the first nine months of the VP use, information on current development and future plans for development.

INTRODUCTION

The Virtual Paramedic (VP) provides an environment within which AV paramedics can practice their responses to mass causality, major incidents. The paramedic roles executed within the VP are those of the Triage officer as specified in the Victoria State Health Emergency Response Plan and the Ambulance Victoria Emergency Response Plan. The motivation for the Virtual Paramedic and description of the initial motor transport scenario was provided in Dunlop (2013).

The goals of the VP are to:

- Provide a low cost, student centred, experiential learning environment
- Be available any time and anywhere
- Support assessment against training objective for the Transport and Triage Officer (Dunlop 2013)

The VP is a Virtual Training Environment, which is comprised of an immersive, serious game like environment, and a Learning Management System (LMS), which provides the student with scenario briefing at the start, and feedback on their performance after they have executed the scenario.

The VP provides all of the facilities for a paramedic to execute their role, but does not force the student along a particular course. The student is free to execute the role in whatever way they believe is appropriate. They then receive feedback through the LMS on how effectively they performed.

The Virtual Paramedic has been developed through three rounds of Grant funding from the Office of the Emergency Services Commissioner. The scope of development for each grant as been as follows:

Development of initial capability including motor transport accident scenario. Completed 2013
Development of fire scenario and refinement of User Interface. Completed early 2015.
Enhancement to include Transport Officer and paramedic role. In development and scheduled to be completed 2015.

INITIAL RELEASE AND RESULTS

Initial Release

Following a limited pilot period to obtain feedback from the field in September 2012, Virtual Paramedic was officially launched by the Victorian Minister for Health in September 2013. It was rolled out across the Ambulance Victoria network in late October 2013.

The application was installed on 300 workstations across Victoria and was announced to personnel in early November 2013.

In the seven days between roll out and announcement, 51 personnel had accessed the system. Within a week of announcement 150 personnel had accessed the system. This is comparable to the total number of trainees that undertake traditional mass casualty training in an entire year.

In addition to the organisational roll out, a total of 85 personnel downloaded the system for personal use in the first nine months the system was deployed.

Results

In the first nine months that the system was deployed, 167 personnel accessed the system. However only 124 of these personnel undertook triage during a simulation session. 15 personnel completed all learning objectives.

Use of Virtual Paramedic during this time was voluntary and was undertaken by paramedics during personal time or down time when on shift.

Approximately 70% of activity occurred in the first three months of deployment (see Figure 1).
A total of 391 simulation sessions were undertaken (an average of 2.3 sessions per student). 17% of sessions were undertaken on weekends (see Figure 2) and 21% of sessions were undertaken overnight (i.e. between 1700 hours and 0700 hours, see Figure 3).

The system recorded a total of 104 contact hours (an average of 16 mins per session). However, 40% of sessions undertaken were less than 5 mins in duration (see Figure 4). Further analysis is required; however, this could be an indication that future development would be best targeted at short duration scenarios.

A total of 3,243 triage decisions were recorded (an average of 19.4 decisions per session) with an overall accuracy of 79%.

By way of comparison, during the same dated matched period, Ambulance Victoria achieved seven traditional mass casualty training exercises involving 88 participants (1 session per student). Of these, only 7 undertook the role of Triage Officer (all students undertake this role in Virtual Paramedic).

A total of 1,100 patient case studies were presented for triage (an average of 12.5 patients per student). As the triage decisions are not recorded in traditional training a direct comparison cannot be made.

Total contact time for the traditional training was 340 hours for the same period.

Table 1 illustrates the significant improvement that VP provided over traditional training over the same time period for a range of metrics.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Virtual Paramedic</th>
<th>Traditional Training</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Training Sessions</td>
<td>391</td>
<td>88</td>
<td>4.4 fold</td>
</tr>
<tr>
<td>No. Training in triage role</td>
<td>391</td>
<td>7</td>
<td>55 fold</td>
</tr>
<tr>
<td>No. Triage Decisions</td>
<td>3,243</td>
<td>1,100</td>
<td>2.9 fold</td>
</tr>
<tr>
<td>Training Time</td>
<td>104 hours</td>
<td>340 hours</td>
<td>30%</td>
</tr>
</tbody>
</table>

It is also important to note that the initial deployment of Virtual Paramedic was voluntary while the traditional exercise training relied on staff being rostered and paid to attend training.

With this in mind, the enhanced training metrics achieved with Virtual Paramedic are impressive and they were achieved with zero staff cost.

Virtual Paramedic allowed personnel to undertake simulation training out of hours, on weekends and at home when traditional training is not available.

Using Virtual Paramedic, training could be targeted toward the key roles to be rehearsed, where as traditional exercise training requires personnel to undertake support roles, and may not be exposed to the key role directly.

Virtual Paramedic does not require an instructor or special infrastructure which traditional mass casualty training requires.

Finally, Virtual Paramedic recorded all key student activities and made them available for review and personal reflection.
FURTHER DEVELOPMENT

Virtual Paramedic 2.0
The second major release of the VP, which is due in early 2015, includes a fire scenario, additional paramedic capabilities, enhancements to the Graphical User Interface (GUI) and improved results reporting through the LMS.

Fire Scenario
Motor transport accidents are the cause of 40% of AV’s escalations to major incidents with fire resulting in 30% of escalations. The fire scenario adds complexity to the Triage Officer role through:

- establishment and staffing of a Health Monitoring Post, from which the health of firemen is monitored;
- periodic situation reporting to the Incident Commander, the addition of a paramedic health status which is affected by unsafe behaviour, such as venturing too close to the fire, and
- more dynamic victim profiles

The VP incorporates a victim database which contains 130 road transport accident trauma victims, although only 40 are used in the road accident scenario. As part of implementation of the fire scenario, 130 fire victims were added. As with VP 1.0, the victims are inspired by patients from AV’s clinical database and their condition is dynamic, with their future state affected by the treatment they receive.

While a large number of victims are not currently used, they support future enhancements as discussed in section 0.

Learning Management System – Results Management
The learning management system has been enhanced to provide the facility for an AV instructor to manage student results by viewing results of all paramedics, as a group, and by drilling down to review the detail of the results for an individual student. The facility to look at overall workforce results provides information which can be used to make effective decisions on targeted training, as identified in section 0.

The results also provide individual student feedback on performance in each scenario and feedback on overall performance compared to peers.

The LMS is hosted outside AV’s firewall, which was done to avoid the cost of integration with AV’s existing LMS. As part of VP 2.0, a SCORM interface was added to allow results to be sent back to AV’s LMS for inclusion in student records.
Virtual Paramedic 3.0 – Transport Officer

As identified in Dunlop (2013), the behaviour of first paramedics on the scene is critical in an optimal to achieving an optimal overall outcome. The lead paramedic roles at a major incident scene are as follows:

Triage Officer. The senior of the first two paramedics on the scene with overall leadership responsibility until the arrival of the health commander.

Transport Officer. Responsible to the Triage Officer for patient management and scene logistics.

Incident Health Commander. On arrival, has overall responsibility for the on scene health response.

VP 3.0 is currently in development, with the primary outcome being the development of a student playable Transport Officer. Because the Transport and Triage Officer work closely together, this also requires the development of a virtual or Non Player Character (NPC) version of the Triage officer, which was played by a student in VP 2.0. A secondary objective is the inclusion of a payable paramedic on scene character. This character would work under direction from the NPC Triage Officer and will provide an opportunity for volunteer personnel, new employees and partner agencies to perform a role more aligned to their real world responsibilities.

Transport Officer Learning Objectives

The Transport Officer is responsible to the Triage Officer for ensuring patients are effectively managed and transported to hospital in the most efficient and effective manner. This involves managing the ambulance Holding Point (where ambulances are held until required at the loading point), the Loading Point, the Causality Clearing Post (CCP) and the appropriate transfer of patients through these, from the accident scene to hospital.

Table 2: Transport Officer Learning Objectives

<table>
<thead>
<tr>
<th>Learning Objective</th>
<th>Method Objective Breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinate transport vehicles</td>
<td>Request crews from Triage Officer for transport</td>
</tr>
<tr>
<td>Ensure appropriate transfer of patients</td>
<td>Identify available destinations</td>
</tr>
<tr>
<td>Maintain Casualty Movement Log</td>
<td>Complete casualty movement log</td>
</tr>
<tr>
<td>Ensure appropriate access and egress for responding vehicles</td>
<td>Confirm CCP location being appropriate</td>
</tr>
<tr>
<td>Manage Loading Point</td>
<td>Identify appropriate loading point</td>
</tr>
<tr>
<td>Manage Holding Point</td>
<td>Identify appropriate holding point</td>
</tr>
<tr>
<td>Manage CCP</td>
<td>Identify appropriate layout for CCP</td>
</tr>
</tbody>
</table>
All of the functionality required to develop the playable Transport Officer role largely exists in the Virtual Paramedic 2.0. New functions include: being able to control the layout of the CCP, and managing the tracking and allocation of patients being transported to hospitals.

**Beyond Virtual Paramedic 3.0**

The Council of Ambulance Authorities has sponsored a federal government grant request to enable further development and the adoption as a standard training tool for Triage Officer training across the ambulance services of Australia and New Zealand.

Areas for potential enhancement include:

- Support to various levels of paramedic proficiency through the addition of different level of complexity. This would be implemented by providing different patient numbers and increasing levels of acuity for increasing complexity.
- Support for Health Commander training. This is likely to involve on-scene elements in the virtual accident and virtual Incident Command Post elements.
- Support to collaborative training by enabling multiple human players to collaborate in the same scenario. This could be paramedic, Triage or Transport Officer.

AV is also seeking to engage with a local university to undertake a study into the effectiveness of the VP in improving paramedic execution of the Triage Officer role.

While the VP was envisioned primarily as a tool to support ambulance services in developing major incident competencies among staff, there has also been strong interest from universities in employing the Virtual Paramedic within their modules on emergency management.

**CONCLUSION**

The VP has demonstrated the efficacy of a VTE in exposing paramedics to the Triage Officer role, with 55 times more staff exposed to the role than was achieved with traditional mass casualty training exercises. Additional benefit was that results of the VP training for AV are stored and can be used to provide individual feedback to students, or make decision about targeted training which may be required.

*Funding for this project was provided under the Natural Disaster Resilience Grants Scheme – Victoria.*

**REFERENCES**


https://youtu.be/skCarHppxUo, AV Virtual Paramedic Video
SimHealth
Free Papers - Research

The Relationship Between Recent Adversity, Affective States And Anaesthetist Diagnostic Skill Investigated Using An Online Simulation Based Assessment

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Aims. The aim of the present study was to investigate the relationship between recent adversity, affective states and diagnostic cue utilisation amongst anaesthetists.

Background. Expertise is the capacity to consistently produce high performance under pressure (1). Consequently, it is a complex interaction between technical skill and psychosocial factors. With regards to diagnostic expertise, the technical skill component is relatively well understood: as practitioners gain experience in the domain, they acquire diagnostic patterns comprised of cues (patient characteristics/symptoms/history) associated with specific conditions (2). These cues allow the practitioner to quickly and accurately recognise the underlying diagnosis, without exceeding the constraints of working memory (3, 4).

A number of psychosocial factors are also thought to facilitate or impair performance. For example, positive affect can facilitate efficiency, thoroughness and accuracy of decision-making and diagnoses amongst physicians (5, 6). Conversely, recent adversity is thought to have negative relationship with diagnostic performance (7, 8). Recent adversity might take the form of financial difficulties, an ill family member, or more serious and potentially traumatic experiences like the death of a patient. Recent adversity can be distracting and create stress that impedes performance by occupying memory (9). This suggests that the relationship between affect, recent adversity and performance may be because those variables occupy (or release) working memory, allowing practitioners to engage in more thorough and effective cue utilisation. Consequently, the present study examines the impact of recent adversity and affective states (i.e., positive and negative affect) on cue use amongst practicing anaesthetists. It was hypothesised that: H1. Positive affect would be associated with increased cue utilisation; and H2. Negative affect and recent adversity would be associated with lower levels of cue utilisation.

Methods. Sixty-six practicing anaesthetists from Australia, Canada and the United States participated in the present study. The participants began by completing the Positive and Negative Affect Scale and a Recent Adversity checklist. They then completed an anaesthetist form of EXPERTise. EXPERTise simulates the cues and information sources (i.e. bedside monitors) used by anaesthetists in four tasks. The four tasks capture, respectively, the capacity to extract diagnostic cues, the capacity to recognise whether diagnostic cues are related, the capacity to distinguish important cues from non-important cues, and the complexity of the practitioner’s information search strategy. Performance in the tasks can be collapsed into a grand mean, providing an overall indication of the practitioner’s capacity to effectively utilise diagnostic cues (10, 11).

Result. An Analysis of Covariance (ANCOVA) was performed to investigate the effect of positive affect, negative affect and recent adversity on cue utilisation. This analysis revealed a significant three-way interaction between Negative Affect, Positive Affect and Recent adversity on the cue utilisation grand mean, p = .007. Specifically, the analysis demonstrated that the effect of adversity on cue use was dependent on both positive and negative affect experienced after those events. For anaesthetists reporting highly frequent positive emotions, cue utilisation was unaffected by recent adversity. However, for anaesthetists experiencing a low frequency of positive affect, cue utilisation was impacted by both frequency of recent adversity and the levels of negative affect experienced.

Discussion. The present study investigated the relationship between affective states, recent adversity and cue utilisation. The results revealed that, although practitioners who had recently experienced adversity were lower in cue utilisation, the strength of this relationship was dependent on their recent experience of positive and negative affect.

Although the present study provides compelling evidence of the important moderating role of affect in the relationship between recent adversity and impaired cue utilisation during diagnosis, the online simulations used in the present study provide only limited experimental control. Consequently, this research program will be expanded into full clinical simulations of patient deterioration in the operating theatre (funding provided by ANZCA). The use of simulation suites as a research tool provides both the experimental control and realism necessary to ensure that the relationship between affect, adversity and diagnostic cue utilisation is valid and reliable. If the present results extend to the more robust study design, medical training programs may want to incorporate techniques for improving the
psychological resilience of their workforce to improve diagnostic cue utilisation. This will help practitioners to cope with the unavoidable adversities faced in healthcare, like unexpected patient deaths. Performance in the online simulation will also be contrasted with performance in the simulation suite to determine the criterion validity of the online tool.

**Conclusions.** The present study investigated the effect of recent adversity and affect on cue utilisation. The results suggest that recent adversity has a deleterious impact on effective cue utilisation. This is likely the pathway by which recent adversity produces poorer diagnostic outcomes (7, 8). However, positive affect can reduce the size of this effect. Consequently, health services may want to consider providing point of care personnel with psychological resilience training to increase positive affect and decrease negative affect.

**References.** Times New Roman, 9 pt.


Clinical supervision: The use of DVD simulations to teach effective communication to clinical supervisors

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Background. The aim of this project was to develop an educational toolkit including DVD simulations and run a number of activity-based workshops for clinical supervisors, focusing on communication with students in a variety of circumstances.

Methods. Throughout September and October 2014, nine 3.5 hour workshops were delivered throughout Victoria (urban and rural locations) to current clinical supervisors. The central theme of each workshop was the use of two 20-minute DVD simulations using professional actors. Each simulation included:

• Simulation #1: This simulation focused on a student's poor clinical performance.
• Simulation #2: This simulation focused on student behaviour.

A number of other small group-based activities were used throughout each workshop.

This project combined both quantitative and qualitative methods. At the conclusion of each workshop participants completed a retrospective pre-post questionnaire, which was designed by the project team. The questionnaire contained 18 items and included items such as 'how confident participants were at providing feedback to poorly performing students' or 'how would you describe your knowledge about conducting 'difficult conversations'.

Follow-up in-depth interviews were undertaken with participants 2 months after workshop delivery, with an aim of approximately 20% of sample size.

Result. A total of n=117 participants attended the nine workshops. The majority of participants were from nursing n=62 (53%), followed by speech pathology n=19 (16%) and physiotherapy n=10 (8.5%). Participants had an average of 17 years (median) as a health professional, and had mostly worked as a clinical supervisor n=70 (59%). The vast majority of participants were female n=108 (92%) and had a median age of 40 years of age.

Using a 7-point unipolar Likert rating scale (1=Strongly Disagree to 7=Strongly Agree) yielded improved confidence mean scores following the workshop. For example, ‘How confident are you about having difficult conversations with colleagues?’ (before mean=3.81 (SD=1.30) vs after 5.38 (SD=.87), p<0.0001); ‘I am confident to confront someone more junior about a mistake that they have made’ (before mean=4.97 (SD=1.22) vs after 6.09 (SD=.78), p<0.0001); and ‘I am confident to confront a peer about poor or disrespectful behaviour’ (before mean=4.97 (SD=1.22) vs after 6.09 (SD=.78), p<0.0001).

Pre and post results also produced positive results using a 7-point unipolar Likert rating scale (1=Nil to 7=Extensive) regarding knowledge acquisition. For example, item ‘How would you describe your knowledge about conducting difficult conversations?’ (before mean=4.11 (SD=1.08) vs after 5.85 (SD=.67), p<0.0001) and ‘How confident are you about having difficult conversations with colleagues?’ (before mean=3.81 (SD=1.36) vs after 5.38 (SD=.87), p<0.0001).

Almost all those who were interviewed (20 participants) saw that it was more difficult to have a difficult conversation with a senior, then a peer and then a student or junior. Although it was acknowledged by some that it also depended on what the conversation was about and the personality of the people involved. When asked what most difficult conversations were about, they were generally placed into two categories, those relating to clinical skills and those related to behaviour and attitudes. The later was seen as more difficult in terms of conversations.

Conclusions. Feedback on the workshops was very positive, and reflected a clear appetite to undertake more workshops using DVD simulations, and participants from multiple professions. Whether actual clinical supervision behaviour translated into actual practice following workshops beyond the scope and aims of the project, it provides opportunity for further research and examination.
Evidence Of The Contribution Of Simulation To New Graduate Nurses’ Clinical Judgement And Practice

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Aims. To determine the contribution of simulation learning experiences in university nursing courses to new graduate nurses’ clinical judgement and practice.

Background. There has been little focus on the ‘thinking’ aspects of simulation research in relation to subsequent practice, particularly in the area of clinical judgement. Beyond the perceived benefits of enhancing task oriented skills and competence, inquiry is now focussing on how simulation can contribute to the holistic elements of health professionals’ practice. The relationship between simulation and these multifaceted elements of clinical practice are challenging to determine yet important to elucidate (McGaghie et al. 2011). A research based framework of clinical judgement (Tanner 2006) highlights the steps experienced clinicians use to determine patient care requirements – that is: noticing, interpreting, responding and reflecting. This framework has been used by other nurse researchers to frame simulation and clinical experiences (Cato, Lasater & Peeples 2009; Nielsen, Stragnell & Jester 2007). Richer and more detailed investigation of how simulation contributes to these aspects of clinical judgement may help to determine the wider benefits of this contemporary teaching and learning approach in preparing graduates for their professional roles and supporting their transition to practice.

Methods. Qualitative research approach using a convenience sample of final year nursing students at one large metropolitan university. The study was approved by the university ethics committee. Nine students agreed to be followed up as new graduate Registered Nurses to determine the contribution of simulation to their subsequent practice specifically in the area of clinical judgement. Tanner’s (2006) Model of Clinical Judgment informed the research. Each participant was interviewed within the first three months of employment. The interview format was based on semi-structured questions, ranged between 60 and 90 minutes, were audio recorded and then transcribed. Data were analysed using an iterative approach with final themes confirmed by the second researcher (Creswell & Plano Clark 2011). Participants were allocated a pseudonym for reporting results to maintain anonymity.

Results. Each of the nine new graduate nurses recalled specific occasions where their recollection of university simulation experiences triggered independent inquiry or actions during subsequent patient encounters. Major themes of the study included: similar clinical contexts and situational awareness; anticipating options and actions; confidence and knowledge to respond independently; and different contexts but similar processes.

Discussion. These new graduate nurses recalled the context and used the processes modelled within the university simulations in subsequent patient care episodes. Recalling a paediatric simulation, when faced with the actual situation of assessing a baby’s heartbeat, ‘Mary’ was more cognisant of the mother and engaged her in the interaction. This recollection of a similar clinical context to the simulation revealed ‘Mary’s’ attunement to the wider situation beyond the assessment skill. ‘Lilly’, a mature aged international nurse, gained particular benefit from several sources during simulations and in practice to then form her own opinions about options and actions. Observing others and participating in the post-simulation debriefing conferred substantial benefit within the noticing and interpreting aspects of ‘Lilly’s’ clinical decisions and responses. Six other graduates illustrated how they used the processes of the simulation learning experiences, particularly how to recognise and respond to patient deterioration, in similar and different contexts to the university patient scenarios. This highlights the generalised contributions of simulation encounters to subsequent clinical practice. The final graduate nurse provided a unique illustration of how the process aspects of a trauma simulation conferred benefit in managing an acutely unwell mental health client with limited staff members on hand.

Conclusions. The study has provided insights into the contribution of simulation to clinical judgement and benefits for new graduate nurses in subsequent clinical practice. The nurses each reported episodes where they recalled the university simulations when presented with actual patient scenarios of similar or different patient contexts. In particular, the simulation learning experiences promoted the aspects of noticing, interpreting and responding in relation to the clinical judgement framework. Triggered by their enhanced noticing skills, each of the nine nurses demonstrated their self-belief to anticipate and intervene in patient ‘situations’. The question is now posed – had these new graduates not participated in the university simulations, would patient outcomes have been different?
References.

Figure 1 – Tanner’s (2006) research based Model of Clinical Judgment highlighting the key aspects of noticing, interpreting, responding and reflecting.
Simulation-based Evaluation Of A New Tertiary Hospital Prior To Opening

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Aims.

To develop a process to use simulation as a tool to assess a new institution’s operational readiness.

Background.

The use of simulation in healthcare has increased markedly and has achieved widespread acceptance by education providers. However, it also offers benefits in other areas, such as safety and quality. Simulated events in the actual facility (“in-situ” simulation) allow teams to practice responses to uncommon or catastrophic events and to assist with understanding why certain errors or lapses have occurred in practice. Recently, simulation teams have been involved in testing newly-constructed healthcare facilities prior to accepting patients. Traditionally, new hospitals have opened after standard inspections by building inspectors, occupational health and safety officers, medical gas and other equipment inspectors and “walk-throughs” by heads of departments. However, as hospital designs change, it is common to discover some problems only during the course of patient care. A significant number of these problems pose a risk to patient safety. Clearly, it is important to identify such latent threats to safety (LSTs) prior to introduction of real patients and make improvements to the facility (1).

Simulation methodologies offer real opportunities to:

1. Identify resource deficiencies
2. Uncover systems issues
3. Identify unsatisfactory facility spaces or patient care areas; including interfaces between the hospital and external agencies
4. Performance gap of multidisciplinary care teams

Fiona Stanley Hospital is Western Australia’s brand new Flag Ship Tertiary Hospital and was opened in 3 phases from October 2014 to February 2015. It provides a full range of medical and surgical services within a 783 bed facility, on a site that occupies approximately 150,000m² of floor space.

The Clinical Scenario Testing (CST) project was tasked with using hi-fidelity simulation to model and test whole of hospital services prior to opening as part of the hospital’s Clinical Readiness Assessment (CRA)

Methods.

A core team was established to identify hospital events that posed threats to patient safety and institutional productivity/efficiency. Common risk interfaces in these episodes were extracted from this list of events. Provisional scenarios were scripted specifically to test these interfaces as key objectives.

Provisional scenarios were then developed within a formulaic framework prior to real-time simulation testing.

For each scenario, an initial meeting was held with representative stakeholders; clinical leaders, hospital administrators, facilities management staff and external agencies (DFES and WA Police) to assist with scenario planning. Hospital protocol and policy development was often occurring in parallel with this process. The scenarios were then pre-tested with walk-throughs to ensure the validity of the test and maturity of the service/processes being scrutinized. Finally fully immersive real-time, in-situ scenario tests were scheduled and provisioned with operational staff in role with operational equipment. The scenario tests utilised a spectrum of simulation modalities including standardized patients and actors, part-task trainers and high fidelity mannequins.
Each scenario was formally assessed against objectives that were outlined in the planning stages. Observers from stakeholder groups were given key performance indicators to assess and the scenarios were fully debriefed immediately afterwards involving all participants. Video footage of the scenarios was recorded and used to provide further information.

Clear governance structures ensured that data extracted from the tests and debriefings were effectively fed through to the hospital’s commissioning executive committee for remediation of any issues raised.

Observers from staff of other metropolitan hospitals undergoing construction were invited to participate and learn from this process.

Result.

The CST project tested 8 distinct scenario scripts in a total of 14 separate tests. The tests raised a total of 355 significant issues for remediation. Of these issues, 40% were deemed high risk, 35% medium risk and 25% low risk. The issues were classified into categories (Figure 1).

At the completion of the CST project 104 of these issues remained unresolved but with robust plans in place to ensure that remediation takes place. The remaining 251 problems were successfully resolved by reporting through the appropriate governance channels to effect the required changes.

Discussion.

This project highlighted a great number of potential problems prior to hospital opening without exposing a single patient to risk as a result of these hazards. It drove the refinement of many immature hospital protocols, services and systems towards completion. Issues raised were entered into a risk matrix to assess the need and urgency for remedial action prior to the hospital receiving its first patient. This was a powerful tool for the commissioning team to leverage appropriate change in a resource poor environment under significant time pressure.

Conclusions.

The use of simulation to evaluate new, and established healthcare facilities, offers unique opportunities to observe, analyse and improve resourcing, whilst simultaneously exposing latent systems issues that might otherwise go unnoticed. This promotes both patient safety and generates cost savings in both the short and long term.

References.

SimHealth

Workshop

The SimLab: From Frankenstein to the Future

Dr Christopher Denny\(^1\); Dr Ken Harrison\(^2\); Dr Andrew Fagan\(^1\); Greg Brown, Manager & CNC, Education\(^2\)

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Presenter Details.

Dr Ken Harrison is a cardiac anaesthetist and Director of Trauma at Westmead Hospital, Sydney. He has 20+ years’ experience in pre-hospital and retrieval medicine with CareFlight NSW, works as a State Retrieval Consultant for NSW Ambulance and has extensive experience in Disaster Medicine.

Mr. Greg Brown NSC: Manager and Clinical Nurse Consultant - Medical Education at CareFlight. 15 years’ experience in command, management and leadership positions in Australia & overseas with Government and Non-Government agencies.

Dr Christopher Denny works as an Emergency Medicine Specialist at the Auckland City Hospital and is HEMS Medical Director at the Auckland Rescue Helicopter Trust. Chris is an Honorary Senior Lecturer in Emergency Medicine at the University of Auckland as well as Adjunct Assistant Professor of Medicine at the University of Toronto. He also led the NZMAT team to Samoa, and has an ongoing commitment to USAR and NZMAT in New Zealand.

Dr Andrew Fagan is a Canadian Emergency Medicine Fellow with a keen interest in simulation and medical education. He worked at the Auckland Rescue Helicopter Trust with Chris Denny for 12 months and was involved in the simulation exercises with the NZMAT and USAR teams.

Overview.

The SimLab concept is used widely in other industries and is a form of usability testing. In this workshop we will explain the concept and work through a topical example of how this concept has been used in our respective medical retrieval organisations to address a very real challenge.

Expected Outcomes.

Increased knowledge of the SimLab concept and the ability to apply it to a variety of healthcare and high performance team environments.

Detailed Description.

The concept of the SimLab can be credited to Jeffrey Cooper, PhD from the Centre for Medical Simulation as a space to try out new concepts in 3D using simulation prior to going "online." Within the health world, allowing new protocols, equipment and working environments to be trialled using simulation mimicking the operational environment, allows those who will be using it to refine the end product, thereby increasing end-user buy in, improving the end product and reducing post-implementation changes. This concept is also described as usability testing and has been used by the ARHT and CareFlight to assess, test drive and implement a range of interventions from paediatric resuscitation cards to winching an intubated patient. The surface of this concept’s potential has only been scratched and both organisations continue to see many additional ways this model can be used in the future. How does this differ from just a series of mini – simulations? The answer is the feedback loop and the moulding of whatever it is one is testing into the final product which results from the “cooking time” in the SimLab.
Some examples of how this process has been used in both organisations are:

1. Usability testing and comparison of two airframe rear cabins for clinical work

2. Design and implementation of new multi-role packs for medical equipment to reflect a new system but integrate with the existing rescue mandate.

3. Design of a SimCheck process: check scenarios as an annual competency for senior medical staff to ensure clinical currency along with application and refinement of clinical protocols.

4. Introduction of Paediatric Resuscitation Dose cards.

In this workshop, participants will briefly hear the SimLab concept explained and examples of how it can be used to improve development and implementation of new protocols, equipment and procedures. Then, using a hands-on, simulation-based approach, participants will then participate in the SimLab process in smaller groups, looking at different aspects of this in the context of a real challenge in pre-hospital and retrieval medicine. The groups will finally put their learnings and product together to show how the SimLab process allows creative thinking and problem solving prior to implementation, both improving the end product, and increasing buy in from key stakeholders who have had a chance to be part of the development process.

**Evaluation.**

Evaluation forms will be handed out at the start of the workshop and participants will be asked to fill them out as they go.

**Timeline.**

90 minutes
SimHealth

Free Papers - Education Rural

Using A Birth Suit And Patient Simulation To Enhance Skills For Implementing Massive Blood Transfusion During A Postpartum Haemorrhage

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2 Albury Wodonga Health, Wodonga, Australia
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Aim of the Education Program. In regional and rural services, postpartum haemorrhage requiring massive transfusion is a significant time critical event for some women. A lifelike birth suit worn by a simulated patient actress allows a flexible, realistic and mobile approach to simulating postpartum haemorrhage in limited resource settings. Albury Wodonga Health (AWH) services north east Victoria and southern New South Wales, providing care for 1700 births annually. Our aim was to highlight key clinical information relevant to the massive transfusion policy (MTP) and identify opportunities to improve the current process at AWH. This was the first multidisciplinary workshop to simulate activation of the AWH MTP between the maternity unit and pathology service at Wodonga during real time.

Methods Adopted. Twenty one multidisciplinary clinicians attended an extensive didactic session including MTP and simulated postpartum haemorrhage facilitated between the pathology service and birth suite. Following the scenario, constructive feedback included input from pathology, anaesthetic, obstetric, midwifery and blood transfusion nurse expertise to inform a site specific action list.

Evaluation Data from the Program. Pre and post surveys detail the usefulness of the workshop to improve individual levels of knowledge, confidence and competence to implement the MTP and how the simulation exercise enhanced learning. Qualitative data supports the need to reinforce core skills, particularly in regard to the release, collection, administration, equipment and transport of blood products. Systemic changes as a result of the workshop include; increased stock levels for O negative red blood cells, positioning MTP flow charts in clinical settings, development of MTP packs and increased inservice education across all disciplines involved in maternity care. MTP simulated activation at AWH has now been expanded to include all high acuity areas using a multidisciplinary team approach. Access to emergency blood has been listed on the blood committee risk register, requiring risk reduction which has raised its profile and engaged lead executive support.

Conclusions and Recommendations for Future Use and Development. Simulating postpartum haemorrhage in real time is an excellent quality activity to identify areas for clinical improvement and practice team work skills. High fidelity low resource mobile simulation tools that are flexible and life like and adapted for multiple use in a variety of environments are time efficient and effective. Participants engage with the simulation exercise on a personal level because they are engaging with a real woman and the birth suit looks and feels real. Working in their own environment with their team allows clinicians to practice important clinical skills such as fundal massage, bimanual compression, speculum examination, rectal medication, urinary catheterisation and estimation of blood loss in a clinical setting. Patient simulation enhances the opportunity to practice communication skills with the woman and family during an emergency. Additional simulation aides such as a uterus, placenta and blood pump contained within the birth suit allow the session to be tailored to learning needs of the group. This is particularly important for new clinicians who may not have experienced caring for a woman with a postpartum haemorrhage requiring massive blood transfusion.

Results from this exercise support the need to include MTP in future maternity emergency simulation programs. The birth suit supports a more flexible mobile approach to simulating postpartum haemorrhage on site in a maternity care setting.

Disclosure of Conflict of Interest (COI) statement: The author has collaborated with Model Med International to develop the birth suit used in this program.
Remote Simulation Based Training: Developing A Sustainable Model

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Aim of the Education Program. The WA Country Health Service (WACHS) is the largest country health service in Australia and one of the most vast in the world, delivering a range of comprehensive health services to more than 541,000 people, including over 47,000 Aboriginal people, covering an extensive 2.5 million square kilometre area (1). With a highly transient population of tourists that travel throughout the seven regions there is no such thing as a “typical patient” in the rural clinical setting; instead healthcare providers are exposed to a breadth of clinical presentations and experiences (1, 2). The aim of this initiative was to create a sustainable, locally embedded simulation based training (SBT) model to meet the unique needs of regional Western Australia.

Methods Adopted. An assessment of current practice and resources within the organisation, specifically for SBT in medical education, and a review of other national rural SBT in Australia was undertaken. As a result a revised model was adopted to address significant constraints within the proposed setting.

A model consisting of hospital based regional educators with central coordination and support, along with a shared system for the use of equipment to maximize use and minimize disruption of education programs was implemented. Each region has the ability to adapt the model to meet their individual needs based on staff and patient populations.

The model adapted by the Kimberley region will be used as an exemplar during this presentation.

Evaluation Data from the Program.

The initial learning needs analysis conducted at the end of 2013 of JMOs working in WACHS highlighted that there was minimal SBT occurring within the regional sites, with 50% of respondents having never encountered a simulation based activity during their rural rotation. This number reduced to 37.5% in the 2015 survey. The data also shows that there was an increase in frequency of attendance at SBT at least fortnightly from 7% in 2013 to 50% in 2015.

The top three topics rated by respondents in 2013 as areas for further training remain the same in 2015; management of deteriorating patients, adult advance life support and paediatric advanced life support. There has been a significant increase in request for SBT activities in the area of managing aggressive behaviours.

Results will be further expanded during this presentation.

Conclusions and Recommendations for Future Use and Development. The implementation of a sustainable model for the delivery of SBT in remote Western Australia has highlighted many opportunities and issues for future use and development.

Lessons learnt: a “one size fits all” model is not effective, and each region needs to adapt the model to their unique requirements. The process needs to be constantly reviewed and adapted to achieve success; projected plans may not resemble the final product. Enablers: regions where the program has been successful in a short amount of time have had local champions who have been a positive influence in their regions, and shown local educators the utility and benefits of simulation education. Threats: adequate recruitment and retention is a challenge in rural areas, with a high turnover in staff. It is widely accepted that simulation educators have an additional skill set, which requires some development. While we invest in these staff, the turnover means we need to retrain staff often, which takes considerable time, travel and ultimately funds. A significant threat has been the existing “silo” approach to education, whereby different professionals train independently. This continues to be a challenge to break down these ingrained traditions in education and training.

References.


Malignant Hyperthermia Scenario: Testing The Clinical Boundaries In A Rural Hospital

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Aim: of the Education Program.

1. To provide a clinical scenario of the medical emergency Malignant Hyperthermia in the Operating Theatres
2. To provide a multidisciplinary team approach to crisis resource management
3. To focus on non-technical skills: team work and communication
4. To provide an opportunity to rehearse policy and evaluate

Methods Adopted.

A core working party, with medical and nursing representation, planned the education session, over a seven month period. The timing of the session and availability of the Operating theatre was critical to the scenario, as such; the session was run after hours. There were challenges in the preparation phase which included the logistics of transporting the SimMan3G mannequin and sourcing expired dantrolene stock. The Staff were allocated roles prior to the session. The set-up was a basic general theatre set and sutures, with non-sterile theatre drapes. However, of note the abdominal drape was inclusive of a bowl to simulate the surgical field of the bowel with a Boerewors continuous sausage. Multiple op-site dressings were applied over the bowl to simulate skin for a surgical incision. The naso-gastric bag connector taped to the mannequin to simulate intravenous access for cannula insertion, with the reservoir bag placed under the theatre table. This enabled the anaesthetist to have simulated intravenous access for fluids and medications. Milk was drawn up, labelled and utilised as simulated propofol, as was packaging Styrofoam used as ice packs for cooling phase. SimMan3G’s computer became the anaesthetic monitor and the Instructor’s computer was located on the outer periphery of theatre.

Brief
Mr Jack Sims is a 58 year old gentleman with a Body Mass Index of 30.9. Past History Smoker: 30 cigarettes a day, Allergies: Nil, Previous surgeries: Nil, History: Distant relative had anaesthetic issues, Elective surgery: Inguinal hernia repair (bowel obstruction)

A pause and discuss method of debriefing was utilised to enhance the learning experience and provide a changeover time for anaesthetists. There were 12 participants in the scenario and 24 staff members attended the session. This was an interprofessional session with two general surgeons, four GP anaesthetists, two NUMs, two nurse managers, twelve theatre nurses, two nurse educators, one emergency department registrar, one theatre technician, and a simulation educator. The surgical team diagnosed the complication of a bowel obstruction and the provision of arterial blood gas results gave the additional diagnosis of malignant hyperthermia. The diagnosis of malignant hyperthermia tested the team leader and team to communicate and manage the situation. The team focus switched to the mixing of the dantrolene bolus dose and obtaining more staff assistance and ice packs for the cooling phase of the management plan.
Evaluation Data from the Program.

The evaluation was overwhelmingly positive.

**Table 1: Evaluation Summary.**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
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<tr>
<td>The simulation session helped me feel more confident to manage malignant</td>
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<td>hyperthermia</td>
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<td>The scenario had clinical relevance to my work area</td>
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<td>Undertaking simulation in the theatre improved my learning experience</td>
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<td>Interprofessional/peer feedback helped build the theatre team</td>
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<td>The debrief as a team provided valuable feedback</td>
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<td>The Malignant Hyperthermia task cards helped staff know their roots</td>
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Data presented as mean ± standard deviation.
Chi-squared analysis of results found no statistical difference between professional groups for each question.

Conclusions and Recommendations.

Teamwork and communication were highlighted in the scenario. There were logistical issues also highlighted such as sourcing the ice from the local service station and getting extra dantrolene stock from the next town (70km away). These issues resulted in the revision of task cards and unit policy for malignant hyperthermia and the development of a second *on call team* list of staff living in close proximity to the hospital.

References.

CREST - Being Heard About Health Through Broadband. A Simulated Patient Communication Program For Rural And Remote Learners

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Aims. This research aimed to test the potential to use an effective Cultural Respect Encompassing Simulation Training (CREST) program and deliver this to learners in rural and remote locations through video conference technology. An additional aim was to determine whether the nuances and effects of interaction with culturally diverse simulated patients (SP) were sufficient to achieve the outcomes of the cultural sensitivity training, via video link.

Background. The CREST project was developed with funds from Health Workforce Australia in 2012. The program delivered culturally sensitive communication training to health professional students and graduates in face to face immersive simulation sessions. The simulations were developed with culturally and linguistically diverse (CALD) simulated patients (SP) who contributed authentic individualised content to the patient profiles they portrayed. Using a rigorous cultural competency evaluation framework the CREST program achieved significant outcomes.

Seed funding was awarded by the Institute for a Broadband-Enabled Society in 2014 to explore the potential to deliver CREST to learners in rural locations with SPs located at a central location. Rural health care students and providers are often limited in access to teaching and learning resources.

Methods. The city campus hosted the SP and facilitator whilst rural participants were recruited at four separate sites; three academic settings and one clinical setting, n= 45. The individual sessions linked the city site with one rural site via video conferencing. The CREST session was run and then cultural competency teaching and learning evaluations conducted using both quantitative and qualitative data and analysis.

Result. 28 nursing students, 10 medical students and 7 medical practitioners participated as learners. Pre and post session evaluations were conducted representing 5 cultural competency domains. These were: cultural skills, cultural awareness, cultural knowledge, cultural desire and cultural encounters. Participants reported statistically significant improvement in 4 of 5 domains, particularly in cultural skills.

The simulation evaluation reflected the participant’s beliefs that the SPs were authentic and had enhanced their understanding and the subject matter was relevant. Participants also rated the learning environment as conducive and felt better prepared for interaction with people from cultures other than their own.

A thematic analysis of the responses to reflection on the learning experience revealed five themes. These themes were attitudinal affirmation, change in perspectives, practical and useful training, increased confidence and more training is needed.

Three themes emerged from the request to describe the most useful aspect of the learning; these were; quality of teaching, remotely accessing resources and interactivity.

Discussion. Health professionals and students need practice and education in communication. Australia is a multicultural nation with differences represented by both health care providers and patients. This is the context in which communications skills must be learned and practiced. Culturally competent communication has a large skills component best served via practice (1). CALD migrant and ethnic groups have poorer health determinants and health outcomes due to complex factors including language and cultural barriers (2).

Practitioners in rural areas lack access to the variety of teaching and learning resources available in more populous areas (3). Whilst mobile simulation resources are bridging the gap for some areas of practice, a specialised resource such as a CALD SP group is unlikely to be achieved. The interactivity of learner and SP is a critical outcome in CREST teaching and learning modules allowing the student to explore a unique and individual cultural context rather than suggesting or presenting a cultural stereotype. CALD SPs are underrepresented in most SP programs (4) and
require specific training and support mechanisms where English language proficiency and cultural requirements need to be facilitated.

Rather than try to reproduce a varied CALD SP group or require the SPs to travel, the opportunity to test the broadband network initiated the possibility of creating a simulation consultation mediated by technology. In this encounter the learner can view the SP for non-verbal communication signs and receive immediate and individually directed feedback which are the hallmarks of an immersive simulation. The improvement learners showed in the cultural competency domains suggests the learning achieved, using the CREST program, is effective and that video linkage sufficiently facilitated this interaction.

**Conclusions.** Broadband enabled video linkage can achieve conditions conducive to experiential learning such as communication training using simulated patients. This research showed the capacity of the learners to improve in 4 of 5 cultural competency domains measured via a pre and post-test of 26 reliable items, where training occurred using a video-conference link.

**References.**


Introducing A Simulation Program Into A Paediatric New Graduate Registered Nurse Transition Program

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Aim of the Education Program.

With limited paediatric exposure and clinical experience during undergraduate studies, evidence suggests that new graduate registered nurses (RN) often lack the knowledge and ability to interpret signs of patient deterioration once working in the clinical setting (1, 2). With clinical deterioration and arrest less common in the paediatric population, new graduate RNs pose a risk to patient safety due to lack of exposure to sentinel events. It was identified that there was a need to give new graduate RNs commencing at the Children’s Hospital at Westmead (CHW) additional opportunities to develop skills and expertise in recognizing and managing the deteriorating paediatric patient. By utilising simulation, the new graduate RNs are given an opportunity to develop their skills in a realistic, safe and supported learning environment. With limited evidence on the use of simulation based education for paediatric new graduate RNs, there was also an opportunity to determine its appropriateness within a new graduate RN transition program.

A pilot simulation program was incorporated into the 2014 CHW First Year RN Transition Program. The aim of the program was to provide new graduate RNs with the knowledge and skills to be able to manage a deteriorating paediatric patient in a ward setting within the context of a simulated environment.

Methods Adopted.

Immersive simulated scenarios were developed and facilitated by ward clinical nurse educators and transition program educators, with objectives targeting the recognition and initial management of the deteriorating paediatric patient in a ward setting. Both experiential and vicarious learning opportunities were incorporated into the program, with new graduate RNs participating in immersive scenarios and observing their peers. Debrief was centred upon the roles of new graduate RNs in recognising and managing a deteriorating paediatric patient. All 42 participants of the CHW First Year RN Transition Program participated in a centre-based, 4-hour simulation program.

Post program evaluation was conducted using a Likert scale, with the evaluation focusing on knowledge and skills, communication and teamwork, and attitudes towards shared learning. As this was a pilot program, the evaluation also focused on relevancy of the program to the scope of practice for a paediatric new graduate RN. A two month follow up evaluation was also conducted to determine knowledge, skills and attitudes of the new graduate RNs in recognising and managing the deteriorating paediatric patient.

Evaluation Data from the Program.

The initial program evaluation was positive in regards to its relevance for the new graduate RNs with 83% of participants agreeing that the scenarios were a valuable learning experience and 88% agreeing that shared learning was an effective learning experience. At the 2 month follow up evaluation, participants indicated that they had been able to incorporate knowledge and skills gained during the program into their clinical practice, such as management of the deteriorating child skills, communication and teamwork. Interestingly, of the respondents of the follow up evaluation, 77% had indicated that they had still yet to encounter a deteriorating child situation in their ward environment.

Conclusions and Recommendations for Future Use and Development.

Results from this pilot indicate that the implementation of a new graduate RN simulation program on recognising and managing the deteriorating paediatric patient has the potential to bridge the gap between theory and practice by providing participants with opportunities they may not otherwise see in clinical practice. This opportunity not only has the potential to improve the RN’s clinical practice, but also improve patient safety within the paediatric hospital setting. As a consequence of this pilot program, the importance of senior RN guidance during the initial management
of the deteriorating paediatric patient was recognised. Ensuring this resource is available to new graduate RNs has the potential to enhance their learning and development during simulated and real events.

References.


Development Of A Pre-Hospital Interdisciplinary Simulation Training Program In Neonatal And Paediatric Emergencies For Rural Areas

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Aim of the Education Program

Health care practitioners working in the pre-hospital environment in rural areas operate in an unpredictable environment with limited access to clinicians experienced in paediatric and neonatal emergencies. Compared to adult emergencies, these events are uncommon and real-life opportunities to practice their management are relatively infrequent. We aimed to design a high fidelity interdisciplinary simulation training program to connect and test multidisciplinary protocols and practice guidelines for the management of life-threatening paediatric and neonatal emergencies whilst considering best practice and the impact of outcomes in patient care. Collaboration between the Local Health District, Ambulance Service, and a paediatric simulation outreach program (KSA) and utilisation of pre-hospital and hospital settings allowed realistic practice opportunities and feedback on existing care processes with potential for streamlining and modification of guidelines.

Methods Adopted

An innovative simulation program incorporating two separate scenarios, each with a three stage longitudinal insitu design was developed. The first stage of each of the scenarios involved community health services and personnel. Scenario 1 included a private home midwife and paramedic teams attending a complicated home birth and utilised a high fidelity and realistic newborn patient simulator (SimNewB™) and a high fidelity birthing simulator (SimMom™); scenario 2 included paramedic teams attending a rare trauma event and utilised a high fidelity child simulator (SimJunior™). The second stage of the scenarios utilised an ambulance (Ambulance Service of New South Wales) to enhance the clinical authenticity of all aspects of emergency transfer from the community to the hospital setting. The third stage of the scenarios continued insitu in the Emergency Department of the local hospital setting with a focus on handover, collaboration within and between multidisciplinary teams and management planning and delivery. To achieve appropriate levels of realism to meet the program’s aims and to field-test local protocols, scenarios were delivered in ‘real time’, with multiple patients and normally available equipment and resources. The time taken to achieve specific management goals and to deliver patient care across a range of services including ambulance response times, handover and time to appropriate treatment and referral was noted. Video cameras capturing first person and third party views were utilised to enhance reflection and debrief of events from a patient and carer perspective.

Evaluation Data from the Program

A questionnaire was created to explore the effectiveness of both formal learning activities and experiential learning components. Response rate was 61% (n=18). 87% of respondents strongly agreed that they had gained knowledge from the session and 75% strongly agreed that they had learnt new skills. 100% of respondents agreed that the session would benefit other staff members of all disciplines. Response times indicated treatment decisions were made and implemented within adequate time frames utilising to local protocols.

Conclusions and Recommendations for Future Use and Development

Multidisciplinary team collaborations spanning community and hospital settings are vital for best outcomes of out of hospital paediatric and neonatal emergencies, and represent a major challenge, particularly in rural areas where practice opportunities are rare. This interdisciplinary neonatal and paediatric emergencies simulation training program utilises a longitudinal design, and appropriate levels of realism to test local protocols and train for management of real life emergencies spanning community and hospital management. This training program, built on collaboration between Local Area Health facilities and disciplines and a paediatric outreach simulation team has the potential to field-test and improve local protocols and skills and to improve real patient outcomes.
Simulation And Five Minute Team Training: Exploring Nurses Roles And Responsibilities Prior To Response Team Arrival

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Aim of the Education Program.

With nurses being the first responders to patient deterioration and arrest in the paediatric ward environment, it is imperative that they have all the knowledge and skills required to manage the critical event (1). From previous critical events on Hunter Baillie (HB) ward at the Children’s Hospital at Westmead (CHW), it was identified that nurses on the ward often failed to coordinate teamwork and nursing roles prior to arrival of the multidisciplinary arrest team. Though aware of the importance of teamwork and communication during a critical event, nursing staff identified that their roles and responsibilities for managing the deteriorating patient during the first few minutes was often unclear.

As patient deterioration on wards most often initially involves a nursing only team, it was identified that nurses on HB required an opportunity to focus on their teamwork and communication skills during the first five minutes of a critical event on the ward prior to the arrival of other response team members. An in situ simulation program was developed, aiming to give HB nurses an opportunity to develop their teamwork and communication skills and clearly define nursing roles during the initial stages of a critical event in a realistic, safe and supported environment.

Methods Adopted.

A one hour in situ simulation session was developed with focus on nursing roles and responsibilities and how this impacts teamwork and communication in the first five minutes of a deteriorating paediatric patient before the arrival of the multidisciplinary response team. The session commenced with a short interactive session on nursing roles and responsibilities during a critical event to highlight each individual role and its impact on teamwork and patient outcomes. Nurses then participate in an immersive in situ simulated scenario with SimBaby®, followed by a debrief, focusing on nursing roles and responsibilities prior to the multidisciplinary response team arrival. Nurses were then given an opportunity to re-run the same simulated scenario, to allow opportunity to practice knowledge and skills identified in the initial scenario and debrief.

Evaluation Data from the Program.

The HB in situ simulation session has currently run successfully six times, with 30 nurses participating. Utilizing a Likert scale, post program evaluation focused on communication and teamwork as well as knowledge and skills within the context of nursing roles and responsibilities. As this program is new to the ward, the evaluation also focused on relevancy of the program to HB nurses. Post program evaluations were positive, with 95% of participants agreeing that the scenario was an effective learning experience to help focus on nursing roles and responsibilities and its impact on teamwork and communication during a paediatric critical event. A six month post program commencement follow up evaluation will be aimed as assessing changes in knowledge, skills and attitudes of HB nurses during the first five minutes of a patient deterioration on the ward.

Conclusions and Recommendations for Future Use and Development.

With initial program evaluation being encouraging, the in situ program gives HB nurses the opportunity to practice and reflect upon the impact of nursing specific roles and responsibilities within the multidisciplinary team during a paediatric critical event. As critical events involve a multidisciplinary response team at CHW, future development within the program will involve scenarios that integrate all the roles and responsibilities of the team to further identify how this impacts teamwork and communication during a paediatric critical event. HB nurses would then be able to reflect on how their initial teamwork and communication during the first five minutes of a patient deterioration impacts the dynamics of the multidisciplinary response team in the management of an unwell paediatric patient.

References.

Using Simulation Based Training To Inform Safe And Effective Work Practices: Lessons From A Statewide Paediatric Ebola Centre

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Aim of the Education Program.

Following the outbreak of Ebola in 2014, the risk of highly infectious viral haemorrhagic fever (VHF) spreading outside African borders became a genuine threat. As the nominated state wide paediatric centre for New South Wales, the Children’s Hospital at Westmead (CHW) began to design and operationalize appropriate personal protective equipment (PPE), and safe processes of care for management of highly infectious infants and children. Given the highly infectious nature of the disease, the unsuitability of some of the adult guidelines to the care of the young child and family, and the lack of experience in the care of children with VHF or similarly contagious diseases at CHW, it was imperative to ensure staff and patients would be safe during their time in hospital. As CHW had never cared for a child with VHF, many of the proposed processes of care were unpractised and untested. We aimed to utilise simulation based training to test and inform use of new equipment and novel care processes, and to identify latent errors and enable appropriate risk management within the organisation.

Methods Adopted.

A group of recognised experts in infectious diseases and emergency and intensive care worked together to produce a detailed guideline for the management of infants and children with suspected VHF. Elements of the guideline were then developed into specific standard work practice (SWP) documents. Simulated events were designed and undertaken with the dual purpose of firstly training CHW staff and secondly field-testing and informing the SWP documents. Specific SWP documents for VHF developed and tested in this way included the communication cascade to be used upon identification of suspected cases, safe transfer of suspected patients to the very highly infectious diseases unit, safe use of PPE including the development of a detailed sequence for donning and doffing of this equipment, initial patient evaluation and treatment procedures, and safe transfer of biological specimens. Key aims common to all the simulated events included identification of enhanced processes of care for maintenance of patient and staff safety, minimisation and containment of contamination risk, and modification of practices and equipment necessary for the delivery of high quality clinical care. In addition to traditional video recording, first-person video utilising Go-Pro ® technology was used to capture the patient perspective during the simulated events.

Evaluation Data from the Program.

Over 90 health care staff from nursing, medical, executive, domestic services and communications participated in three simulated events designed to train staff and inform further development of 9 SWP documents across 11 hospital departments. Simulated scenarios were able to demonstrate effective teamwork, communication and spill containment procedures and to inform all SWP documents field-tested in this way. Serious barriers to safe and effective patient transfers were identified and major alterations in guidelines initiated as a result. First person video from a patient perspective provided invaluable insights and informed specific elements of the process of care for infants and children with VHF.

Conclusions and Recommendations for Future Use and Development.

Interdisciplinary, hospital-wide simulation based training was successfully used to train staff in novel equipment and modified care processes and helped to inform safe, high quality patient care for infants and children with suspected VHF. Innovative use of first person video capture provided valuable insights and allowed modification of SWP documents to better meet the specific needs of the child.
Aims. The aim of the research was to evaluate the experience of students from a range of disciplines who undertook workplace-based interprofessional simulated learning, with a focus on non-technical skills such as communication, reflective practice and teamwork, in a regional setting.

Background. The Hume Simulation Alliance (HSA), a partnership of La Trobe University, Charles Sturt University and the University of Melbourne, received funding from Health Workforce Australia to provide simulation education across 10 small rural and sub-regional health services in the Hume region of Victoria in 2013/14. A main aim of the HSA project was to advance clinical training for professional-entry students through curriculum innovation, by introducing structured interprofessional learning (IPL) through simulation as a component of the clinical placement experience, rather than as an adjunct learning activity.

Methods. The IPL simulation was delivered in situ at 10 health services or ‘hubs’ where the students were located for clinical placement (therefore integrating it as part of the clinical placement experience). Students were from a range of disciplines but predominantly Medicine, Nursing, Occupational Therapy and Physiotherapy, by design. Participants were evaluated before and after each simulation session by pre- and post-evaluation questionnaires that had received University Human Ethics Committee approval, and were based on the validated TeamSTEPPs® tool. Our questionnaires consisted of 64 items asking participants to indicate on a Likert scale their agreement with statements about familiarity of working and training in teams, learning and performance, learning environments, skills, leadership, situation monitoring, mutual support, communication and essential practice characteristics. Data was analysed using quantitative descriptive methods.

Result. A total of 806 students from 10 disciplines, most in the final years of their course, participated in IPL simulation over an 18-month period. A preliminary analysis of the data reveals students’ attitudes to IPL were generally positive prior to the IPL simulation. There was trend of increased confidence in all domains measured following IPL, however. In general, there was an increase post-simulation in the number of participants who strongly agreed that they have a good understanding of:

- the benefits of inter-professional education;
- the association between patient safety and inter-professional collaboration;
- how to share information effectively in an inter-professional team;
- how to advocate for the patient in an inter-professional team;
- the importance of offering assistance and asking for help as appropriate;
- inter-professional communication skills, and
- team leader brief/chuddles.

Importantly, IPL simulation conducted in the hubs seemed to demonstrate the link between patient safety and interprofessional collaboration, with a majority of students strongly agreeing (56.7%) and a third agreeing (39.5%) that there is an association between the two. This is further supported by our findings that students felt better prepared to share information effectively in an interprofessional team, as well as having improved understanding of how to advocate for the patient in an interprofessional team, following simulation.

Discussion. Healthcare teams are rarely static. In a hospital environment, members of multidisciplinary teams can change frequently during care of a patient. A challenge for education providers, therefore, is how to train students to be effective team players and communicators so they can slot into any team with relative ease when they graduate. Our results suggest that there is great benefit in providing ‘realistic’ simulated clinical experiences in real clinical settings, at a level that is commensurate with the students’ knowledge and experience. Moreover, offering simulation to students in a safe environment within a clinical setting provides us with a valuable opportunity to design learning experiences not typically facilitated by clinical placements, including those of understanding team working and solving problems as a team.(1-4) It has also been suggested that delivering IPL simulation on clinical placement could have a positive outcome for clinical skills and for patient outcomes, by allowing students to develop and hone their skills in a low-risk setting and then have those skills immediately reinforced in a real clinical environment.(1) which our experience tends to support.
It remains to be seen whether we can continue to effectively deliver IPL during clinical placement without placing strain on health services. The capability of staff who are responsible for facilitating IPL simulation in clinical settings is highly important to the student’s experience of IPL. (5–7) While HWA funding permitted the resourcing of SLE educators to support this innovative program at regional hospitals, continuation of such a simulation program has obvious implications for staff training into the future.

Conclusions. The Hume Simulation Alliance has introduced core competencies that go beyond competence in a discipline and take a more holistic view of healthcare delivery.

References.


Time For Reflection – The Balance Between Repetition And Feedback In Resuscitation Training

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Aims. The aim of this study was to compare the ability of two groups of novice learners to stay adherent to the ALS guidelines in their provision of advanced life support (ALS) in a simulated setting where one group received 8 simulated resuscitation scenarios with a simulation:feedback ratio of 1:1 and the other group received 12 simulated resuscitation scenarios with a simulation:feedback ratio of 3:1, both in four hours.

Background. Mastery of the ALS algorithm requires a number of skills and competences like pattern recognition, specific knowledge to ensure swift decision-making when examining the heart rhythm, ability to identify the aetiology of the cardiac arrest, and ability to decide which treatment should be instituted in response to the possible, reversible causes of the underlying condition 1-2. The many parallel tasks to be handled when examining the heart rhythm may in part lead some ALS instructors to seek to increase repetitions within the same timeframe. This may be done by increasing the number of scenarios by decreasing the time for feedback. However, it remains to be elucidated how many scenarios and how much feedback is needed in the provision of ALS to ensure enough repetitions to consolidate knowledge and skills at a sufficient level within the time given.

Methods. We conducted a randomised, controlled, single-blinded intervention study embedded in a voluntary extracurricular ALS course.

Eligible participants were 7th semester medical students from the Faculty of Health Sciences, Aarhus University, Aarhus, Denmark. Exclusion criteria were prior ALS or other critical care training.

The ALS course was set up as a 1-day course following the ERCs ALS Guidelines 2010 3 consisting of 3 hours of lectures and 4 hours of simulation.

All aspects of the course were identical except for the intervention related to the number of simulation scenarios run in the 4-hour sessions. The intervention (8 Sim) group went through 8 scenarios compared with 12 scenarios for the control (12 Sim) group. The eight scenarios were identical for the two groups, and the additional four scenarios for the 12 Sim group were similar in contents and length. Each scenario, including its introduction, lasted approximately 15 minutes which left 5 minutes for feedback for the 12 Sim group (simulation:feedback ratio of 3:1) and 15 minutes for feedback for the 8 Sim group (simulation:feedback ratio of 1:1).

To ensure consistency between the groups, feedback followed the same generic three phase structure of a reaction, an analysis and a summary phase 4-8 using a variation of the Pendleton model 9 for feedback.

Participants were assessed in a retention test 1 week after the course and in a late retention test 12 weeks after the course. The validated ERC Cardiac Arrest Simulation Test (CASTest) 10, was used in both retention tests. All tests were video-recorded for subsequent rater assessments by three individual raters of whom two were blinded.

Result. Forty-six participants completed the course and the 1-week retention test. Of these, 41 completed both the early and the late retention test.

There was no statistically significant difference between the test score/outcome of the intervention (8 Sim) group and that of the control (12 sim) group. In the 1-week retention test, the 8 Sim group achieved a mean score of 89.34 (confidence interval (CI) 84.43-94.26; standard deviation (SD) 11.37), the 12 Sim group’s mean score was 91.21 (CI 86.06-96.38; SD 11.93), (p=0.59). Correspondingly, no statistically significant difference was found between the two groups’ 12-week retention tests; mean score (8 sim) 94.86 (CI 89.87-99.86; SD 11.07) and (12sim) 92.28 (CI 86.98-97.58; SD 10.99) (p=0.46).

Discussion. In the present study, we found no statistically significant difference between the two groups’ retention test scores. This comparison between the two groups indicates that a higher number of simulated scenarios does not
improve performances outcome when participants are tested on their ability to stay adherent to the ALS guidelines. This invites an important question when developing and implementing simulation scenarios: “how much training is needed?”

In ALS training, a tendency has been observed towards running as many scenarios as possible to ensure multiple repetition of the resuscitation algorithm in a variety of settings at the expense of time for reflective feedback. The competencies needed in the provision of ALS highlight the value of deliberate, well-structured practice balancing the quality and quantity of feedback and repetitions, without compromising either.

Conclusions. No statistically significant differences were found between the intervention (8 Sim) group and the control (12 Sim) group.

Our study suggests that a lesser number of repetitive ALS simulation scenarios do not diminish learning when the feedback is equally prolonged to ensure sufficient time for reflection. Present result supports the possibility of being flexible when designing and conducting ALS training as it appears that the quality of feedback is as important as quantity of scenarios when a learner centred focus is present.

References.


Early Days of an Interprofessional Learning Program

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Aim of the Education Program. Using Interprofessional Simulation Training to develop communication and teamwork skills within deteriorating patient scenarios, incorporating the Compass deteriorating patient education used at Southwest Healthcare and abiding by the National Standards of Accreditation, Standard 9.

Methods Adopted. From humble beginnings, the program has grown to twice monthly, three hour simulation sessions, involving the hospitals intern group and nurses from various disciplines and wards. The simulation sessions are focused on developing communication and team work skills, within deteriorating patient scenarios. Each session consists of three simulations, with a debriefing discussion following each individual simulation. Commonly encountered clinical scenarios are presented, to enable embedding of skills required to manage common presentations, whilst developing team work and communication skills amongst changing teams.

Varied approaches are employed, including a session involving mini-tutorials on the recommended approach to medical emergencies, followed by related simulation scenarios, and further sessions involving participants immediately entering simulations with no prior knowledge of the clinical scenario which will ensue, followed by a group debriefing. These latter sessions, in particular, provide an opportunity for participants to learn ‘from, with, and about’, each other. These discussions reveal the reasoning, clinical priorities and varied approaches employed by both individuals and the different professional groups, hopefully leading to improved team work and clinical outcomes. To date, more than 50 interns, and 50 nurses have participated in these simulation sessions.

Evaluation Data from the Program. Pre- and post-session questionnaires indicate that the sessions are well received, with participants expressing views that practicing these common scenarios are beneficial in preparing them for managing similar real situations; improving their understanding of the approach of the alternate professional group; and developing their appreciation of the importance of good communication, team leadership/fellowship and team co-operation.

A follow up survey is currently being created, and will shortly be sent to all participants, to assess the longer term impact of these sessions on participant’s clinical practice.

Conclusions and Recommendations for Future Use and Development. Healthcare professionals see the benefit of, and appreciate involvement in, IPL via simulated scenarios.

Further evaluation of the benefits of such educational activities is necessary to provide evidence required to push for greater funding, thereby allowing a wider roll out of such programs.

Potential barriers include: Shift times, involving different units, ability of managers being able to free up staff to participate, variables in clinical adeptness between individuals and potential learning outcomes (ie. sessions involving interns and nurses from grads to experienced critical care nurses), and funding education units to provide training.

Further evidence of the benefits of IPL.

An appreciation of the relative ease of commencing such a program with the good will and co-operation of stakeholders. An example of a way to commence and build an IPL program within a health service.

Start small, then gather evidence of effectiveness of the program, to support an argument for expansion. Appreciative word of mouth from past participants is helpful in improving acceptance of the program.

References.


Lessons Learned Whilst Developing Interprofessional Handover Simulations for Paramedic, Nursing and Physiotherapy Students

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Aims. The pilot study aimed to:

Evaluate four purpose-designed clinical handover simulations developed for paramedics, nursing, and physiotherapy students.

Appraise factors which facilitate or impede interprofessional education in a simulated environment, including students’ readiness for interprofessional learning.

Background. Current handover practices are variable and may be unreliable causing clinical handover to be a high risk area for patient safety. Breakdowns in information transfer have been identified as one of the most important contributing factors in preventable adverse events. Patient handover between different health professionals is a particularly vulnerable time because of the differences in professional training and clinical roles, resulting in variations in language and handover styles. Contemporary paramedic, nursing and physiotherapy curricula provide limited content on, or opportunities to practice, interprofessional handover techniques. The commissioning of a new simulation laboratory afforded the opportunity for Monash University, Peninsula Campus to develop and test scenarios for assessment and clinical handover between paramedic and nursing students and nursing, and physiotherapy students.

Methods. Permission for the study was granted by the Monash University Human Ethics Research Committee. Four scenarios in the case of an elderly patient with a fractured hip and pneumonia were developed by the research team.

1. Preadmission handover between patient, district nurse and paramedics attending a patient who has fallen at home.
2. Emergency Department handover between paramedics and nurse following patient transport to hospital.
3. Preoperative acute orthopaedic unit handover between nurse and physiotherapist when patient’s respiratory status deteriorates.
4. Postoperative acute orthopaedic unit handover between physiotherapist and nurse prior to first mobilisation post total hip replacement.

We used a high fidelity Laerdal Advanced Life Support (ALS) Simulator manikin for the patient. Members of the research team and academic staff role-played supporting characters as needed. Participants were recruited from years 3 of the Bachelor of Nursing, and Bachelor of Emergency Health, Paramedic, and years 2 and 3 of Bachelor of Physiotherapy. Readiness for interprofessional learning (IPL) was assessed pre and post scenario using the 19 item, Readiness for Interprofessional Learning scale (RIPLS). Possible RIPLs scores range from 19-95, with higher scores indicating more positive attitudes to IPL. The 20 item, Simulation Design Scale (SDS) was used to measure students’ perceptions of the quality of their simulation preparation, support, feedback and fidelity. Possible SDS scores range from 20-100, with higher scores indicating greater satisfaction with the simulation design. IBM SPSS version 21 was used for data analysis.

Results. A total of 12 students (6 paramedic, 4 nursing, 2 physiotherapy) participated. The majority (n=7) had no prior IPL experience. Scenario 1 and 2 were run 3 times and scenarios 3 and 4 were run twice. There was no significant difference between student’s pre simulation (M 83.25) and post simulation (M 85.75) RIPLs scores. Summary scores from the SDS (Table 1) and feedback in the debriefing sessions indicate most students were very satisfied with their simulation experiences.
Scenario & Participants | N* | Range | Mean (SD) |
--- | --- | --- | --- |
1. Prehospital; simulated patient and district nurse to paramedics | 6 | 65-98 | 83.25 (13.42) |
2. Emergency Department; paramedics and nurse | 6 | 65-99 | 85.13 (14.54) |
3. Preoperative respiratory deterioration; nurse and physiotherapist | 4 | 87-99 | 92.25 (5.73) |
4. Postoperative first mobilisation; nurse and physiotherapist | 4 | 81-88 | 84.33 (3.51) |

Table 1: Simulation Design Scale scores
* Students completed either scenarios 1 & 2 or 3 & 4

Discussion. Four scenarios were written by the multidisciplinary research team and piloted with a small group of health professional students. Testing the scenarios presented several challenges. Timetable clashes extended recruitment and will present ongoing challenges if the simulations are to be included across curricula. Participants generally presented with positive attitudes towards IPL, and maintained their support for this learning model post simulation. Data from the SDS provide preliminary evidence that students felt well briefed, supported, received adequate feedback and considered the simulations to have a high level of fidelity.

Conclusions. Piloting the scenarios highlighted the current limited curricula addressing IP handover between paramedics and nurses and nurses and physiotherapy students and the logistic challenges of timetabling IP simulations. The positive student evaluations support the use of the ALS manikin in a diverse range of pre-hospital and acute care IP simulations.

Declaration. None of the authors have a financial interest/arrangement or direct affiliation with Laerdal Medical.

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Finding The Balance Between Theory And Practice: Student Nurses’ Perceptions Of Inter-professional Simulation-based Advanced Life Support Training

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Aim of the Education Program. The aim of the inter-professional Advanced Life Support simulation is to prepare future nurses and doctors to work together as a team to improve patient safety in clinical emergencies. There is an expectation that on graduation nurses will work as effective team members during emergency situations. However, undergraduate nursing education cannot ensure every student is provided with the opportunity to be involved with a cardiac arrest or similar life threatening situation during their clinical placements. Simulation-based training provides a platform for students to apply their theoretical knowledge and skills during patient emergencies, such as cardiac arrest, in a safe environment. Additionally, inter-professional simulation allows for a more realistic experience that includes team work, which is a hallmark of effective care (Baker, Salas, Battles, & King, 2012).

Methods Adopted. Final year nursing students and sixth year medical students work collaboratively in a simulation-based resuscitation team. Eight or nine nursing students at a time attend a one day ALS course. During the day they work in small groups comprising two or three nursing students and five or six medical students. In their groups students managed a series of simulations designed to develop their teamwork and communication skills during clinical emergencies. Each simulation was followed with a debriefing session that provided students with the opportunity to reflect on their practice and provide feedback on their team’s performance.

At the completion of the day students completed a course evaluation which includes a Likert scale for responses to questions drawn from the organisation’s pre-tested evaluation question bank. In addition to 11 mandatory questions three questions were specifically selected from a list of optional questions to ascertain student nurses’ perceptions of their problem solving skills, their ability to work as a team member and whether the course offered scope for student discussion of ideas. The evaluation also provided a section for qualitative comments to two questions; “What was most helpful for your learning?” and “What improvements would you like to see?”

Evaluation Data from the Program. These interim findings are based on the responses of 53 students. Anonymous student responses were collated and analysed.

Key factors identified as most helpful for students’ learning included: Working as a team, problem solving as a team, understanding other health professionals perspectives, preparing for real life emergencies, feeling what it is like during an emergency, thinking and applying knowledge in challenging situations and gaining confidence in practice. The students particularly commented that learning alongside and interacting with the professionals they will be working with in teams during emergency situations was the most beneficial aspect of the simulation experience.

Conclusions and Recommendations for Future Use and Development. Following simulation training the nurses felt better prepared and more confident. The course evaluation has shown that student nurses perceived simulation-based training with medical students as a positive opportunity to learn how to work together and interact as a team of professionals, while experiencing an authentic, but safe real life emergency. Further research ideas include following the nursing students to explore how learning in a simulated environment translates into practice in the real world when they become registered nurses. Additionally, students asked for more simulation-based learning.

References.

Enhancing Existing Nursing Curriculum With Simulation Based Learning: Students’ Experiences

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Aim of the Education Program.

To identify areas in an existing Bachelor of Nursing curriculum where simulation-based enhancements could be applied to 3rd year nursing student’s preparation for workplace learning and then develop, deliver and evaluate these changes.

Background: The School of Health Professions (Murdoch University) in partnership with St John of God Healthcare (Murdoch) received a Health Workforce Australia grant to establish a simulation team to develop and deliver an enhanced program of simulation-based learning. One target area focused on 3rd year nursing students’ preparation for workplace learning. The use of simulation environments to develop clinical judgment and skills in undergraduate nursing curricula is a teaching and learning strategy widely used in nursing education (Gough, Hellaby, Jones & McKinnon, 2012; Dearmon et al, 2014). Some of the benefits of simulated learning include the ability to provide students with a safe environment to practice clinical skills, learning to deal with errors without harm to the patient, developing critical thinking skills and improving the ability to process difficult cases in their own time. In addition, a simulated learning environment can help students to develop communication skills in relationships with patients, relatives and professional colleagues and boost confidence when undertaking clinical placements (Hope, Garside & Prescott, 2010).

Methods Adopted.

The simulation team worked with 3rd year unit coordinators in the BN and identified fourteen specific simulations that could be used to enhance the current curriculum across the academic year. This was followed by a twelve week capstone clinical placement for each student. At the end of the year all 83 third year students enrolled in the BN completed a six question survey requiring qualitative responses to capture their perceptions of the simulated learning experiences. The survey tool was based on the theoretical framework described by Kirkpatrick (Yardley & Doran, 2012) and explored personal responses to the simulated approach, what they learned and how this could be applied to their clinical practice, any potential changes in of self-confidence and any problems or disappointments they experienced with learning through simulated approaches.

Evaluation Data from the Program.

The data from the hard copy surveys were collated using a word processor and then content analysed (Berg & Lune, 2011). The key findings were as follows:

Reactions: Students were overwhelmingly positive about the addition of the simulations to the existing curriculum.

Learning: Students reported that the simulated approach helped them to learn more broadly and more deeply and also assisted to consolidate previous learning in areas such as communication skills, using ISOBAR, improving time management, learning to delegate, working more effectively in teams, administering medication thinking critically and providing holistic care.

Application to practice: The students were able to clearly articulate examples of how the simulation-based approach assisted them in the 12 week clinical practice placement that followed the on-campus work. The simulation enhanced the student preparation for the realities of clinical fieldwork.

Disappointments: Some students identified disappointing aspects of simulation-based learning including a lack of reality, the negative impact of judgemental facilitators, not enough time to compete the activity and the stress associated with being observed.
Conclusions and Recommendations for Future Use and Development.

The simulation enhancements of the existing curriculum proved to be an engaging one for the student cohort and ensured that students were challenged in a supportive environment prior to their capstone clinical placement. It also challenged the staff to review significant parts of the curriculum with the assistance of the specialist team dedicated to the simulated enhancement of student learning. The resources developed can now be used and built upon further as the curriculum undergoes continued renewal.

References.


Scaffolding The Integration Of Simulation Through The BN Curriculum – Educational Development Work In Progress

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Aim of Educational Program.
The School of Nursing at Flinders University has recently revised the curriculum with a desire to increase simulation across the undergraduate nursing curriculum (School of Nursing and Midwifery 2012). Simulation with the use of SimMan is well established in semester 2 second year, and now in semester 1 third year. Our aim is to not only integrate simulation, but introduce a scaffolded learning environment beyond the individual topics. We begin this scaffolded integration from first year with a gradual progression from low-med fidelity to high fidelity as the curriculum progresses. Each topic has its own scaffolded learning approach which is then further integrated into the wider course curriculum.

Method adopted.
Li, Black & Gao (2012) and Yin, Song, Tabata, Ogata & Hwang (2013) explored scaffolding in simulation based learning environments and found the participants in the scaffolding condition performed better than those in the non-scaffolding condition. Simulation has potential to increase competence and protect our nursing students by offering a safe and reflective learning space (Carson 2013). This is supported by Lin’s (2001), Vincent et al’s (2002) and Wang and Reeves’ (2007) studies that reveal student learning by reflection in areas of simulation can have positive outcomes. After Action Review is a repeat process during an educational experience consist of more than reflecting upon and avoiding making the same mistakes once more. Scoresby and Shelton (2014) demonstrated how students can improve their metacognition, reflection and learning by practicing and re-doing a scenario. In order for learning to be improved metacognition is involved, meaning that learners are thinking about their thoughts and become more aware of their reflective abilities and how to apply those abilities (Scoresby & Shelton 2014).

Our scaffolding includes integration of simulation in a gradual way through the undergraduate nursing curriculum. Three of the main scaffolding measures introduced are positioning an RN in the simulation suite to aid and assist learning during simulation, a reflective ‘re-do station’ post simulation and debrief, and personal Lab Log student reflection entries.

Our desire is to extend the scaffolded integration beyond our 3rd year and initiate this learning method in both 1st and 2nd year curriculum (see table). At the moment only 2 topics contain embedded high fidelity simulation however, work is progressing on additional two topics (1st year s2 and one 2nd year s1) to include more structured medium fidelity with an introduction to high fidelity. We currently use part torso in various topics but wish to introduce vital sims to help with early assessment of vital signs as well. The final 3rd year topics are undergoing further review next year and it is hoped that this will enable high fidelity simulation to be introduced into some components.

Evaluation data from program.
The data is sourced from the detailed topic review surveys and by maintaining the set questions over the 1st, 2nd, and 3rd year student groups and analysing student wording, we have the opportunity to assess students prior to going on clinical placements. By using simulation in the form of standardised patients we are able to also assess the progress in student outcomes re communication and history taking.

Conclusions and recommendations for future use and development.
Initiation of a scaffolded topic process has proven successful in the 3rd year, semester 1 topic so we are aiming for a similar backwards stepped process to 1st year, semester. This will remain a work in progress as we continual enhance the topics after review of the student feedback.

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Innovations and Emerging Trends - Cultural Trends and Reflections

Intercultural Competence as a Personal Security and Social Issue

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Abstract

What are Intercultural Competencies? Why are they important? How does the use of simulation contribute to developing these competencies in an appropriate and timely manner? Tertiary education largely focuses on the acquisition of knowledge about concepts and understanding of analytical methods needed to enter a professional career. In this context the development of important process skills, especially those related to the affective domain are often ignored or devalued with an expectation that capability for doing the work in the profession will follow on from the learning. While professional education often includes time spent in some form of apprenticeship to introduce the protocols and processes used in a discipline less attention is paid to the complexity of what we actually involved in demonstrating appropriate inter-cultural competence especially when such protocols and processes vary so widely, and are so deeply embedded in the particular cultural context.

1. INTRODUCTION

This research explores the development of means of providing opportunities for students to acquire Inter-Cultural Competence in tertiary education programs as a way of ensuring that graduates are adequately aware and capable of operating in the wide array of contexts where cultures intersect. The particular focus in this paper is on devising and implementing tools and learning strategies that incorporate an understanding of the need to address the safety of participants both within the academic context and in their careers after graduation.

This issue of personal security in regard to culturally sensitive issues is increasingly important in two key areas. Much work is being done in training Australian military personnel and aid workers in cultural awareness before they go overseas to areas of conflict, for trade, aid or military purposes. A key purpose is to ensure they are sufficiently inter-culturally competent so that they do not become a catalyst for a backlash against the team in the country or back in Australia (Carr 2013). In tandem with this overseas focus there is a growing recognition of the need for cultural training within Australia to ensure that everyone understands, respects and acknowledges the culture of Australian Indigenous peoples.

There are already many excellent games developed for the purpose of international cultural awareness, including Johnson (2009) and Barbieri et al (2013). However some of these are little more than a collection of information about a particular culture. Other activities include some form of experiential learning including computer-based simulations that allow the user to make decisions and choices within a culture, and then observe how those from the other culture might respond to their actions. This approach enables learners to prepare themselves to respond more appropriately to situations they face in the country of the particular culture represented. In addition there are role-play based face-to-face simulations including BARNGA (Thiagi 2005) and BaFa’ BaFa’ (Shirts 2015) addressing generic issues of self-management within unexpectedly unfamiliar cultural contexts.

In the specific context of learning to interact with Australian Aboriginal cultures there has been policy developed on the importance of cultural security in the training of professionals as well as the design of service delivery. The authors are writing from the perspective of our roles as teaching professionals using face-to-face and computer-based simulations and scenarios. In this paper we present a teaching approach we have developed to incorporate the concept of cultural security as it is used in international contexts.

2. BACKGROUND

The Human Rights Commission states that for Indigenous Australians

Cultural safety encapsulates the relationships that we need to foster in our communities, as well as the need for cultural renewal and revitalisation. (AHRC 2011)

In order to ensure that Australia can provide this type of cultural safety we examine how training and learning programs can be
developed and delivered, with especial attention to the design and application of simulation-based activity. This involves non-Aboriginal Australians in learning about the oldest continuous culture in the world, which was born in a land where many cultures now live side by side, and Aboriginal knowledge holders being able to share openly with their own people.

As more is learnt and understood about Aboriginal culture, one desired outcome is that Aboriginal people are treated with greater respect in their own land. As an example the social and environmental commitments of an Aboriginal person will differ from those of other cultures, and such differences need to be respected and held in as high regard as non-Aboriginal commitment to family and work.

At present there is a general lack of awareness about such differences and many non-Aboriginal Australians do need cultural sensitivity to understand the importance of these values, and the effect on people when these values are denied because of an absence of understanding. Effective cultural renewal in Australian communities also provides a powerful environment from which to provide an education about Aboriginal culture.

The Human Rights Commission continues

*Cultural security on the other hand, speaks more to the obligations of those working with Aboriginal and Torres Strait Islander communities to ensure that there are policies and practices in place so that all interactions adequately meet cultural needs. (AHRC 2011)*

It is surprisingly difficult for humans to appreciate cultures that are not their own. We are born and grow up in a familiar, tightly structured and highly specific cultural context. While we may know as an intellectual exercise that all other cultures are not like ours, appreciating the impact of such differences on our own sense of worth and self takes longer, and may be very confronting. We know that they have different values and protocols, different expectations about use of language, social behaviours and acquisition and care of knowledge, to name just a few of the myriad differences.

Yet we do not really comprehend those differences until we find ourselves interacting with them. A frequent response is to think that they are wrong in some way. While it is may be agreed that racism emanates from ignorance of other cultures, it is less well understood that a good deal of fear can be generated by the discovery that how we do things is not the only way and is not inherently right. Furthermore there is fear that other ways may take precedence over our own (Babacan & Babacan 2007). And it is this fearfulness that often drives reactions and responses that, however understandable, are a trigger for cultural clashes. For example, describing the events surrounding the development of BARNGA Thiagi (2005) recalled his flash of insight that:

*Serious conflicts arise not from major obvious cultural differences but from unrecognized minor ones.*

As humans develop an understanding of ourselves, and our relations to each other, we become more aware of the situations and processes that can generate harm for ourselves and others. For example the current relatively low level of understanding about the intricacies of the beliefs and principles informing Aboriginal culture may be seen to be a serious contributor to such things as increasing suicide rate in Aboriginal communities (Smye & Browne 2002).

3. SIMULATION FOR CULTURAL SENSITIVITY

3.1 This Project

The project discussed in this section was developed from an existing repository of forty one health stories and extended to include about twenty five stories about the effects of kinship on peoples relation to others and expectations of others behavior.

We explain here how this project developed and grew as the teaching needs and expectations grew. We also explain how the technology available now in terms of game scripting tools and web services to collate and combine resources is offering greater opportunities for teaching through community stories.

3.2 Sources of information

Simulation in various formats can be used to reduce levels of fearfulness, as well as increase awareness and understanding. Racism workshops in the women’s movement were an powerful component of efforts to address the difficulties experienced by Aboriginal women accessing refuges and other women’s services in the 1980s as part of a general move to confront racism in the feminist movement (Meyers 1997). These activities used role-plays involving workers from refuges, and Aboriginal participants, acting as clients.

Levels of awareness of the effect of language in racism were slowly developing and feminists wanted to bring this new knowledge
into their practice. These early role-play based activities continue to influence training for service providers working with Aboriginal people.

They emphasize the fact that learning about other cultures is difficult and can be protracted. Social learning requires an experiential component, yet it is not possible for everyone to experience Aboriginal culture at first hand. However it is possible to use stories from many different people to build online repositories drawing on stories collected from trainers, which may relate to, or contrast with, typical experiences of those attending training. In doing so the stories draw out the differences among cultures.

One program developed with knowledge of the value of role-play based simulation is the Black Card course which was developed in Brisbane, and based on an Aboriginal Perspective developed by Lilla Watson and Mary Graham (Black Card 2015). The overarching themes of this course are based on two contrasting influences. One is the Aboriginal Terms of Reference (available on their website) and the other concerns concepts of colonialism. Together these provide crucial understanding of the position of Aboriginal people and non-Aboriginal people in society today.

3.2 Contextually Relevant scenarios

Such contexts are evolving ways of dealing with the conflicting needs for Aboriginal people to have their voice and express their experience, and the difficulty of enabling students to learning about the cultural contexts and issues they can be expected to encounter at some future point.

It is now known that the complexity of the differences among cultures is hard to represent purely through story telling about culturally specific episodes and events. Knowing this, and with experiences of those earlier role-play initiatives various projects have been exploring new ways of presenting the content involved in acquiring intercultural awareness and competencies through use of immersive and engaging in simulations.

After early projects involved in the collection of stories the domain of health services in WA (WA Health, 2008) an OLT/ALTC project (Rudd et al 2011) collected Aboriginal stories of experience with health services in WA. The Aboriginal Reference Group on this project then collated a number of themes representing typical concerns in Aboriginal communities, and used these as the basis for four video scenarios that were then scripted and filmed.

However, when these videos were shown to three different groups of Aboriginal people from different states, they expressed concern that the stories, as presented, were not relevant in all the different situations across all Australian states. In particular different historical experiences have led to Aboriginal people adopting different attitudes and expressive different expectations of health services.

3.3 Health collection enhanced

A second ALTC grant was obtained for work done with the University of New South Wales (Kutay et al 2013) to improve the teaching resources linked to these stories and make more use of the existing story repository.

The first stage was to provide tools for teachers from different disciplines to develop a playlist of the most relevant stories for their students and link these to further resources on the site (Health workshop 2014) as shown in Figure 1.

![Figure 1: Embedding stories into course development software.](image)

Teacher using the story site come from a wide range of health professions and university courses, include nursing, paramedics and pharmacists. Hence the web service allows them to select stories, or clips from stories, and link these to questions relating to that segment in the playlist. Students’ comments are collect as well as emailed to the teacher. These comments, if made public by the student, can be selected by the teacher for suture version of the playlist.

3.4 Kinship story collection

At the same time the Reference Group felt that an underlying issue in the health stories, and in all teaching of Aboriginal culture, is the Kinship system, and how this effected relations between Aboriginal and non-Aboriginal people.

The second OLT/ALTC project began to collect stories to be used for teaching issues on kinship across many disciplines. About twenty five were collected and selections are now being used to create new kinship scenarios.
This time the focus was on developing representations of the kinship system, as a core theme within many different contexts, and how these affect Aboriginal clients and professions in education, health and social policy research. These stories are being used as part of an online workshop. The original concept came from a face-to-face presentation (Riley 2011) and videos were made of this to be shared on the web. This presentation includes a description of the kinship relations used in Aboriginal cultures and how these affect people’s interactions with each other and with mainstream services (Kinship Workshop 2014).

To enable these concepts to be understood by professional students in relation to their future work in many different disciplines, the online workshop is then linked to the collection of NSW community stories. These stories focus on incidents where misunderstandings initially arose though different expectations of relationships, language and responsibility to family.

The stories can be continually added and linked to the location in the video which the story narrator best relates to their story. In this way we hope community people will be encouraged to continually update the issues presented on the site and provide relevant experience for the students to hear.

3.5 Making scenarios for reflection

The Health Workshop includes two collections of scripted scenarios written in a gaming contexts, using 3D models and focused on stories from different states. Further scenarios have been developed but have yet to be approved. The use of scripted editing tools allowed teachers to request re-scripting of the scenarios and ensure that each iteration best fits the different emphases and situations relevant to Aboriginal people in different locations and historical experiences.

Also teachers can add specific questions to the scenario for students to answer relevant to the emphasis the teacher wishes to draw out in their course.

The first scenarios were based on the Health videos and stories collected in WA. This means that the project can use the voices of selected community people speaking through 3D characters in the game. These stories can be selected by theme. The combined game, with scripted scenario and recorded voices, provides a fairly non-interactive but immersive environment for students to watch and learn about community experiences.

The game provides a responsive and authentic way to combine the individual stories into themes, more so than a story playlist.

4.1 MAKING THE PASSIVE ACTIVE

However such types of simulation-based representations of interactions are very passive, as the user simply watches exchanges among characters on screen.

While the notional game environment allows a teacher to add questions and pose ideas, we were quickly convinced that a more active immersion process would better contribute to achieving the learning goals. So the next stage of development involved looking at intelligent agents that can be developed to replicate the varying cultural protocols, rituals and varying representations of social importance with the community.

These agents were developed in Portugal (the FAtiMA agent system is available on Sourceforge 2011) and provides en-cultured character models with a rule-based scripting system to specify their interactions with each other and the user.

4.2 Developing Active Scenarios

We used the concept of kinship system as the basis for the first animated interaction. However we developed the scenario within the context of a less traditional setting, creating a scenario within which the player is imagined as working in a school and has gone to the clinic to collect data on a particular health issue. This is a scenario likely to be relevant to workers in the area of social policy, education and health.

In the scenario you have worked with staff from school, these are the people you know, and who know you. So they are the ones to define your social importance in the community.

In the game you can use the mouse to select to talk to a person, or to ask your favour, that is to be able to talk to clinic staff and ask them questions about the issues you have to raise there.

A staff member from the school is at the clinic when you arrive and if you greet them you get a positive emotional response and they guide you about who to talk to next.

If you then talk to the suggested person first to introduce yourself, then ask them your favour, to collect information, they will go and ask the person with authority in the clinic to allow you to do so. If you by skip any of these steps, you will be answered politely but your requests will be ignored.
We are using the totemic aspect of kinship here. In the traditional form it provided a way to allocate knowledge to individuals, who then shared the responsibility for using and distributing the knowledge. In this approach the totems, or different areas of expertise, are respectively the school and the clinic. Different individuals have different status within this hierarchy, as do elders within the traditional totemic system.

The agents work on a system of social importance, which is achieved by approaching the right people and following the right steps to develop a protocol. This is important to respect the sharing of knowledge, which is traditionally done through approaching the right authority and with the right respect for the Aboriginal people, who may wish to control broader access to that knowledge.

4.3 Using agents
The FAiMA agents (Kutay et al. 2013a) provide a testing interface that allows the teacher, community member and developed to verify that the cultural rules are being set up correctly within a scenario. The agent interface show the social importance that each character assigns to other agents, and also the Theory of Mind or the agents' perception of how much social importance each agent assigns to the others (see Figure 2). This is to allow the trainer to verify during user tests that the reaction of the characters is valid in the context.

As an outsider the player comes in with low social importance equal to the teacher (Samson in this scenario) but builds status up during the interchange so that the elder (Jacob in this scenario) will then show more respect for them, as someone suitable to gain knowledge.

The interchange is text based and uses point and click for interactions, but the agents can be linked to speech recognition and speech generation tools to improve immersion (see Figure 3).

Figure 3: A screenshot of FAiMA agents in kinship interaction.

5. CULTURAL SECURITY IN TRAINING
The next stage in this project relates to the cultural security of the training in two aspect. Firstly the culture as represented by the community stories, the playlist selected by teachers, the scripted game scenarios and finally the agent interactions, must be a valid representation of aspect of some of the many Aboriginal cultures in Australia.

Secondly we need to ensure that these tools are used in the classroom in a way that retains respect for the stories, the storytellers, and the Aboriginal community.

Issues such as how people are addressed can become significant. When people are treated in word or deed as the other the language used to address people can be very harmful (Spender, 1980). Thus, when providing cultural training, the need to be aware of the safety of those in the class is becoming more significant.

Whether students are Aboriginal or not, it is reasonable to assume that some will have some affinity with Aboriginal people, and further, that these individuals will find it harder to learn in the presence of people expressing racist views.

Teachers who have used the original story collections in class tell of how some students have reacted angrily and defensively to Aboriginal people expressing their critical views of non-Aboriginal people (Alexander per. Com. 2013).

As cultural trainers, we are focusing on the process as much as the content, and need to encourage students to speak openly to encourage reflection. Furthermore, it is possible that those who are most vehemently opposed to an Aboriginal viewpoint at first, are most likely to be those who speak most clearly of their changed perspective at the end.

However the tensions arising from conflicts in
perspectives may mean educators are allowing harm to be done to other students in the class for this to occur. So what kind of process can support a more secure teaching space?

6. WHAT WORKS

There have been many reviews of government-funded programs to establish what works and what does not in Aboriginal communities (What Works 2015). An analysis of these reports (Cox 2015) included work by the Australian Institute of Health and Welfare (AIHW) provides nine points that are important for a project such as this one to work, and another five that may prevent it working. These points are fairly simple, such as ensuring proper consultation with the community. Yet they are less often achieved in Aboriginal projects.

We believe that it is the process that is important, and it is this, which needs to be taught. In particular we are looking at projects which develop a repository of stories that can be used by teachers to create content suitable for their students learning domain and professional application. For this to work, the teachers need to be provided material that can be used within a correct process.

Hence we propose that the following five points (developed through another project through the OLT) provide a minimal framework for achieving positive engagement and discuss here how they relate to this work.

1. Right People - Do we have the Right People for our project goals? Are we connecting with the right community people?

The projects discussed in this paper originated from people stories and used these to create the knowledge content and focus of the simulations. The web system is designed for people to continue to contribute stories and these to be sorted under themes to create more scenarios.

2. Right Place – for meetings, for working together etc.

We are using the games so that we can re-create the stories in the right setting for each different application of the teaching material. The scene and content can be edited, as can the character appearance. The script can be altered to highlight different significant points. Then the game re-generated and exported for use as a course resource.

3. Right Language – this is not about using a particular language but about how to speak and communicate appropriately.

In particular we are focusing on the cultural safety aspects of how subjects are raised in class and providing teachers with resources to understand and handle this. We encourage reflection without creating a hostile or critical environment and emphasis the reflective process over the specific content the students bring to class.

4. Right time – is there time to do the project? Are there other conflicting demands on time? does this fit with what else is happening in the context?

By providing the material online we allow more people to contribute stories, and students to listen to them, in their own time and space. At the same time the stories are only selected by teachers who can see the relevance to their student’s context.

5. Right way – how things are done differ markedly across the array of Australian Aboriginal communities. Specific actions can be right in one context, and totally unacceptable elsewhere.

The use of game scripting allows us to reuse resources where we can, but adapt these to portray the different aspirations and focus of the communities of that region or storytellers with experience in the area of the course developed.

CONCLUSION

The Human Rights Commission concludes that cultural safety and security requires the creation of:

- environments of cultural resilience within Aboriginal and Torres Strait Islander communities
- cultural competency by those who engage with Aboriginal and Torres Strait Islander communities.

Thus, cultural awareness involves not just providing training to non-Aboriginal people to ensure they behave in an educated way in relation to Aboriginal communities, it also involves providing resources and support for Aboriginal people to maintain the culture we now recognise as a valuable component of human understanding.

However during training we need to be aware of the difficulty for many students in dealing with racism and the questioning of their own beliefs, whether they are Aboriginal people confronted with the ignorance of their peers, or non-Aboriginal students who have a family that supports racism.

The Department of Aboriginal Affairs says cultural security is a commitment to service provision that does not compromise the legitimate cultural rights, views, values and expectations of Aboriginal people. We can no
longer claim that we are providing services to a community if in the process we are denying them validity in their culture.

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Reflecting and Gaining Wisdom: Self-Assessment Rubric Model for Optimising Simulation Based Learning

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Abstract. There are three methods to gaining wisdom. The first is reflection, which is the highest. The second is limitation, which is the easiest. The third is experience, which is the bitterest (Confucius). This paper discusses an approach to scaffolding on simulation exercises with a Self-Assessment Rubric to optimise outcomes from simulation exercises in police education - gaining wisdom through reflection. Universally, educators have grappled for the past 40 years with the adequacy of performance assessment and feedback processes as applied in simulation based exercises. Historically educators have applied a traditional scoring approach to rubric design and application for summative based assessment of learner performance. A more recent trend heralds the application of rubrics designed for a formative based assessment process where performance criteria is scaled by levels of quality of demonstrated capacity (Panadero & Jonsson, 2013). The widely acknowledged educational domains in which rubrics have the potential to inform are broadly established as learner performance, instructional design and reflective practice (Anrade, 1997; Reddy & Andrade, 2010; Hollman & Grillo, 2014). The design and application of rubrics for assessing performance, either summative or formative, in simulation based exercises is not new. The point of difference with the self-assessment rubric (SAR) discussed in this paper is its objective to combine building the reflection in action, reflection on action and reflection for action (Bruce, 2001) of participants with the briefing and debriefing of a simulation based learning exercise. The key goals with this approach are to (1) optimise the learning for the participant through building their reflective practitioner skills and (2) sustain the pivotal learning outcomes of the exercise and the post simulation performance of the learner through reference to a common set of criterion. A pilot application of the self-assessment rubric was conducted with a cohort of New South Wales Police officers participating in a Hydra/Minerva simulation exercise. The findings indicate the self-assessment rubric guides purposeful reflective practice; promotes a sustainable criterion reference for future learning and skill application; the common set of transparent criterion enables simulation participants to understand the learning objectives of the exercise and to ‘measure’ themselves against performance expectations. The design characteristics of the self-assessment model offers educators and simulation exercise instructors an approach which accommodates lowered demands on instructor-participant one-to-one feedback; continuity of performance criterion and is replicable across professions and disciplines for formative assessment of simulation exercise performance. The work will have resonance with public bodies that need their staff to make important ‘on the spot decisions’ often in high stakes high risk situations.

INTRODUCTION

The increasing investment by education and training organisations to leverage on the affordances of simulation technology creates challenges for educators and instructors. One area which has cause for concern is the scramble to keep pace in developing the associated educational ‘tools’ to aid optimization of the learning value of the investment in simulation exercises. Similarly, the investment by participants in simulation exercises encourages a desire to understand the level of their performance in the exercise. Accommodating these areas of concern and expectations for simulation exercises is the pivotal focus of the self-assessment rubric designed for application with NSW Police Force (NSWPF) Simulated Operations Unit (NSWPF/SOU) exercises. The varying demands on both human and physical resources to conduct simulation exercises can create an imbalance with optimising the learning outcomes for the exercise participants. In particular individualised feedback whilst desirable is not always achievable dependent on the size of the participant cohort and the exercise specifics. These circumstances provide opportunity to rethink the approach to participant feedback and assessment in simulation exercises and extend the learning from the exercise to embrace self-assessment as an avenue for developing reflective practitioners.

1.1 Reflective Practice

The seminal work of Dewey (1916) and Schön (1983) in developing and discussing the fundamental concepts of reflective practice have informed the design approach and application of the self-assessment rubric under discussion in this paper. Importantly, both Schön and Dewey advocate that reflection is not a static state of thinking about one’s actions rather it is active. Schön (1983) discusses the notion of reflection-in-action as the learner continuously reflects on their actions in order to modify/adjust their next action. Similarly, Dewey (1916, p. 107) offers the suggestion that reflection is about connecting what went before, what comes after and reflecting in the moment of activity, thereby influencing future activity. How then does this translate into an educational product which guides such reflective practice for simulation exercises? The answer lies in part in the design content of the self-assessment rubric and its place within the
learning framework for the simulation participant. To understand the rationale for employing a rubric styled self-assessment tool with simulation exercises it is helpful to establish (1) the key concepts underpinning rubric design and (2) the connection between reflective practice and a self-assessment rubric.

1.2 Rubric design

There is a wealth of literature devoted to the design and application of rubrics in the education field. In general this literature is in agreement with the description of a rubric as offered by Andrade (1997, p. 14) as:

…a scoring tool that lists the criteria for a piece of work, or what counts; it also articulates graduations of quality for each criterion...

Similarly, Reddy (2007, p4) suggests rubrics are:

…descriptive scoring schemes, a set of scoring guidelines ...and are aligned to an outcomes based approach to education. (p.4).

Reddy (2007, p.4) further explains that rubrics provide for:

…criterion-referenced discrimination of performances and enables monitoring of students learning against each criteria.

Reddy and Andrade (2010) extend the explanation provided by Reddy (2007) in suggesting that rubrics contain performance criteria and articulate what a student needs to demonstrate to achieve a specified level of performance across a performance scale.

The earlier work of Simon and Forgette-Giroux (2001) laid the foundational concept that a key characteristic of rubrics is their criterion referenced approach to assessment. The notion that rubric design embraces the capacity to assess or measure performance against a core set of criteria to be demonstrated at a specific level of competence and or confidence aligns with the extensive work of Peirce in 2006. Peirce (2006, p.1) in discussing the application of rubrics to assess higher order thinking suggests that using rubrics which describe graduated levels of performance

Helps professors evaluate consistently and efficiently

Lets students know what their professor is looking for and how to meet the expectations

Provides feedback to students.

Of note is the extensive and as yet unlimited education domains into which rubrics have been employed due to the potential of their fundamental characteristics which provide for assessing performance. The health sciences field for example (see Shipman et al., 2012; Wald et al., 2012) has extensively adopted rubrics for assessment and learner reflection. Appreciatively, the education field is a rich source of the design and implementation of rubrics for assessment (see Pandero, Tapia & Huertas, 2014; Hurerta, Lara-Alecio & Tong, 2014). The military training arena (Keista et al., 2014) and the business education field (Makani-Lim et al., 2014; Aparicio-Chueca, Dominguez-Amorós & Maestro-Yarza, 2014) present an array of rubric applications. All of these fields offer valuable insight into the educational design considerations to be addressed in progressing the development and implementation of rubrics. Chief amongst such considerations is to identify the rationale for employing a rubric approach to assessment.

1.3 Summative or Formative Assessment

An important rubric design determination is whether the rubric will be utilised for formative or summative assessment. Traditionally summative assessment is based on the awarding of scores or marks which collectively total the level of award for a student for the assessed task. Crawley et al. describe summative assessment as that which:

…Gathers evidence at the end of an instructional event, such as a major project, a course or entire program.

Results of summative assessment indicate the extent to which students have achieved the intended outcomes of the project, course or program (2014, p.165-166).

The point of agreement which resonates throughout the rich volume of literature devoted to discussion of summative assessment is its role in:

…Serving to document the learning that has occurred.

(Kine, Hasenbank & Coffey, 2014, p.110)

The emergence of a formative approach to assessment has gained traction for its core focus on supporting the developmental learning progress of a student. Here also there is considerable literature devoted to the implications for learning of formative assessment (see Keefer et al., 2014; Ng, 2014; Valle & Andrade, 2014). The work of Crawley et al. (2014) articulates formative assessment as that which:

…collects evidence of student achievement while students are in the process of learning. Results of formative assessment inform students about their progress, help monitor the pace of instruction and indicate areas of instruction that may need to change (p. 165).

Further clarification of what constitutes formative assessment is provided by Lipenvich et al. (2014) in suggesting that this approach encompasses identifying and articulating a student’s actual level of performance against a desired level of performance and the discrepancy between these two levels.

It is this fundamental concept of formative assessment which lends itself to application for self-assessment within the simulation-based learning exercise environment. The combination of a set of criteria or standards accompanied by explanation of ‘what it looks like’ to demonstrate these standards at a given level offers potential for students to reflect-in and -on and -for performance.

Table 1 presents an extract from the self-assessment rubric which has been developed for application with simulation exercises conducted by the NSWPF Simulated Operations unit. In the traditional style for rubric design the dimension criteria is identified in the left hand column and the range for levels of achievement are displayed across the page. In this instance the level ranges from Foundational to
Advanced. A cross reference between the dimension and level reveals explanation of ‘what’ the learner would demonstrate at that level. In the context of application of the self-assessment rubric with simulation based-learning exercises, a pivotal element is reinforcement of the associated learning outcomes. A feature of the self-assessment rubric is the commonality of the key dimensions which is designed to support the articulation of the learning outcomes through the exercise briefing, debriefing, self-assessment /reflection and relevant to the field of application.

Table 1: Extract from NSWPF Self-Reflection Rubric for Decision Making

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Foundational</th>
<th>Adept</th>
<th>Advanced</th>
<th>Personal Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define the problem</td>
<td>-Did not identify underlying issues and problems</td>
<td>-Attempted to ascertain the nature of underlying issues and problems</td>
<td>-Identified underlying issues and problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Did not have a clear understanding of what was to be achieved.</td>
<td>-Developed a basic understanding of a desired outcome</td>
<td>-Correctly identified nature of the problem (significant V insignificant)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-No attempt to understand significance of problem</td>
<td>- Attempted to understand the nature of the problem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collect necessary information</td>
<td>-Did not gather relevant information</td>
<td>-Reviewed information at hand.</td>
<td>-Gathered relevant information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Failed to interpret information</td>
<td>-Sought limited or excessive information</td>
<td>-Identified deficiencies in information and sought extra relevant information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-Did not seek additional information</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In 2015, the Self-Assessment Rubric (Table 1) has been piloted with two simulation exercises conducted by the NSWPF Simulated Operations Unit. Exercise No.1 is an Incident Command and Control (ICC) exercise requiring a policing response to emerging public order incidents.

It is valuable to the overall objective of the research to include this simulation exercise as it was the analysis of a prior ICC exercise which highlighted the participants’ advocacy for exercise performance assessment/feedback (Davies, 2013). Exercise No 2 with which the Self-Assessment Rubric was piloted centred on a simulation exercise which required a policing response to a critical incident (investigation of a death). The following sections described the evaluation of the pilot project.

CASE STUDY

The case studies included in the evaluation research centred on a Hydra/Minerva decision-making simulation exercise. The key focus of the exercise is to provide opportunity for senior officers to apply their decision making knowledge and skills to the management of a policing response. The Hydra/Minerva environment was designed by Professor Jonathan Crego and comprises: a plenary/lecture room which acts as both a briefing and debriefing room three or four syndicate rooms containing a computer, video screen, telephone, each of which is net-worked to the control room, conference table and whiteboards; the rooms are outfitted with the equipment the participants would need in a real life event a fixed command support/control room from which each syndicate room is monitored via closed-circuit television and boundary microphones. The technology network enables the feed of information to the participants; it may consist of intelligence briefings, police radio traffic, newscasts, or telephone calls. Officials control the exercise and feed of information to the trainees. The control room houses the subject matter experts, program training staff, and replicated police radio communications. (Davies, 2013).

Figure 2: Hydra/Minerva simulation environment
The simulation exercise is conducted in real time. Exercise No. 1 comprised 13 participants and Exercise No. 2 comprised 20 participants. The participants are divided into teams which are assigned to the syndicate rooms. An exercise briefing and debriefing is included in the full day exercise. It is important to note that the philosophy underpinning the design of the Hydra/Minerva simulation environment is for the application of knowledge and skills without formal assessment of performance.

3. DATA COLLECTION

The data collection methodology chosen to provide a comprehensive evaluation is important to the potential extent, insightfulness and quality of the data. In this research a mixed method data collection approach was employed. Employing a mixed method approach combining qualitative and quantitative data is premised on the seminal work of Bryman (1988), Denzin (1978) and Green, Caracelli and Graham (1989). The mixed method approach has the potential to allow the quantitative and qualitative data to complement each other and provide scope and breadth to the study.

A post-simulation survey was conducted which included Likert scale and short answer questions. A field based interview, post-simulation was conducted with participants. These interviews were designed to capture the participants’ reflection on their understanding and application of the self-assessment rubric. Further the survey and interview questions were designed to inform on the contribution the self-assessment rubric offered to supporting and engaging the learner in reflective practice. Whilst the interview questions were similarly worded to those of the short answer survey questions, conducting interviews offered the opportunity for participants to expand the articulation of their experience with the self-assessment rubric. The intrinsic nature of policing does not readily lend itself to officers’ having opportunity to complete surveys or participate in interviews within a research project timeframe irrespective of their commitment to assist such evaluation initiatives. The result is often less than optimal survey and interview response rates. To address this anticipated situation, this research project is considered a preliminary evaluation with further application of the SAR planned following revision on the basis of feedback during the initial pilot project.

DATA ANALYSIS

The presentation of the data analysis is organised into categories which align with the key objectives of the evaluation project.

SAR influence on learning from simulation exercise

Question 1 of the on-line survey asked participants to indicate their level of agreement that the SAR assisted their learning from simulation exercise. The data indicates 85% of responses \((n=13)\) Agreed, Strongly Agreed or Very Strongly Agreed with the statement.

The remaining 15% \((n=2)\) were undecided on this statement. This was an important question for (1) the capacity to contextualise the survey and draw the focus of the participants to the theme of the survey; and (2) to identify the ‘general’ perspective on the SAR by the participants.

Common Set of Standards –briefing, debriefing & SAR

As discussed earlier, a design intent of the SAR was as a tool for connecting the key learning goals to the core performance criterion. Further this connection to be consistent and sustained through briefing, debriefing and self-reflection. Whilst this was perceived by the SAR developers as a key learning support initiative, it is the experience of the learners who ultimately determine its value to their learning experience with the simulation. Interestingly, as presented in Table 2, the data indicates support for establishing the common set of standards/criterion across the three domains – briefing, debriefing and the SAR.

Table 2: Common Set of Standards/Criterion

<table>
<thead>
<tr>
<th>Question</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>The consistency of a common set of standards for the briefing, debriefing and SAR is helpful to my learning</td>
<td>Very Strongly Agree, Strongly Agree, Agree</td>
</tr>
<tr>
<td></td>
<td>Un-decided</td>
</tr>
<tr>
<td></td>
<td>Very Strongly Disagree, Strongly Disagree; Disagree</td>
</tr>
</tbody>
</table>

The data in Table 2 is further supported by the comments offered by participants to Question 9: How does using the SAR assist in connecting the briefing, debriefing and your performance reflection? In the words of Participant 4:

…the rubric provides a tool during performance reflection to measure performance against the briefing and debriefing information.

The notion that embedding the common set of standards/criterion across the three phases is further endorsed by the comments from Participant 2: …It all ties into the one; and Participant 3 suggested:

…Ties the process together by acting as a revision or review matrix.

The participants’ perspective of the value to their reflection and learning of the role of the common set of standards/criterion aligns with their perspective of the SAR as a tool to guide self-assessment and reflection.

Role of SAR as guide for self-assessment of performance

A key design objective for the SAR was to offer a tool which supported guided self-reflection of performance.
on a continuum to building capacity as a reflective practitioner. The data offers a clear vision of the participants’ perspective of the SAR’s role in guiding self-assessment. In particular the responses to the question: How has the provision of a SAR assisted you in reflecting on your learning experience in the simulation exercise? offered valuable insight in this area. Table 3 presents examples of participant responses to this question.

A total of ten responses were received for this question with the exception of one response indicating ‘unsure’ the remaining nine responses identified positive examples of how the SAR assisted their self-assessment and or reflection.

**Table 3: SAR as guide for Self – Assessment**

<table>
<thead>
<tr>
<th>Question</th>
<th>Example participant responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>How has the provision of a SAR assisted you in reflecting on your learning experience in the simulation exercise?</td>
<td>The rubric provides a useful reminder of good and poor examples of competencies in each area. By looking at each dimension and assessing my performance against those criteria provides some guidance of assessing my performance (P4); The self-assessment rubric provided an opportunity to evaluate your own performance based on the performance of your peers during the exercise (P3); Assisted me in breaking down the decision making processes and identifying where I performed well and poorly and will assist me in future incidents of this nature (P7); Provides a tool to assist with self-reflection (P8); It has assisted me in reflecting on areas of strength and weakness during the course of the Hydra (P1).</td>
</tr>
</tbody>
</table>

**4.4 Influence of SAR on future practice**

As discussed in Sections 1.2 and 1.3 the application of a SAR with simulation exercises is premised on the concept of building participants’ capacity to reflect-in, -on and –for performance. Understanding how the participants will use the SAR in their future professional practice provides evidence as to the contribution of the SAR to (1) extending the educational value of simulation learning exercises and (2) the contribution to developing participants’ reflective practice.

The question: How do you think you will use the SAR in the future? was posed to the participants. Interestingly, this process also highlighted a level of unfamiliarity with SARs, with two of the ten responses indicating they were unsure how they would use the SAR in the future. One participant indicated they would not use it in the future, however, the remaining seven respondents indicated a clear and direct role for the SAR in their individual future practice. The following responses illustrate the potential application of the SAR for participants in this study.

Participant 3 commented:  
...to identify areas of weakness/deficiency and research methods of improvement or strengthening.

This perspective is similarly reflected in the following participant responses:  
...I will probably use the rubric more as a reminder of examples of strong competencies, and benchmark my performance against those (P4);  
...As a review process after involvement in complex incidents (P5);  
...assist in taking time to reflect on my own performance (P7);  
...to review performance in [the] future (P2).

**DISCUSSION AND CONCLUSIONS**

Whilst as acknowledged here the concept of rubrics and specifically, rubrics which embrace a formative approach to assessment are not new, there is limited published work in the field of rubric design and application in the simulation exercise environment.

It is acknowledged that the data reported from the evaluation of the SAR in this project is limited (small number of trial participants), it does nonetheless provide encouraging evidence for the future of this SAR model and application.

The two key overarching goals of the SAR design and application as discussed earlier focussed on optimising learning from simulation based exercises through 1. building reflective practitioner skills; and 2. sustaining longevity of learning through establishing a common set of standards/criterion through briefing, debriefing, the SAR which are premised on real world operational expectations.

The SAR model applied to the NSW Police Force simulation exercises and its subsequent evaluation offers a contribution to the future initiatives of those educators and trainers responsible for maximising learning outcomes from simulation based exercises. Grounded in the seminal education focused literature for reflective practice and rubric design, an encouraging characteristic of this SAR model is its adaptability to the many and varied professions engaged in simulation based learning.

The NSW Police Force Simulated Operations Unit continues to revise, apply and evaluate the SAR model through its commitment to best practice simulation based training.

**REFERENCES**


Towards A Leadership Simulator: Models Of Skill Acquisition And Decision Making

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Independent Developer
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Abstract. In an age where leaders are subject to unprecedented scrutiny, and held to ever-increasing standards leadership simulators will provide opportunities for educational failure at reduced risk of real-world consequences. One of the functions of leadership is to develop organizational capability – one of the major methods for improving organizational capability is to improve the skills of the people who make up the organization. This paper notes commonalities between the Dreyfus model of skill acquisition and the Cynefin decision-making framework, and concludes with practical implications for constructing the supervision component of a leadership simulator.

RATIONALE
To date a large number of simulators and games have addressed managerial themes. These products are typically concerned with resource allocation and exclude the human dimension. Where the human dimension is included models tend to be based on outcome components (e.g. losing a battle reduces morale) rather than interpersonal components (e.g. breaking a promise reduces morale). As such, current simulators do far more to prepare participants for the impersonal components of management rather than the inter-personal components of management such as supervision.

Leadership outcomes such as “engendering faith, trust and respect” and “convincing individuals that they can perform beyond their capabilities” rely on interpersonal interactions between leaders and others. Leaders are expected to “tell subordinates what to do, not how to do it, and then supervise, intervening only when necessary” (Centre for Defence Leadership Studies, 2007). This indicates that one of the questions that should be asked by a leadership simulator is, “when is it necessary for a leader to intervene, and what form should that intervention take?” This paper presents a model that can be used to answer that question.

Leadership must proceed towards an objective to be meaningful. This paper will focus largely on leadership in the management domain (leading the organization towards improved capability). These models can be applied in other leadership domains, and a potential application for a leadership among aircraft pilots will be presented, based on the original Dreyfus study for the US Air Force.

DOCTRINE
People learn best when they are able to make decisions and to observe the impact of those decisions. In the real world there are decisions that have fatal consequences among a wide range of adverse possibilities. Trustworthy simulators allow us to make a disastrously bad decision, experience the impact, and escape real-world consequences.

To be beneficial the simulator must be trusted and trustworthy. To be trusted, the simulator must present itself as an accurate model of the circumstance that it simulates, and reward good behaviour with realistic positive consequences. To be trustworthy, the simulator must have an accurate model of the circumstance that it simulates, and provide opportunities for the user to fail. The user must have the opportunity to engage in risky, dangerous or inappropriate behaviours, and those behaviours should produce appropriate negative consequences; otherwise, the simulation trains users to have false confidence and not real-world skill.

Leadership is an activity with far-reaching consequences that are often difficult to observe at all, let alone to arrive at reliable associations between cause and effect. In social interactions, including leadership interactions, we often experience a lack of meaningful feedback. Simulations can improve the visibility of feedback through status bars or progress bars that show users more than they might learn from a real-world interaction. Simulators can also dramatically increase the immediacy of feedback, with consequences for the users’ decisions being made visible within minutes or hours, instead of months or years.

THE DREYFUS MODEL OF SKILL ACQUISITION
The Dreyfus model of skill acquisition is well respected in clinical practice, and evaluation of the model over a 21-year period concluded that “these studies demonstrate the usefulness of the Dreyfus model for understanding the learning needs and styles of learning at different levels of skill acquisition.” (Benner, 2004) Table 1 shows Dreyfus and Dreyfus’ proposition that adults
progress through a set of stages when acquiring new skills.

<table>
<thead>
<tr>
<th>Skill Level</th>
<th>Components</th>
<th>Perspective</th>
<th>Action</th>
<th>Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Novice</td>
<td>Context-free</td>
<td>None</td>
<td>Analytic</td>
<td>Detached</td>
</tr>
<tr>
<td>2. Advanced beginner</td>
<td>Context-free and situational</td>
<td>None</td>
<td>Analytic</td>
<td>Detached</td>
</tr>
<tr>
<td>3. Competent</td>
<td>Context-free and situational</td>
<td>Chosen</td>
<td>Analytic</td>
<td>Detached choice of saliences and of action. Involved in outcome</td>
</tr>
<tr>
<td>4. Proficient</td>
<td>Context-free and situational</td>
<td>Experienced</td>
<td>Analytic</td>
<td>Involved experience of saliences. Detached choice of action</td>
</tr>
<tr>
<td>5. Expert</td>
<td>Context-free and situational</td>
<td>Experienced</td>
<td>Intuitive</td>
<td>Involved</td>
</tr>
</tbody>
</table>

Table 1: Skill levels in the Dreyfus representation (Dreyfus, 2008)

Here we can see that the learner experiences progressively greater sophistication in the way that they perceive a situation, and that improved performance is related to this increase in sophistication. As novices, we perceive only the components, but as we make progress we start to see the context that those components inhabit. ‘Competence’ is defined as understanding that the same context can be seen through multiple perspectives, and to consciously choose a perspective that is appropriate to the context and the goal. ‘Proficiency’ is when we have a feel for what is important. Instead of paying undue attention to the biggest and loudest features of a situation; our attention is automatically drawn to the most important features. At the ‘Expert’ level there is no longer any need to contemplate what to do, the expert simply ‘does’, and does so correctly.

There are some interesting parallels between this model of decision-making and the Cynefin model for decision-making.

THE CYNEFIN MODEL

Where the Dreyfus model exists to help us understand how people learn, the Cynefin model exists to help us understand what method we should use when making a decision (Snowden, 2010). It helps to remind us of the limits of formalized knowledge (French, 2005).

![Diagram of the Cynefin model](image)

Figure 1: Diagram of the Cynefin model

In an obvious situation, we already know what to do, so we should do what we know to be effective in that situation. A complicated situation is one that has many moving parts, and each of those parts can be well understood. The model says that this situation is one where we should study and plan, then act. A complex situation has parts that are not well-understood, with relationships that are not well understood: we are advised to conduct experiments, understand the patterns that emerge, and use those patterns to construct our response. In a chaotic situation, we don’t know what the variables are, or if they relate to each other, let alone how. When we are completely lost in this way, Cynefin advises us to act first and think later. When it is impossible to understand any of the consequences of our actions, the only achievable goal is to generate some consequences in the hope that we will learn something.

COMBINED CONSIDERATION

If we consider the Dreyfus model and the Cynefin model at the same time, we can say that problems
change in appearance when we become more skilled. Many workplaces seem chaotic to the uninitiated. Cynefin tells us that when a situation is chaotic, the trick is to pick something and do it. Dreyfus tells us that the novice is only able to deal with one part of the problem at a time that the picture as a whole is incomprehensible – in other words, the role of the teacher is to pick something for the learner to do, and get them to do it.

As we start doing things, patterns start to emerge. We no longer see the situation as an incomprehensible mess, we see it as something that can be understood. The advanced beginner can experiment, and start to succeed. The competent practitioner understands which perspectives can be applied to yield productive results quickly.

When we understand the rules of cause and effect, and how they apply in multiple contexts, we are proficient. We can use our proficiency to make plans, and have confidence that those plans will succeed. Our perception of the problem domain is that it is complicated. The expert doesn’t need to think through the problems, because they have a memory of what works, from an expert point of view, problems are simple.

In recent work, Stuart Dreyfus has been writing about a level called Mastery. Mastery is a level beyond expertise, where the practitioner continues to reflect and improve on their performance, despite attaining Expert capability. (Dreyfus, 2008) Progression into Mastery is a way of avoiding a problem that Snowden calls “Expert Entrapment”. Expert Entrapment is a phenomenon where a practitioner perceives a problem to be Complicated or Simple, and relies on their existing knowledge. Unfortunately for the entrapped expert, there’s something about this particular problem which means it should have been classified as Complex or Chaotic – this is the reason why Cynefin has the irregularly-shaped boundaries between categories: as a warning against complacency. (Snowden, 2009) (Argall & Snowden, 2014)

**PRACTICAL IMPLICATIONS**

The fact that world-leading theorists have developed compatible models in the same problem domain suggests that the models are accurate. If we accept these theories as true then we can apply them to constructing the supervision component of a leadership simulator:

The simulated population should contain practitioners of all skill levels
Increase in simulated skill levels should result in increased rewards for the user
Methods for achieving an increase in simulated skill level should be appropriate to the current skill level

The system must not represent ‘Expert’ as ‘Infallible’, and should realistically portray Expert Entrapment
The types of failure caused by simulated agents should relate to their skill level
Leadership methods that protect against failure should be realistically effective
Leadership failures that undermine skill development should undermine simulated skill development

Table 2 shows the behaviour selection strategies that simulated learners would use if behaving according to the combined model, and the leadership interventions that should be rewarded according to the Dreyfus model:

<table>
<thead>
<tr>
<th>Skill level</th>
<th>Behaviour Selection</th>
<th>Optimal supervisory intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>Comfortable behaviours, regardless of relevance or appropriateness</td>
<td>Choose behaviours on behalf of the learner (micromanage)</td>
</tr>
<tr>
<td>Advanced Beginner</td>
<td>Appropriate to the goal, but not necessarily to the circumstance</td>
<td>Select the appropriate perspective for the situation on behalf of the learner</td>
</tr>
<tr>
<td>Competent</td>
<td>Appropriate to the goal and the circumstance</td>
<td>Assist learner to overcome fear of failure</td>
</tr>
<tr>
<td>Proficient</td>
<td>According to an optimized plan</td>
<td>Expose to a wider range of experience</td>
</tr>
<tr>
<td>Expert</td>
<td>According to optimized instinct</td>
<td>Expose to questions</td>
</tr>
<tr>
<td>Master</td>
<td>Conducts experiments</td>
<td>Provide boundaries for experimentation, take advantage of new knowledge</td>
</tr>
</tbody>
</table>

**Table 2:** Behaviour selection by a simulated learner according to skill level

A realistic challenge in a leadership simulator might be to infer a subordinate’s skill level from their behaviour, and to select a supervisory intervention that is appropriate to the subordinate’s needs. An optimal supervisory intervention should improve the learner’s skill level and the relationship between the learner and the supervisor. An intervention one step removed from the optimal intervention should still produce a positive impact. At extreme distances from the optimal and actual
intervention, skilled performance might be reduced, and the relationship between the learner and the leader might be damaged.

The model can also be applied outside the management context, to trigger appropriate failures in simulated subordinates, demanding a response from the user who leads them. For instance, in a leadership simulator for air force pilots, a subordinate pilot may fail to consider the crab angle of their approach to a landing strip. Which pilots will make this mistake? The concept of a crab angle is learned by a competent pilot. It is at the Proficient stage that a pilot is able to make consistently good judgements about how important the crab angle is to a particular situation (Dreyfus & Dreyfus, 1980). Therefore, a simulator for squadron leaders should trigger this type of error in the ‘novice pilot’ AI, or in AI pilots who have been overwhelmed by a new context.

Using the model presented here, it will be possible to design a number of leadership challenges and incorporate them into a leadership simulator. By tackling those challenges, students of leadership will have the opportunity to understand the relevance of the Dreyfus model, and apply it to anticipating failure and promoting learning among their subordinates (both simulated and real-world). By using the Cynefin model to understand how perspective drives decision-making tendencies, we can ensure that simulated learner behaviour is realistic; this improves the usefulness and credibility of the simulation.

When simulated subordinates / learners act, the simulation engine will cause them to fail in realistic ways, driving a potential need for the user / leader to intervene. When users do intervene, they will have a selection of possible interventions to choose from. Those interventions will have realistic consequences that will assist the user to develop their leadership skills. By practicing on simulated subordinates, the trainee leader minimises the amount of distress, disappointment and frustration caused to real subordinates.

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Summary Graphics for Interpreting Virtual Reality Simulator Surgical Performance

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Abstract. Virtual reality surgical simulations provide a unique opportunity to evaluate surgical skills. Here we describe a new method for visualizing simulator interactions in a way that promises to simplify performance evaluation and facilitate the development of new and improved performance metrics, especially those based on motion analyses. The new Summary Graphics are discussed in the context of a haptic virtual reality volumetric tissue removal task. The motions used during the task, together with the rate of volumetric tissue removal are clearly depicted in these graphics, thus providing a strong basis for the development of more informative and robust performance metrics.

INTRODUCTION

Simulators are emerging as important tools for improving technical proficiency and reducing surgical error (Chowriappa, et al., 2013; Myers, et al., 2013). Virtual reality simulators provide an opportunity for anatomically accurate visuals, haptic feedback that mimics human tissue properties, repeatable tasks, and immediate automated feedback of quantifiable metrics that assess a user’s style and ability (Ho, et al., 2012). Most surgical simulator validation studies have focused on a few simple parameters that show a difference between experts and novices such as time to complete the task, accuracy of the cuts and number of errors made (Cannon, et al., 2006; Chalasani, et al., 2011; Panait, et al., 2009). Others have simply studied face validity, subjectively gathering survey data from surgeons on simulator performance (Dequidt, et al., 2013; Ho, et al., 2012). The complexity of surgery means that analysing the time and errors made is not enough to teach good surgical technique. This paper describes a new method of visualizing recorded user interactions to facilitate the development of better performance metrics.

THE SIMULATION

The simulation was developed using an in-house haptic simulation engine that has been developed using C/C++ for Windows 7 (Ruthenbeck, et al., 2011). Graphics are rendered using the DirectX graphics API (application programming interface), specifically DirectX 11.

The tissue model is described in detail in (Ruthenbeck, et al., 2015) was configured as a hemisphere of pink “healthy” tissue that has within it a smaller hemisphere of discoloured “un-healthy” tissue. The simulator task was deliberately made abstract; unlike any real part of the body or any real surgical intervention to reduce user assumptions (for example, if the task appeared like a real part of the anatomy, sizes and scale would become significant, or the behavior of the simulated surgical instruments may be unrealistic).

User interaction was via a Geomagic Touch™ (formerly known as the Sensable Phantom Omni™) haptic interface device that controls a virtual cutting stylus. Haptic rendering of the stylus interaction with the tissue model was performed using penalty-based voxel-driven haptic rendering (8). This provided haptic feedback during palpation and cutting. We define cutting as the progressive volumetric removal tissue intersecting the stylus (when the hand-piece button is pressed). The cutting stylus is modelled as a small sphere that cuts (removes tissue) uniformly in all directions.

The simplicity of the simulated scenario allows us to explore the characteristics of user interactions without the complications normally associated with more complex anatomically accurate models.

The simulator recorded two data streams; 1. The state of the model and, 2. The state of the haptic interface. The voxel model state was recorded at a fixed interval of 10Hz. The uncompressed voxel model would require bandwidth of 80MB/s (1283*4bytes/voxel*10Hz) to record at 10Hz. To address this the voxel model was down-sampled to 1 byte-per-voxel and compressed using zlib resulting in an average of less than 2MB/s at 10Hz with insignificant data loss. The second data stream recorded the device position, orientation, and button states together with, the current time (millisecond precision), the force sent to the haptic device driver, and whether a snapshot of the model (the voxel data) was recorded during the frame. These data were stored in an uncompressed binary format (requiring less than 74kB/s) that was easily accommodated with negligible impact to the simulation software’s performance.
Our Proposed Summary Graphic

The graphic creation software was written in C# using the Microsoft XNA Framework 4.0 libraries to simplify working with 3D vectors and matrix transforms.

Each Summary Graphic was generated by drawing a small circle for each sample of the recorded session data. The location of each sample was obtained by projecting the recorded 3-dimensional position onto a 2-dimensional plane that is equivalent to the screen plane. Samples were drawn only when cutting was active (determined by the haptic device button state). The color of the circle transitions from blue to red as the session goes from beginning to ending. The opacity of the circle was set according to the amount of cutting, which is proportional to the amount of intersection between the cutting stylus volume and the occupied parts of the voxel model, as given by the force magnitude (opacity $\propto$ cutting-rate $\propto$ haptic force magnitude). To enable visual discrimination between regions of slow movement with less cutting, and fast movement with more cutting we modulate the circle diameter according to cutting rate.

The opacity-scale and radial-scale used when generating each Summary Graphic were normalized for each data-set.

RESULTS

The utility of the proposed Session Graphic is demonstrated using three examples shown in Figure 1 that are based on the interactions of different individuals with 8, 2, and 10 years of surgical experience respectively.

Figure 1, Example 1 (left-most) shows the Summary Graphic (top) and a screen-shot (bottom) of the final state of the tissue model. It can be seen from the Summary Graphic that the user begins by making a cut directly into the model slightly above and left of the center, depicted in the Summary Graphic as a large blue spot. The user then makes a slow cut that is almost horizontal. The user then proceeds using circumferential (tangential) cutting movements of apparently even cutting rate and speed. There is an outlying cut around the top-left of the tissue model that removes some healthy tissue. Overall, movements are predominantly tangential and apparently well controlled. The final state depicted in the figure (right) shows a neat final state with minimal discolored tissue remaining.

The Summary Graphic for Example 2 shown in Figure 1 (middle-top) shows that the cutting motions of the user were less regular. Very few tangential movements were used. Some nearly vertical and nearly horizontal cutting movements were made. Several dark spots indicate where fast cuts (fast rate of tissue removal) in the z-direction (into the screen) were made. These can be seen as round hollows in the final tissue model state (Figure 1, middle-bottom).

The final example (shown in Figure 1, right column) shares characteristics with Example 1 and Example 2. Tangential movements were used but not as predominant as Example 1. The rate of cutting is more uniform than Example 2 and less than Example 1. More movements were used to remove tissue in the top-right, lower-right, and lower-left quadrants than the upper-left quadrant. This may indicate that the user was more adept at cutting in some directions than others.

Figure 10: Left to Right: Example 1 to 3. Top-row: Summary Graphic. Bottom-row: Screenshot of the final state of the simulation tissue model.
CONCLUSIONS & DISCUSSION

The Summary Graphics provide a fast and intuitive way of summarizing surgical performance for this simulated cutting task, and simulated surgical tasks more generally. The Summary Graphics enable assessors to see the session recordings in a single image, rather than a video recording, and therefore has potential to reduce the burden on assessing user performance. As such, Summary Graphics can inform the development of more precise and informative metrics for incorporation into computer-based performance assessment and feedback mechanisms.

As an assessment tool, Summary Graphics could be linked with video recordings of user interaction such that points of interest can be identified via the Summary Graphic and easily replayed from the video. Further, Summary Graphics could be annotated to provide better feedback to trainees.

In the future we will explore the potential of motion analysis to contribute a deeper and more detailed understanding of surgical proficiency via more detailed performance metrics.

REFERENCES


Augmented Reality as an Interface to Air Combat Multi-Agent Simulation

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Abstract. This paper explores the application of augmented reality to air combat constructive multi-agent simulation. Specifically, it describes work undertaken to explore the feasibility of applying augmented reality technology to constructive simulation environments which have used traditional mechanisms for developing scenarios and simulation playback. As part of this exploration, a prototype was developed utilising off-the-shelf augmented reality software. An overview of the design of the prototype is presented. The prototype was used to make an evaluation of the current state of augmented reality and its potential application to air combat constructive simulation. Issues, strengths and weaknesses are discussed.

INTRODUCTION
This paper presents an evaluation of augmented reality (AR) technology applied to air combat constructive simulation used in the context of operations research studies.

Monte-Carlo constructive simulation has a long history as an effective computational science tool to study complex sociotechnical systems. Multi-agent simulations of adversarial NvM air combat scenarios are an example of where these types of systems are modelled. These systems are used to undertake operational analysis studies to support acquisitions, upgrades, tactics development and the exploration of novel concepts of operations [1],[2].

There has been limited innovation in approaches for constructing scenarios and visualising the results of air combat simulations. However, recent advances in AR and virtual reality (VR) technologies provide the opportunity to revisit traditional methods for designing scenarios and visualising simulation runs [3],[4].

In the air combat simulation domain, AR and VR technologies have the potential to make operations analysts more productive and allow for a more collaborative and engaging experience with domain experts and clients.

Aim
The aim of the work presented here was to assess the potential for an AR interface to air combat simulation through the construction of a prototype and its subsequent evaluation against a set of criteria. While the feasibility of developing the AR interface was the most important consideration, other criteria such as scalability, interoperability, usability, performance and user engagement were also considered.

Scope
The scope of this work was limited to the development and assessment of a single prototype of an AR interface to an existing air combat multi-agent simulation. Similarly, a single AR technology (Qualcomm’s Vuforia [5] in conjunction with Unity3D [6]) was used to develop the interface. A qualitative assessment of the prototype was undertaken against a set of predefined evaluation criteria.

MOTIVATION
Air Combat Constructive Multi-Agent Simulation

Constructive multi-agent simulation of air combat has been used as an effective tool in operations research studies to provide advice supporting acquisitions and upgrades of combat aircraft as well as a mechanism for the assessment and development of tactics [7].

The complex nature of many constructive simulation environments has often posed challenges for usability and productivity for operations analysts making use of constructive simulation environments.

More recently however, issues such as usability, productivity, explainability and effective visualisation have risen in prominence in the development of complex scientific models. The ability to explain, present and interact with a scientific model or simulation is becoming as important as the specification, design, implementation, verification and validation of the model itself. The domain of air combat constructive simulation is not an exception to this trend. For example, Figure 1 shows an image from the scenario editor component of the Air Combat Environment (ACE), a modern air combat constructive simulation tool.
Modern user interface and visualisation technologies are enablers. They have the potential to increase analyst productivity as well as providing stronger engagement with defence subject matter experts. Applied correctly they provide a mechanism for greater insight and increased explainability for what is often very complex scientific and engineering models.

The application of constructive simulation to support non-traditional operations research activities is likely to increase. For example, exploratory activities such as wargaming, futures exploration and the development of new concepts of operations (CONOPS) are likely to make extensive use of constructive simulation to complement existing tools, techniques and methods.

It is in applications such as wargaming where multiple military, technical and analytical subject matter experts work collaboratively to explore scenarios that newer technologies such as AR and VR have significant potential. An AR interface to a constructive simulation environment could have many benefits in these types of applications. Consider the case where AR could be used in a collaborative manner to design and then visualise the outcome of a scenario in an interactive workspace.

In the air combat domain an AR interface could be conducive to the rapid prototyping of scenarios allowing for the quick positioning of fighters, modification of parameters and viewing results of test runs in collaboration with aircrew. A table top AR interface with subject matter experts positioned around a virtual battlespace has the potential to encourage stronger collaboration and provide all involved a more immersive experience in the wargame.

Advances in Augmented Reality Technology

Recent advances in accessible AR technology have made such visions for immersive and collaborative wargames a possibility. The announcement of high profile AR project such as Google Glass [8] and Microsoft HoloLens [9],[10] has seen a significant increase in the AR community. Subsequently support for AR software development and integration into existing tools and libraries has significantly expanded.

One of the earliest accessible AR libraries was released in 1999 by the University of Washington’s HIT Lab. Called ARToolKit [11],[12], it is still in use today and available on a number of platforms. Today, developers have access to a range of AR toolkits and libraries which allow for the rapid development of AR enabled software. For example, Metaio SDK [13], Wikitude [14],[15] and the Vuforia SDK all have significant development communities.

These advances in AR software technology have been matched by advances in hardware technology including input, display and mobile platforms. Many of the most popular AR software development kits (SDKs) can be deployed to a range of desktop and mobile platforms.

Many SDKs support Android and iOS mobile platforms as well as traditional desktop operating systems. More advanced AR applications can be deployed to PCs to interface with additional hardware such as webcams and Head Mounted Displays (HMDs) [16].

Handheld devices such as mobile phones and tablets are particularly suitable for AR applications because they provide an integrated AR platform. The cameras on a modern phone or tablet can be used to capture the real world and the corresponding devices can be used to display the AR scene. The recent advances in CPU performance and display resolutions as well as their ubiquity and affordability make mobile devices such as phones and tablets ideal platforms for exploring AR applications.

Key Drivers

There are three key drivers for the work presented here. First is the future need for more immersive and collaborative interfaces to multi-agent simulations of air combat. This is especially true as the applications of these types of tools gain traction in areas such as wargaming and futures exploration. Second is the availability of affordable and accessible AR software development kits and libraries and their integration with commonly available visualisation engines and libraries. Third is the proliferation of affordable and high performance mobile computing platforms.

METHOD

With these drivers under consideration, a decision was made to explore the possibility of using AR in conjunction with an air combat constructive multi-agent simulation. The decision was made to develop a prototype to assess the feasibility of developing an AR interface for these types of simulations. Although a rapid prototyping approach was used to develop the software, a set of basic requirements were drawn up. Additionally a set of criteria were identified to assess the prototype.

Rapid Prototyping

The rapid prototyping approach employed aimed to maximise reuse of existing tools and libraries. The final prototype made use of the following libraries:
Unity3D: Game Engine developed (Unity Technologies)
Vuforia: Augmented Reality Toolkit (Qualcomm)
AirDice: Prototype Air Combat Constructive Multi-Agent Simulation (DSTO)
Section 4 contains further technical details of how the prototype was constructed and how these components were integrated.

Requirements
While a fully developed constructive simulation will have a myriad of use cases, the development goals of the prototype presented here aimed to meet three major requirements:
Create an air combat scenario using an AR interface.
Execute the simulation specified by the scenario using an AR interface.
Visualise a replay of the scenario using the AR interface.
More specific requirements included:
Add Fighters to Scenario: The user should be able to add at least four flights (a flight is comprised of four fighters) to the scenario.
Modify Fighter Parameters: The user should be able to modify fighter parameters such as initial position, altitude and speed.
Modify Fighter Configurations: The user should be able to modify the configuration of a flight such as the initial formation and the side (e.g. blue side or red side).
Position Fighters: The user should be able to precisely position and orient the fighter aircraft in the scenario.
Navigate Replay: The user should be able to navigate the replay of simulation run.

Evaluation Criteria
Although the feasibility of constructing an AR interface to an air combat simulation was the primary consideration in the development of this work a broader set of criteria were considered. These included:
Feasibility
Scalability
Interoperability
Usability
Performance
User Engagement
A qualitative assessment of the prototype against these criteria can be found in the section 5.

PROTOTYPE ARCHITECTURE AND DESIGN
The concept of the prototype was that it was based around a table-top battlespace, allowing participants to move objects (image targets) representing flights of fighters, around a table. Figure 2 illustrates the overall concept of the prototype:

Figure 2: The prototype running on a tablet device. Two image targets have been positioned by the user on the table, which are being detected by the prototype. The augmented scene is displayed on the tablet screen.

System Description
After an investigation of several of the SDKs identified in section 2.2, Qualcomm’s Vuforia SDK was chosen. Vuforia uses image recognition technology to detect and track targets including planar images, text and 3D objects. Following detection of the target the developer is notified, allowing the developer to augment the scene with virtual objects (such as 3D models, videos, buttons), which are positioned relative to the detected targets.
A key reason behind the selection of the Vuforia SDK was that it provides an Application Programming Interface (API) for Unity 3D. Unity is a cross-platform game engine and Integrated Development Environment (IDE). While separate Android and iOS APIs exist for Vuforia, utilising Unity 3D meant the prototype could leverage Unity’s user-friendly graphical editor and existing libraries, allowing for rapid development of the prototype. Unity 3D allows for deployment to tablets and smart phones which use the iOS or Android operating systems. Unity 3D can also deploy to Windows based machines, Mac and Linux.
The majority of the implementation was in the C# programming language. The device’s camera would receive the image of the real world, including any image targets which are in the camera’s field of view. If image targets are detected by Vuforia, Unity 3D responds by inserting 3D models of fighters into the scene, at positions relative to the detected image targets. When the user executes the simulation, scenario data is sent to AirDice which runs the air combat simulation and generates result data. When the user chooses to view the replay of the simulation run, Unity3D processes the result data and updates the positions of the virtual fighters and missiles in flight. The augmented scene is sent to the device’s display. A system diagram of the AR prototype is shown in Figure 3.
Figure 3: System diagram of AR prototype

Workflow
The following sections describe the setup of the environment and a typical user workflow.

Device Setup
The prototype has been tested on Window’s based PCs. This configuration requires a web camera to capture the view and a monitor or projector to display the augmented scene. The prototype was also tested on phones and tablets. In this instance, it would use the integrated camera on the device to capture the view and subsequently use the display to present the augmented scene to the user.

Environment Setup
The user would need to setup an environment for the prototype. While a round table is recommended as this allows other participants to easily interact with the system, a flat surface is all that is required. The prototype also requires good lighting, to ensure the quality of the video produced by the camera.

Positioning image targets
Image targets are images which Vuforia can detect and track. For the prototype, four image targets were created. Each image represents a flight. For the purpose of the prototype, selected images were of Royal Australian Air Force (RAAF) patches. Image targets required significant detail, little repetition and good contrast, which increases the probability that Vuforia successfully acquires the target. An example of an image target is in Figure 4.

Figure 4: Image target for the 1sqn flight of fighters
Vuforia runs image recognition algorithms against the camera’s field of view and determines if it can detect the target by comparing features of the images against its database of targets. When the image target is detected, 3D models representing a flight of fighters is added to the scene, directly above the image target (see Figure 5).

Figure 5: 3D models of fighters positioned directly above the detected image target
The user is able to physically move the image targets on the table, as long as they remain within the field of view of the camera. The user is also able to rotate the image targets to initialise the heading of the virtual fighters.

Flight and fighter parameters setup
Two mechanisms are provided to modify the parameters of the flights and fighters in the scene. The user has the choice of an on-screen UI, or virtual buttons in the augmented scene.

Figure 6: The standard GUI in the prototype
If the user selects a fighter on screen (see Figure 6), two windows will be displayed in the top-left hand corner of the screen. These windows will allow the user to modify the side, formation and fighter type of the flight that the selected fighter belongs to. The user is also able to modify the initial speed and altitude of the selected fighter.

The drawback of the standard UI is that it is not conducive to a collaborative environment. The user driving the simulation is the only participant able to modify fighter and flight parameters. As an alternative, the concept of virtual buttons was included.

The advantage of this is that it enables any of the simulation participants, who may possibly be seated around a table, to contribute to the definition of the air combat scenario.

**Air combat simulation execution**

When the user is satisfied with the positioning of the fighters, they are able to execute the simulation by pressing the *Execute Simulation* button in the UI. The final positions (in world coordinates which are calculated by Vuforia) and parameters of the virtual fighters are passed to the AirDice module. AirDice takes the initial values and runs an air combat multi-agent simulation. Aircraft and missile position data is recorded for each time step.

**Simulation Replay**

The user may replay the executed simulation by pressing the play button. The prototype reads the generated aircraft and missile position data and updates positions of virtual fighters and missiles in the augmented scene. If a missile shot is recorded, a 3d model of a virtual missile is instantiated and positioned at the location specified in the simulation results data. If a kill is registered, an explosion animation is executed and the detonated missile and fighter are removed from the augmented scene. A screenshot of the prototype replaying an AirDice simulation can be seen in Figure 7.

While the simulation is being replayed, the user is able to move the camera around the battlespace as long as the image targets remain in the camera’s field of view.
This allows the user to focus on specific parts of the battlespace and zoom in or out easily.

The UI replay controls, which includes a horizontal timeline, allows the user to accurately control the playback of the simulation replay.

**DISCUSSION**

This section provides a qualitative discussion of the prototype in relation to the evaluation criteria introduced in section 3.

**Feasibility**

The primary aim of this work was to assess the feasibility of integrating an AR interface with an air combat multi-agent simulation. The successful development and employment of the AR prototype demonstrated the feasibility of the stated aim.

The prototype satisfactorily met all requirements specified in section 3.2. The prototype did not require significant development time and was implemented by a single developer. This can be attributed to the high usability of Unity 3D and the quality of the documentation supporting the Vuforia SDK.

The accessibility of AR SDKs, and the prevalence of affordable and high performance mobile computing platforms, significantly contributed to the achievement of the stated aims. This may not have been the case five years ago.

**Scalability**

The scalability of the application would need careful consideration in the event that the prototype is transitioned to a deployed system. One point requiring further thought is that Vuforia SDK imposes a limit of five image targets in the scene. This was acceptable in the prototype as only flights of fighters were simulated. This could be an issue however in complex air combat scenarios where other entities need to be included: such as ships, ground vehicles or other airborne platforms.

Another point requiring consideration is that air combat simulations can require a large set of fighter parameters to be modified (number of weapons for example), resulting in a more cluttered UI, particularly on handheld devices. In a complex air combat simulation, a hybrid approach could be considered; where traditional input devices such as a keyboard and mouse are used in conjunction with AR.

**Interoperability**

Interoperability was a strength of the prototype. The selection of the Vuforia SDK and Unity 3D for the development environment meant that the system could be easily deployed to Windows based PCs, Linux, Macs, as well as smart phones or tablets (iOS or Android operating systems). The prototype was successfully tested on a Windows 8 laptop, a Samsung Galaxy 5 smart phone and a Samsung tablet.

**Usability**

Users noted that while the prototype was highly usable, technical limitations did exist. Positioning fighters in the battlespace through moving image targets on a table, made the process straightforward. The fact that this permitted other users to also participate in the positioning of simulation entities therefore increasing collaboration, was an advantage. However, it was initially unclear to the user what the scale of the battlespace was, hindering precise location of fighters. This was fixed by providing the user with the option of adding gridlines to the augmented scene. The gridlines provided an immediate reference for distances between fighters.

The UI for the prototype allowed the user to easily modify attributes of the flights and fighters. The concept of virtual buttons particularly worked well, as they improved the potential for collaboration and were responsive.

The user was able to replay a simulation run and move the camera around the scene, focusing on specific areas of interest in the battlespace. This was especially the case for handheld devices, where the user was able to intuitively move the camera, 360 degrees, around the battlespace. However, there was a technical requirement that all of the image targets remain in the camera’s field of view for the simulation to be replayed. If an image target was outside the camera’s field of view during the replay, the virtual fighters and missiles in the augmented scene would disappear. The image target would need to be reacquired by the camera for the fighters and missiles to reappear in the replay.

Another technical limitation was observed when the prototype’s camera was situated too far from the image targets (approximately 2 metres or more). This resulted in a lower probability that the prototype would detect the image targets. This problem could be alleviated by either adding more detail to the image targets, allowing the Vuforia SDK to more easily detect the targets, or increasing the quality of the camera used.

**Performance**

There was no observed performance degradation on tested platforms; including smart phones and tablets.

An advantage of using AirDice as the air combat simulation module was that it executes the simulation quickly. As a result, this reduced the total time required for the user to step through the workflow in its entirety: from scenario definition, to simulation execution and simulation replay. A small workflow time promotes experimentation with the definition of scenarios and is conducive to the rapid prototyping of air combat scenarios.

Highly complex, time consuming air combat simulations could be potentially executed off-line (on a super computer for example). This would reduce the performance requirements of the device the system was deployed to.
User engagement

A number of air combat analysts were provided the opportunity to define a scenario and visualise the results generated by the prototype. A formal human factors study was outside the scope of this paper; nevertheless, comments from analysts show a significant level of engagement in using this type of interface.

In addition to the positive feedback, it was observed that users were prepared to experiment with the operation of the prototype, providing another indicator of a high level of user engagement.

CONCLUSION

This paper evaluated AR as an interface to air combat multi-agent simulation. A working prototype was successfully developed and deployed. Several benefits were identified in using AR as an interface to air combat simulation. It provides a system which engages users, promotes collaboration, simplifies scenario definition and provides a natural mechanism for the navigation of air combat replays. The drawbacks of the AR interface were that some technical limitations exist and there are scalability concerns in the simulation of complex air combat scenarios.

The prototype has shown that using AR as an interface to air combat simulation is a concept deserving of further exploration. This especially holds true as it is expected that AR (and VR) technology will continue to evolve and improve.

This work has laid the foundation for further work in this area. A project being considered is the continued development of the prototype to facilitate integration with HMDs, such as the Oculus Rift [17]. In the long term, integrating an AR system with a deployed air combat simulation, such as ACE, would be a beneficial exercise.

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Extending Desktop Simulation Beyond the PC Screen

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Abstract. One of the many requirements of modern military training is to provide training materials - including simulation - in an accessible and effective manner. Simulation delivers training in this manner from a variety of (now) traditional platforms, from desktop PCs through to full-scale simulators. However, another emerging example of an accessible and effective training medium are touch-enabled devices, which allow the user to extend the desktop simulation beyond the traditional PC screen.

Adapting a legacy simulation tool such as VBS3 to a touch-enabled device environment in an efficient manner is a challenge, and requires developers and users alike to think about training in new ways. One approach to this is to split the functionality of the training mediums: use a desktop PC (running VBS3) to drive the out-of-the-window view, while using the familiarity and intuitive nature of a touch-enabled device to control the specific interfaces required by the training application.

This paper discusses the prototypes recently developed by BISim to explore the efficiency and effectiveness of using touch-enabled devices to complement and extend the functionality of VBS3. The focus is on the development approach and process, and demonstrating potential use-cases. The paper concludes by identifying additional areas for research and possible prototype development.

INTRODUCTION

VBS3 (Virtual Battlespace 3) is a desktop simulation tool used by militaries and commercial customers around the world for a diverse range of training and other applications. While it has been adapted for use with simulators and other non-traditional hardware, it is primarily a desktop platform, and runs on desktop computers.

Attempting to rebuild legacy software such as VBS3 to run on mobile or thin-client devices is a lengthy and expensive process which may result in a product with either limited features or a cramped, unintuitive interface. Extending selected capabilities of VBS3 to run on touch-enabled and handheld devices, however, presents a feasible way of utilising the power of touch-enabled devices while not compromising on features or usability.

This concept of using “the handheld to augment and enhance the existing PC” [1] is by no means a new one. Indeed, even with regard to VBS3, handheld devices have been used to enhance some specific facets of the simulation, including radios (such as Calytrix’s CNR-skins) and language and cultural training [2]. While these systems represent specific applications, BISim has recently been developing prototypes to utilise touch-enabled devices with VBS3 in a more flexible manner. The initial aim of this prototyping is to analyse and identify the typical use-cases they are best suited for, with the ultimate aim of determining their effectiveness as a training medium.

THE NEED FOR A NEW APPROACH

The original use of simulation in the military was driven by a need to train more soldiers on increasingly complex systems without damaging or reducing the life of limited military resources [3]. Simulation provided a means to deliver this training on a desktop PC which could be scaled up to a full mission simulator for more detailed training. VBS3 has been designed and developed to provide simulation-based training on both desktops and simulators, and has found many innovative uses across these platforms.

As new capabilities and tools become available, the training environment must adapt to incorporate them. In particular, the drive to increase the fidelity of system representation as well as the availability of new technologies allowing mobile, and touch-based interaction requires a new approach to the traditional desktop simulation environment. As VBS3 is used by many of the western world’s defence forces, it is logical to attempt to adapt these new capabilities and tools to VBS3, rather than to attempt to start from scratch with a new product.

Maximising screen ‘real estate’

One of the core features of the VBS3 software suite is its extensive UI development tools that are capable of developing customisable, complex interfaces for all manner of training applications. These tools can be used to develop interfaces to emulate the hardware on real vehicles and equipment, but the primary limitation is that they must be running inside the VBS3 window to be visible and used. This fundamental limitation restrains the
usefulness of these tools, particularly for large and/or detailed systems, which may require a significant portion, or all of the VBS3 screen “real estate”.

The solution to this problem is to somehow create more screen real estate. One approach is to create a bigger screen so that more, or larger, interfaces can be created on it. This approach works for some applications but creates problems with resolution (a larger screen is generally placed further away from the user, so while the scene can be small, the interface needs to be large), screen interaction (a large screen is probably further away and therefore more difficult to interact with) and cost (bigger screens are typically more expensive).

Another approach is to use independent screens, so that while the interface may take up all of the real estate of a single screen, the user can view further information on a separate screen(s). Within this approach there are two solutions. The first is multi-channel, which allows simulation output for a specific view or camera to be displayed on multiple screens. With regards to VBS3, this method is sufficient for cases where the target hardware is Windows-based, has sufficient graphical, storage and computational hardware, and does not require a drastically different output to that typically in VBS3. However, in many cases these conditions are not met, in particular mobile devices used to control or display sub-systems.

The second solution, and the topic of this paper, is to use touch-enabled devices as independent screens and input devices. This solution enables the use of devices that are capable of running software which connects to the base simulation software, but does not necessarily require a similar output to VBS3 or the full hardware specification. This opens the door to develop simulation-based training software on consumer handheld devices, and can also be scaled up to larger touch-screens for desktop PCs or simulators if required.

**Leveraging the tactility of touch-enabled devices**

The explosion of consumer touch-enabled devices makes them an obvious target for simulation-based training, but deciding how these devices should be used in training is not always apparent [4]. For the purpose of this paper, touch-enabled devices refer to handheld, touch-screen devices such as tablets and mobile phones, but also includes non-handheld devices such as touch-screen PC monitors.

One advantage of using touch-enabled devices is that they can provide an interface that more closely represents the real hardware being emulated. Adding hardware emulation into the loop increases fidelity, which has been shown to benefit training, in particular for trainees at early stages of the learning process [5]. Another advantage is that touch-enabled devices, in the form of tablets or mobile phones, are also inherently mobile. This allows users to move the device to a location appropriate for a specific training application, without significant effort or secondary hardware requirements such as cables or stands.

Use of mobile and touch-screen devices in relation to VBS3 is not without difficulties. Primarily, solutions need to be found to:

- provide a method to communicate between software products
- provide the tools to develop interfaces for them
- understand the use-case for developing for touch-screens
- understand how touch-enabled devices are used in a training context and validate their usefulness.

The first two problems are addressed in the next section, Developing a Robust Framework, and are a question of software technology. The third is addressed in An Iterative Development Process, and is a more blended question of software design and technology, and training requirements. The final issue is left to the Future Work and Conclusion section.
DEVELOPING A ROBUST FRAMEWORK

Touch-enabled devices can be integrated with VBS3 in a number of ways. The development examples listed below were primarily developed as prototypes. All of them have the following components:

**VBS3.** The existing VBS3 application, controlled either by the player or an automated process.

**Transfer interface.** The method used to transfer data or information between VBS3 and the client (and vice-versa).

**Client.** The application operating on the touch-enabled device.

![Figure 11: Graphical depiction of the Unity application (left), via the network interface and Fusion API, to VBS3 (right).](image)

**Transfer interface**

A fundamental question that arises when communicating between desktop PCs, or to other devices, is how the information should be transmitted between VBS3 and the client efficiently. This can be done manually, with a human extracting data from one application and entering it into another, or automatically where data is transferred across a network or between applications on a PC/device. In the case of an automated process, this is termed inter-process communication, or IPC.

The task of IPC is made more difficult given that devices often come from different manufacturers and may be developed using different standards. While there are a number of IPC methods available, almost all devices support socket-based communications at some level. Sockets offer a common, fast platform. In particular, User Datagram Protocol (UDP) sockets offer a fast, well-supported method for sending data between devices.

In the case of VBS3, the VBS3 application programming interface (API), known as Fusion is used in conjunction with a relatively simple bespoke application which receives socket data. This is then parsed to VBS3 scripting commands and interpreted in VBS3. Data output from VBS3 to the client-side application follows a similar path, first being extracted by Fusion and fed into a socket writer application, which is then sent across the network to the client.

The next consideration after the transfer interface is the receiving application at either end. Of course on the client-side the application is largely use-case dependent, but the logical first choice was to use VBS3, or some variation of it. This would have had the obvious advantage of a common framework and in-built networking capability, however, porting VBS3 - consisting of multiple-millions of lines of code and written specifically for Windows x86/x64 architecture - to either be platform independent, or to a different platform (such as iOS) was not only unfeasible, but also unnecessary. Only a handful of the features currently in VBS3 were likely to be used and there are already a number of excellent platform independent software development tools available. It requires significantly less development time to create the necessary features on these development tools than it does to attempt to port VBS3.

For all of the cases presented below, Unity was used as the software development tool. Of course, there are a number of other tools that could have been used, but Unity was selected as it is a popular, cross-platform, 2D and 3D games engine with an intuitive development environment that can export directly to a number of devices. As well as being cross-platform, among other features, Unity allows 3D model files to be imported; therefore, the 3D models from the VBS3 content library can (at least at a basic level) be reused. This combination of an intuitive development environment, 3D model import and cross-platform export made Unity the tool of choice for developing client-side applications.

**Framework**

The image at Figure 12 shows the framework used when developing the applications requiring an automated transfer interface.

This framework starts with the user interacting with VBS3, either by interpreting the visual data, or directly inputting keyboard or mouse commands into VBS3. The user then provides a touch input into a tablet, or other touch-based device, which in turn interprets the input and updates the client application accordingly. If data is required to be sent to VBS3, the client application first parses the data to be sent via a socket before sending it over the network. This data is then received by a plugin developed for VBS3, which receives the socket data, parses specific Fusion commands from it, and uses the Fusion library to pass these commands to VBS3. Depending on the commands sent, VBS3 either responds with a visual update to the user, or sends back data via the same process to the client application, or both.

This framework of a User - Client Application (in this case, Unity) - Sockets - VBS3 plugin (using Fusion) - VBS3 - User offers a flexible method for automated data transfer which, as seen below, can be used in a variety of situations.
The process to extend VBS3 outside of the application was an iterative one. It started with understanding the pipeline to manually move data from VBS3 into Unity and progressed over time to an automated process. This iterative development process also helped to shape the use-case for using external 3D rendering engines with VBS3; initially as a limited extension of current VBS3 capabilities, to eventually adding a new capability to VBS3.

**Step 1 - Basic vehicle viewer**

The first task was to understand the basic Unity development workflow in order to assess the boundaries between Unity and VBS3.

From a technical point of view, creating a simple vehicle viewer in Unity allowed developers to investigate the Unity modelling pipeline, scripting/programming tools, and export pipeline to other platforms.

From a training point of view, even this simple application involving an entirely manual transfer interface, could be extended to provide significant training value in helping trainees understand and observe basic concepts about their vehicle (or weapon, location, etc.), while allowing a scenario to continue in VBS3 at the same time.

**Step 2 - Vehicle walkthroughs**

Following on from the knowledge gained from the vehicle viewer, a more complex task was undertaken to create an interactive walkthrough of an object for use in observing high-detail components that are typically not suited to the large-scale simulation of VBS3. As with the vehicle viewer example, the manual transfer of knowledge between the client and VBS3 provides trainees with the opportunity to understand concepts in greater detail, perhaps even while a related scenario is running in VBS3.

The 3D model for a US Army M1114 HMMWV was taken from the VBS3 library and imported into Unity. A number of steps were required to render the vehicle correctly in Unity, including exporting the model to the correct format, removing secondary Levels of Detail (LODs), and manually importing textures. Once the model itself was available, further programming was required to add features to the model, such as animating components, or toggling between shader states as shown in Figure 13 above. This was then exported to run as both a standalone executable on Windows platforms, and on a web page.

The core knowledge gained from this exercise was that attempting to import vehicles directly from VBS3 to Unity is a non-trivial task. A significant amount of manual work is required to simply get the model in, and then all of the functionality (driving, animations, lights, etc.) needs to be programmed.

The start point of this development was to import the hangar of the UK Navy’s Type 45 model in VBS3 into Unity. Typically, the model development process for VBS3 requires developing a high-resolution version of a model using 3D modelling tools such as 3ds Max. This high-resolution model is then optimised by reducing the number of triangles to simplify geometry for large-scale simulation in VBS3. For this task, to ensure that all components were captured in full detail, the high-resolution version was imported directly into Unity.
The core knowledge gained from this development was that while it is possible to import high-resolution models into Unity, it makes manipulating them slower and more difficult. It also gave us an excellent understanding of the Unity export process to iOS and Android devices, as well as the peculiarities of developing for touch-based interfaces.

**Step 3 - Basic vehicle systems**

As development iterated through stages, so did our understanding of how best to use a games development engine, like Unity, with VBS3. It became clear that replicating capabilities such as showing a vehicle or walking through one, while useful, do not add a significant amount of training value aside from the ability to do this on devices other than a PC.

One of the core capabilities of VBS3 is that it allows the user to operate a number of different vehicles in a large, detailed environment. The trade-off for this is that a number of systems on board the vehicles are often generalised. While it is possible to develop high-fidelity systems for these vehicles, screen real estate limitations often mean that the control interfaces for these systems become obtrusive. This necessitates a need to pull certain components off the main screen, into a secondary screen or device.

As part of a larger contract with the ADF to develop the Husky MkIII mine clearance vehicle and associated systems, the movement of the Interrogator Arm (IA) for one of the Husky variants was developed for VBS3. While VBS3 has a common control system for animations in game (called interact with animations, or IWA), it does not represent the real vehicle system and can sometimes be difficult to use for operators who are learning to use the vehicle, or VBS3, or both. As an alternative, a standalone application was developed to simulate the real control panel used for controlling the Husky IA. This application was relatively simple as the device itself has limited functionality; the communication operated in a single direction only, and was developed using Unity with a UDP socket-based communication method to interact with VBS3.
The advantage of this system is that it allows the user to interact with the IA using a system based on the real controls, and uses an intuitive, touch-based interface. A secondary benefit is that it allows users to become accustomed to the real controls, and to be able to test different layouts and control variants quickly.

This development highlighted the advantage of representing sub-systems using Unity, as opposed to replicating entire models and their functionality from VBS3. Replicating models and functionality can be difficult to do and provides limited additional training value, but representing a small part of a system can add significant training value without complicating development.

**Step 4 - Complex vehicle system representation**

The logical follow-on from a relatively simple system, such as the IA controller, is to develop a more complex system, such as a gunnery control system. In this case, the Remote Weapon System (RWS) from a Bushmaster was selected, largely because VBS3 already has a basic implementation of it in-game. From a software point of view, the RWS is a more complex system largely due to the video stream that is shown on the device, and the necessary bi-directional communication with VBS3 to get and set the state of the weapon and other parameters.

Although the transfer interface framework for communicating with VBS3 was largely completed with the Husky IA controller, basic UDP socket communication only really allows for transmission of simple control inputs, such as switch states. Transmitting a video stream efficiently, even across a local network, requires a different architecture due to the large amounts of data being sent and received. In this case, a trade-off of efficiency to expediency was made, whereby a simpler image compression and transfer protocol was used against a more complex video streaming protocol.

In addition to the video streaming, this development integrated a number of other features on the application-side, such as video shading for brightness and contrast, light rendering to match the relative sun direction, and a more detailed fire control system than is currently available in VBS3.

Many training environments do not have wireless networking capabilities; therefore, it may not be possible to use networked mobile devices, such as iOS or Android-based platforms. While the RWS application was primarily developed for Android and iOS devices, it was also developed as a standalone executable for touch-screen monitors on windows-based PCs for use-cases where only wired networks are available.

One further area that this development highlighted was a need to integrate the gunnery application into the administrative workflow of VBS3. Since there may be multiple vehicles with remote weapon stations in a single scenario, it’s important for users and administrators to be able to assign a particular device to a vehicle. At the time of this development, a relatively difficult system requiring knowledge of the desired system’s IP address was required to connect to a machine.

**FUTURE WORK & CONCLUSION**

The extension of VBS3 outside of the window, and indeed outside of the PC, is clearly possible, but there have been, and still are, a number of questions to answer to ensure that this technology provides more effective training.

From a technological standpoint, one of the major areas this work highlighted was the value in being able to prototype and rapidly develop adjunct tools or systems to extend VBS3 outside of the window. An important
component of this was the framework chosen for both the client and the automated transfer interface. Notably, while standards like UDP are available for basic data communication, these may not be sufficient/appropriate for all use-cases. Also, while the Unity platform has a number of strengths, it is not a trivial exercise to use it for developing simulation training applications, in particular when using content created for other applications.

From a training perspective, developing applications that attempt to simply replicate existing functionality in VBS3 on touch-enabled device have limited value aside from the price and portability inherent in handheld devices. Instead, approaching the use of touch-enabled devices from the perspective of complementing, or extending, functionality enables the software to make greater use of the available technology in touch-enabled devices.

Understanding how to extend VBS3 outside of the window has been evolutionary, with prototypes such as those outlined above being developed in order to understand how best to create applications to work with VBS3, in particular those running on touch-enabled devices. This evolutionary process is expected to continue into further areas of research which may be useful to look into in the future, such as:

- streaming video data more efficiently across a LAN
- integrating touch-enabled devices into the scenario administration workflow
- creating other, more complex interfaces with more functionality being handled outside of VBS3
- investigating how this technology is received by trainees and trainers
- understanding the training benefits of extending VBS3 outside of the window onto touch-enabled devices
- measuring the effectiveness of training transfer using touch-enabled technology and hardware emulation.

The last three points are key. To date, this development has been driven from a technology point of view, based on assumptions regarding the requirements of those who will ultimately use the software. While these assumptions were based on a solid foundation of knowledge of military training requirements, further understanding of how users with varying training requirements interact with software on touch-enabled devices, such as those described in this paper, is needed to drive the next phase of development.

REFERENCES

The Benefits of Glass Mirrors on Flight Simulators

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Abstract. Recent technology advances and aircraft training requirements have converged to produce very high Field of View (FOV) visual display systems on flight simulators well in excess of the 220° - 225° horizontal FOV that has been the maximum for the past few years. Advances in glass mirror manufacturing allow for a significant increase in the FOV capabilities of flight simulators. This paper will first address the history and current state-of-the-art for these large FOV displays. This paper then addresses the trends in flight simulator training that has pushed for increasing FOV to meet training requirements that are more affordably and safely accomplished in a flight simulator compared to the actual aircraft. Several recent case studies will be presented supporting this trend.

INTRODUCTION

During the early 1980s, glass mirrors were introduced into flight simulation and competed head-to-head with film-based (Mylar) display systems on cross-cockpit collimated displays. Eventually film-based mirror systems proved more economically viable and have dominated the cross-cockpit collimated display market until recently, when a combination of factors made glass mirrors viable again. These factors include more demanding geometric distortion requirements, customer requests for larger vertical and horizontal fields of view beyond what is practical for film mirrors, and improved glass mirror manufacturing methods resulting in higher quality, lower weight and lower cost glass mirror systems.

The first very large Field of View (FOV) collimated systems were built by Glass Mountain Optics of Austin, Texas, for the 300° x 45° FOV E-2C/D Operational Flight trainers and Aircrew Procedures Trainers beginning in 2008. The trend continued after FlightSafety International purchased Glass Mountain Optics in 2009 with the 290° x 60° FOV HC-144A system on a motion platform, the 300° x 80° FOV UH-1Y system which achieved the large vertical FOV with the addition of auxiliary displays, and this year on the 260° x 80° CH-53K Containerized Flight Training Device.

Although the push for larger FOV systems has come from military programs, the delivery last year of a 240° x 40° FOV system currently supporting the Gulfstream G500/G600 program indicates this trend will continue for civil aircraft trainers.

COMPARISON OF FILM AND GLASS MIRRORS

History of glass mirrors on flight simulators

In the early 1980’s, Singer Link-Miles (UK) introduced the AWARDS glass mirror visual display system, which had 3 overlapping glass mirror segments. The segments were relatively thick and expensive to manufacture. In the late 1980s, as glass mirrors systems lost out to film-based Mylar collimated systems, an attempt was made to develop rigid mirrors using a substrate other than glass, such as acrylic. However, acrylic proved to be too soft and was difficult to grind and polish without re-introducing scratches in the acrylic surface.

In the 1990’s, Pilkington Aerospace attempted to reintroduce glass mirrors on the C-130, F-18 and Blackhawk visual systems, but manufacturing issues resulted in late or non-existent deliveries and Pilkington abandoned glass mirror production.

In 2001, representatives from Pax River Naval Air Warfare Center approached Glass Mountain Optics, a small private company in Austin, Texas, to produce large, rigid acrylic mirrors for the CH-47 Transportable Flight Proficiency Simulator (TFPS). Since the TFPS was housed in a deployable container, the customer wanted the mirrors to be extremely durable under hostile environmental conditions, such as on a deployment to Iraq. After delivery of 7 systems (28 total acrylic mirrors), the customer requested glass mirrors with a protective backing to eliminate shattering, and 14 more systems (56 glass mirrors) were produced. This also resulted in a retrofit to glass of the original 7 systems. This mass production of large glass mirror segments paved the way for improved fabrication techniques that reduced manufacturing time and labor costs while also resulting in better radius and dimensional tolerances.

After Glass Mountain Optics was acquired by FlightSafety International (FSI) in 2009, the next advancement in mirror quality occurred with the manufacturing of multiple 300° x 45° Field of View (FOV) E-2C/D mirror systems, each of which required precise control of mirror radius and edge matching across seven large 10-foot radius glass mirror segments. These improvements were made possible with an advanced mirror holder design that gave precise control over the spherical mirror shape.

However, the CH-47 TFPS and E-2C/D systems were designed to be static systems. Significant design and analysis would be required for glass mirror segments to be capable of mounting to a full motion flight simulator. Several Finite Element Analyses were performed to determine the best weight-to-stiffness ratio design for the mirror holders and fiberglass
structures comprising a 5-segment, 11-foot radius, 220° x 60° glass mirror visual display system (VDS).

By early 2012, FlightSafety was integrating a 220° x 60° VDS for a Sikorsky S-76D full motion simulator destined for the FSI training center in West Palm Beach, Florida. This system received Federal Aviation Administration (FAA) Level C qualification as well as European Aviation Safety Agency (EASA) Level C qualification in 2013. That same year another 220° x 60° glass mirror system on an Agusta-Westland AW-139 simulator at the FSI Training Center in Lafayette, Louisiana achieved an FAA Level D qualification. These systems were the first successful FAA and EASA qualifications of a glass mirror system, and were followed by a 3rd qualification of a Sikorsky S-92i system also in Lafayette, and a 4th system on another Sikorsky S-92i system at the FSI Training center in Stavanger, Norway in late 2013.

Another milestone that took place in 2013 was the successful integration of the world’s largest Field of View collimated system (290° x 60°) on a Moog Electric Motion system for the United Stated Coast Guard (USCG) HC-144A aircraft simulator. This system required seven large glass mirror segments from FlightSafety to cover the required FOV. The integration took place at the AeroSimulation, Inc. facility in Tampa, Florida, followed by the successful installation at the USCG flight training center in Mobile, Alabama in 2014. The development of this system was the topic of a paper presented at the 2013 IMAGE conference in Scottsdale, Arizona [1].

In 2014, the Field of View of cross-cockpit collimated systems was further expanded on the United States Marine Corps UH-1Y Flight Training Devices #2 and #3, which combined a 7-glass mirror segment 300° x 60° FOV collimated display with 2 separate real-image chins and 2 real-image side displays to expand the vertical FOV to 80° in combination with the mirrors. The details of this system were presented at the 2014 IMAGE conference in Dayton, Ohio [2].

A final milestone will take place later in 2015 when a 260° x 80° FOV system is installed in a transportable container, becoming the largest collimated FOV containerized display ever installed. Like the UH-1Y, the large vertical FOV is achieved through the addition of auxiliary displays below the glass mirrors.

**Performance differences between glass and Mylar film collimating mirrors**

**Ability to achieve a true spherical shape**

Polyester film mirror systems (henceforth referred to by the trademarked name “Mylar”) achieve their curvature by using a vacuum to draw the film, which has been attached at the edges, down into the hollow fiberglass mirror cell until the approximate desired radius is achieved. However, tension in the mirror film is much higher vertically than horizontally. Also, horizontal tension in the film is much higher in the center of mirror than along the top and bottom rims. These differences result in vertical linearity distortions throughout the mirror. This phenomena was well documented in a paper presented at the Flight Simulator Engineering and Maintenance Conference in October 2007 by Robert Lussier of FedEx Express [3]. He found that the aspheric shape of the Mylar mirrors in their MD-10 and MD-11 simulators resulted in visual alignment (glideslope) errors in excess of 1° elevation within a central ±10° elevation zone unless compensated for by the projector or image generator. Figure 1 shows the effect of this glideslope error during simulator approaches.

![Figure 1: FedEx study results showing the effect of flying a no glideslope visual approach with the vertical compression problem in the Mylar mirror.](image)

**Localized radii deviations**

The polyester film in a Mylar mirror is not necessarily of uniform thickness throughout the mirror, the aluminized plating is not always of uniform thickness, nor is the film always attached to the edges of the mirror cell in uniform tension. Thinner/thicker film and looser/tighter sections of the mirror will draw down differently under vacuum, resulting in areas of differing radii. These differences will appear as image “swim” to the pilot as portions of the image appear to get larger or smaller while passing through different radii zones. This effect is sometimes seen as acceleration, especially when viewing star fields.

**Edge roll-off**

Around the edge of the Mylar mirror, where the film is attached to its holding mechanism, the radius change is the greatest. Although some attempt can be made to hide this distortion through masking, or to minimize the distortion using push bars, these methods limit the effective vertical field of view (FOV). As vertical FOV approaches 60°, the encroachment of this distorted area into the active FOV is inevitable due to the maximum width of available Mylar film, which is 145”. The distortion due to edge roll-off results in the following image errors:

*Ground rush:* An increase in speed (acceleration) of objects and textures with decreasing elevation. Pilots often complain about this very common distortion as it produces confusing speed and altitude cues during approach and landing. The effect increases with increasing down look angle

*S-Shaped Horizon:* This optical challenge produces an obviously bent (S-shaped) horizon at the top and bottom of the FOV when the aircraft is rolled. The
effect is generally more pronounced on taller VFOV systems

Bent Runway: Bending of the runway at the bottom of the FOV when the aircraft is rolled, and widening or splitting of the runway center line at the very bottom of the FOV. Pilots report this false cue to be troublesome on approach and landing.

Air-to-Air refueling errors: Edge roll-off is most pronounced along the top and bottom edges, and the receiver aircraft in air refueling scenarios requires maximum look-up where these errors are greatest.

The differences in the quality of the image edge between glass mirrors and Mylar film mirrors is shown in Figures 2 and 3 below. These pictures were taken during a side-by-side comparison test using identical projectors, database, Image Generator (IG), and alignment method. The automatic alignment was performed by FlightSafety International’s Display Management System, which uses a camera located at the eye point to align the image by warping the image files in the Vital X IG. The same alignment was performed on each system to ensure that the only variable was mirror type. Both systems had a Field of View of 180°H x 40°V, and both mirrors had a 10° radius. Figures 2 & 3 show the central ~60° of the displayed Field of View.

**Figure 2:** Typical runway scene on a glass mirrors.

**Figure 3:** Same runway scene on a Mylar film mirror.

**Training tasks sensitive to mirror distortions**

In summary, the non-spherical shape, localized radii deviations and edge roll-off of Mylar film mirrors can result in numerous errors during simulator training. These errors can be divided into fixed wing and rotary wing specific errors.

**Fixed wing errors due to mirror distortion**

- Hard landing due to inaccurate cues for flare height and distance
- Glideslope errors
- Circling approach: difficult to judge relative position/distance of runway distortion at end of mirror prior to turn and distortion at top of mirror during turn (aircraft rolled)
- Reduced confidence in HUD symbology when it does not align with the horizon

**Rotary wing errors due to mirror distortion**

- Hard landings: Eye height above ground
- Distorted size/distance of objects near aircraft

**Horizontal field of view**

The horizontal FOV for Mylar film mirrors is limited by the width of polyester film and the metalizers available to coat the film. This film width limit is currently 145°, which constrains the horizontal FOV for Mylar systems to about 220° - 225° FOV without having to “splice” additional Mylar film sections, making those areas unusable. However, horizontal FOV is not limited in glass mirrors. Mirror segments may be added to increase the FOV until other limits are reached, such as cockpit or instructor station interference with the mirrors or Back Projection Screen. 300° Horizontal FOV glass mirror systems are not only possible, they have been delivered on multiple systems in recent years. The increased horizontal FOV has benefitted pilot situational awareness during maneuvers like circling approaches, and has also been used to meet new training tasks such as checking if the landing gear is in place or if the propellers are feathered.

Increasing the horizontal FOV on the Out the Window Collimated Display from 220° (±110°) to 300° (±150°) has the following benefits:

- **Formation:** Keeping track of wingmen flying in a Wedge formation at a 135° azimuth. Tracking wingmen in Cruise mode at 150° azimuth with 10° step up
- **Threat Detection:** Shoulder-launched surface-to-air missiles launched from the rear quarter, and enemy aircraft engaged in an air-to-air attack from behind
- **Surveillance:** The ability to see more “events” such as smoke, muzzle flashes, etc.
- **Greater sense of realism since visuals are more “immersive” and cover the horizontal extents of the cockpit windows**

More peripheral vision cues create better pilot awareness of attitude, altitude and speed without having to refer to instruments (i.e., more like the real aircraft)
Vertical field of view

Both collimating film and glass mirrors are limited by the same vertical Field of View (FOV) constraints. A large vertical FOV causes the Back Projection Screen to intrude into the instantaneous FOV by obscuring the uplook in order to meet the downlook requirement. Vertical FOV is also limited by the ability of the optical layout to meet collimation requirements. The practical limit to vertical FOV is about 60°; 65° if the customer is willing to accept significant Back Projection Screen uplook obscuration or collimation errors.

Fortunately, the vertical FOV can be supplemented through the use of auxiliary displays placed below the main collimating mirror. These can be either real image displays, such as rear-Projected diffusion screens, or collimated using Wide Angle Collimated (“WAC”) windows. It is essential that the gap, if any, between the main display and the auxiliary display(s) be the minimum possible in order to provide a realistic display and avoid losing critical FOV. The size of this gap is highly dependent on whether the main display is a Mylar or glass mirror array.

Adding auxiliary displays to Mylar mirror systems

As mentioned in the Edge Roll-Off section, the significant distortion zone around the edges of the mirror where the film is clipped or taped to the edges of the fiberglass bowl is typically masked with several inches of black felt or felt-like fabric. The combination of the fabric edging and the fiberglass mirror cell edge results in a significant gap between the usable edge of the Mylar mirror and the OTW display and the outer edge of the mirror cell where an auxiliary display would be located. Unless this gap in the visuals can be hidden behind a window stanchion or other cockpit obstruction, it will noticeably detract from the realism of the simulator and may well “hide” critical views during hover and landing tasks.

Adding auxiliary displays to glass mirror systems

Since glass mirrors are free of distortions to the very edge of the mirror, and are relatively thin (~0.5” for FlightSafety glass mirrors not including the mirror holder), flat or curved screen real image displays can be tucked behind the mirror resulting in a gap-free continuous scene from OTW display to chin or side displays. Figure 4 shows three of four real image rear projected diffusion screens located just behind and below the collimating OTW mirrors. This figure also illustrates an advantage of glass mirrors – they can be custom trimmed to follow a cockpit feature or to reveal more of the auxiliary display. In Figure 4, the mirrors above the chin screens have been scalloped to follow the chin window upper stanchion, and the mirror above the side screen has been trimmed at a -40° downlook from the Pilot Eye Point so there will be no blank mirror beyond the -40° limit of the back projection screen. Instead, more of the side screen display will be visible to the pilot.

Benefits from increased vertical FOV >60°

Increasing the vertical FOV by adding chin and side window displays provides training that was not possible in the earlier 60°V FOV trainer, including:

- Better cues for take-off and hover transition
- Precision approaches to confined areas
- Obstacle avoidance during close-in approaches
- Realistic hover cues during landing, especially height above terrain and drift
- Precision spot landings

“Brown Out” landing training

Figure 4: Chin and side displays nested behind glass collimating mirrors.

Currently, real image chin and side window displays use rear projected diffusion screens, usually with the same or similar projectors as the OTW collimated display in order to reduce logistics support issues. This is due to the current LCD, DLP and Plasma screen monitors having issues with latency and motion smearing, and generally having poor Night Vision Goggle response. However, Organic Light Emitting Diode (OLED) TVs solve many of these issues, and as they become larger they may be used as chin and side displays instead of rear-projected screens

CASE STUDIES OF LARGE FOV SYSTEMS

Case #1: US Coast Guard HC-144A with 290° x 60° FOV

The US Coast Guard has a single training center in Mobile, Alabama, and limited numbers of aircraft and
instructors for maintaining pilot proficiency. In 2012 they were looking for a way to transfer critical training tasks from the aircraft to a full-flight simulator. However, many of these training tasks required a simulator beyond the 225° horizontal Field of View (FOV) limit available on standard flight simulators. These tasks included:

- Viewing the runway during extended downwind pattern so that the majority of transition training can be performed in the simulator
- Providing visual feedback to the crew in case of engine fire or smoke
- Viewing the leading edge of the wing for ice formation and visually monitoring the effective operation of the de-icing boots
- Replicating the US Coast Guard maritime operational environment as seen through the entirety of the aircraft windows; including over water navigation, identification, tracking and interception of targets of interest, survivor relocation patterns, pre- and post-aerial delivery checks, search and rescue, etc.

Observing the nacelle/spinner assembly to determine if the propeller is feathered completely or windmilling, as this directly affects drag and the subsequent checklist to follow. This training task cannot be safely performed in the aircraft

Since the center of the HC-144A spinner is situated at +/-138.3° azimuth outboard from the forward aircraft viewing direction, a horizontal field of view of ±145° was deemed necessary to include the critical portions of the nacelle and propeller assembles. Similarly, a vertical field of view of +20°/-40° was required to replicate the view through the aircraft windows in order to visually support over water operations and work in an extended downwind pattern. Consequently, an unprecedented 290° horizontal by 60° vertical field of view collimated display was designed for the HC-144A Operational Flight Trainer to closely match the out the window view in the actual aircraft and to more effectively meet the Coast Guard’s training needs.

**Figure 6:** HC-144 propeller viewed from cockpit.

The HC-144A successful delivery was achieved by a team consisting of FlightSafety International for the visual display (mirrors, back projection screen, projectors, turret, and fiberglass light tightening), Industrial Smoke and Mirrors for the motion platform, cockpit and instructor operating station, an Image Generator from Aechelon Technology, Inc., all coordinated by the prime contractor, AeroSimulation, Inc.

**Figure 7:** HC-144A full motion 290° x 60° FOV flight simulator.

**Case #2: US Marine Corps UH-1Y with 300° x 60° FOV with auxiliary displays**

**Expanded FOV requirements**

In 2011 FlightSafety International concluded a study sponsored by Bell Helicopter to determine the optimum Field of View for the UH-1Y helicopter flight trainers. The then-current cross-collimated visual display was a typical 220°H x 60° Mylar mirror system without any supplemental chin or side window displays. This limited FOV was deemed to be unacceptable for adequate training in such tasks as hover, taxi, take-off and landing, as well as maintaining visual contact with threats or wingmen. The FOV from the UH-1Y Left Pilot Eye Point (PEP) through the cockpit windows as covered by a 220° x 60° collimated display mirror is shown in Figure 8 below. Figure 9 shows the portions of the cockpit windows not covered by the 220”x60° mirror as viewed the left PEP.

**Figure 8:** Field of View plot for the UH-1Y from the left Pilot Eye Point with 220° x 60° display.
Figure 9: Portions of cockpit windows not covered by the 220° x 60° display from the left PEP.

Figure 10: Field of View Plot for the UH-1Y from the Left PEP with 300° x 60° OTW and auxiliary displays.

As a result of the UH-1Y mirror study, new requirements were added for an Out the Window (OTW) collimated display covering 300° Horizontal x 60° (+20°/-40°) Vertical FOV with additional real image chin windows covering down to -54° downlook, and a real image side displays covering down to -64° downlook, both with minimal gaps between OTW and real image displays. Figure 10 shows the expanded horizontal FOV possible by adding mirrors to the collimated OTW display, and supplementing the vertical FOV with the addition of real image chin and side screen displays.

Manufacturing challenges of very large FOV visual displays

Designing and building the very large FOV display required by the program had its own challenges, including engineering a single piece Back Projection Screen (BPS) to cover the full FOV, manufacturing a matched array of glass mirrors, designing a projector turret that locates the array of projectors across the top of the BPS, and fitting the cockpit and Instructor Operating Station within the wedge-shaped gap left between the ends of the mirrors and/or BPS.

Until recently, flight simulation companies’ Field of View choices have been limited by the BPS vendor’s method of forming screens and their available tooling. FlightSafety had to develop proprietary tooling with its screen vendor that allows the manufacture of screens in excess of 300°, as well as any smaller FOV screens. Figure 11 shows the 300° x 60° FOV screen made for the UH-1Y program.

Figure 11: UH-1Y 300° x 60° BP Screen.

It is also interesting to note that in addition to the very large FOV of the BP screen, FlightSafety was able to incorporate its new high contrast screen technology that exceeded the customer contrast requirement of 10:1, and in fact measured in excess of 13:1 contrast.

The UH-1Y required 7 large glass mirror segments to achieve a 300° x 60° FOV. FSI had experience manufacturing and matching mirror arrays of this size. The 300° x 45°, 7-mirror array E-2C/D system pictured in Figure 12 had been in production since 2009, and the 7-mirror array HC-144A had already been installed on a motion system.

Figure 12: 300º Glass mirror display.

The turret design required to position the projectors in a full array capable of filling the 300° FOV, and to hold the BP Screen, had to be unique. The customer chose to use Rockwell Collins LCOS projectors due to their known capabilities and to maintain consistency with other simulators of this aircraft type. Seven projectors are arranged in portrait orientation on a faceted turret design as shown in Figure 13. The structure is composed of honeycomb panels with custom skin thicknesses tailored to meet stiffness requirements with the least weight possible. It also incorporates fixed OSHA compliant safety handrails and power/video quick disconnect panels.

Figure 13: UH-1Y projector turret.
Case #3: Gulfstream IFS 240° x 40° collimated display

Expanded FOV requirements

For the Gulfstream IFS (Immersive Flight Simulation) lab, the customer needed a visual display that would cover a significant portion of the cockpit windows. As mentioned earlier in the horizontal FOV section, Mylar film systems are limited to 220° – 225° FOV due to polyester film width limits. And, as shown in Figure 14 below, the side window would only be half filled with a 180° FOV display, and two-thirds filled with a 215° FOV display. With a 240° FOV display, over 80% of the side window is covered, as well as 100% of the other cockpit windows. This creates a more immersive experience for the pilots.

Figure 14: G650 cockpit window coverage.

In determining the appropriate horizontal FOV for their lab, Gulfstream engineers performed a series of orientation experiments using an experienced test pilot as the subject. Under four different FOV conditions – 180°, 200°, 215°, and 225 as simulated by multiple monitors – engineers would input various external tilt, roll and pitch commands to determine when the pilot first identified the external input. The tests proved that the larger the FOV, the faster the test pilot identified the external input. They then reasoned that a FOV beyond 225° would result in even faster detection since these cues are likely affected by the pilot’s peripheral vision, and a large FOV that covers a significant percentage of the cockpit windows is closer to matching the immersive feel of the aircraft.

CONTAINERIZING VISUAL DISPLAYS

Types and benefits of Containerized Flight Training Devices (CFTD’s)

In recent years, containers (sometimes called enclosures) have become widespread as a way to house flight simulators. Benefits of containerized flight simulators include:

- Forward deployment to troops in the field for mission rehearsal
- Allocation of training devices to locations with the highest need
- Relatively small footprint on site
- Can be moved in the event of base closure

Provide similar capabilities of full flight simulators with less initial cost, less regulatory requirements and faster deployment.

There are several drawbacks of containerized systems. These include limiting the system to a static (non-motion) display, and the restricted space for a large Field of View (FOV) visual display. As a result, many containerized visual displays have real image displays, such as direct view monitors or screens, rather than collimated displays. However, collimated displays have some distinct advantages over real image displays.

Importance of collimated displays

Visual displays are broken in to two broad categories: real image displays where the scene is displayed using monitors or screens, and collimated displays. In collimated displays, an optical component, typically a mirror, bends the rays of diverging light coming off of a real image display in order to make them parallel (or nearly so) and therefore make the displayed image seem to be a great distance. Collimated displays are required:

- When single pilots need proper parallax/perspective with head movement
- When dual cockpit crewmembers need similar parallax/perspective (crew coordination)

Required by FAA or other regulatory agencies for added realism to flight simulation

Hardware requires collimation – Helmet Mounted Display, Heads Up Display, Night Vision Goggles

Therefore, a confluence of factors has fostered the growth of large collimated FOV visual displays in containers: the increase in training value from large FOV simulators, the relative ease of deploying containerized displays as opposed to conventional buildings, and the benefits of collimated over real image displays.

A brief history of cross-cockpit collimated, containerized visual displays

As mentioned early in the paper, since 2001 Glass Mountain Optics, Inc., and then FlightSafety International, Inc., has delivered 21 CH-47 Transportable Flight Proficiency Simulators (TFPS), with #22 due for delivery later this year. These displays consist of a 180° x 50° “out the window” collimated display created by glass mirrors and supplemented by two real image rear-projected displays for the two cockpit chin windows. This arrangement allows for pilots to use their own Night Vision Goggles (NVGs) in the simulator cockpit during training missions when viewing the collimated main display. But during low hover and landing the pilots have to look under the goggles to view ground images in the real image chin displays since the screen is closer than the NVGs can focus, just as in the real aircraft when viewing the ground through the aircraft chin windows.
Figure 15 below shows one of the main challenges when installing large FOV collimated optics into a transportable container – namely that all large components must be fitted into each half of the container prior to the two container halves being joined together. This must happen before the roof is raised to the final deployed, or “complexed”, height. The figure below was created by merging two pictures and shows that the 180° FOVs fit assembled in one container side, with the back projection screen nested inside the mirrors and the real image chin displays (not shown) mounted under the mirrors.

In 2010, Manned Flight Simulator group of NAVIAIR in Pax River, Maryland awarded the CH-53E Containerized Flight Training Device to FlightSafety International, Inc. This was a 220° x 60° collimated display consisting of 5 glass mirror segments, supplemented with both chin and side auxiliary real-image displays. Fitting this larger mirror array into one side of a container was challenging. Fortunately, the container manufacturer, Oshkosh Specialty Vehicles, supplied the largest container that could be manufactured and transported. Even so, the far left and right mirror segments of the mirror array were within 2 inches of the “split line,” or open side of one half of the container. Had the collimated display been a Mylar film mirror stretched on a fiberglass mirror cell, the usable FOV would have been at least 10° less due to the need to cover the distorted edges and sides of the Mylar mirror with fabric.

In late 2013, FlightSafety was awarded the contract for the US Marine Corps CH-53K Containerized Flight Training Device. The visual display will include a 7 glass mirror 260° x 60° collimated main display with auxiliary chin and side real image displays to extend the vertical FOV to 80° in combination with the main display. When assembled, the main mirror array will cross the “split line” between the two sides of the container as shown in Figure 16, and so cannot be assembled prior to complexing the two halves of the container together. Therefore the mirror segments will remain separate and positioned on one side of the container during complexing, and later assembled into the full mirror array after the container has been complexed. This highlights another advantage of a segmented glass mirror over a monolithic fiberglass Mylar mirror bowl, which is necessarily limited to the width of one half of a container.

Containerized systems with large FOV displays are an extension of the trend in the rest of the simulation market, but have the added advantages of reduced cost and schedule compared to housing the simulator in a fixed building. Collimated visual displays have historically been difficult to package in a container, but glass mirrors’ segmented design offers advantages over Mylar film mirrors on large FOV containerized systems.

CONCLUSION

The field of view of flight simulators is ever increasing in order to meet the needs of trainers trying to transfer training tasks from the aircraft to the simulator. Significant horizontal FOV improvement cannot be done with Mylar film mirror since they are restricted to 225° maximum due to the limited stock width of polyester film and the width of coating metalizers. However glass mirror systems can and have expanded fields of view well beyond the Mylar film limit. Likewise vertical fields of view beyond the standard 60° allow for better cues during low altitude helicopter operations, and these can be achieved using real image or collimated auxiliary displays. By using glass mirrors for the main displays, the gap between the main display and the auxiliary display can be reduced or eliminated, while main displays with Mylar mirrors will have a significant disparity between displays where the fabric used to hide Mylar mirror distortions creates a noticeable gap between displays. Glass mirrors also have several performance advantages over Mylar mirrors, including a true spherical shape without localized radius deviations or edge roll-off.

Finally, the trend for increased FOV collimated displays and the advantages of containerized display systems will result in more requirements for large FOV containerized systems, where the challenges of fitting such a display in a limited space can be met more easily with a segmented glass mirror system than with a single Mylar film mirror.
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Education and Workplace Training - Performance, Evaluation and Future Demands

Preparation for the Cognitive Demands of the Future – Simulation Is the Key

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Abstract. The nature of war is enduring, however the character of conflicts evolves in response to changes in the operating environment, such as increasing connectivity facilitated through advances in information and communication technologies. The Australian Army recognises the importance of cognitively preparing its personnel to outsmart a lethal, agile, adaptable and well connected adversary, to cope with the inherent uncertainty and surprise of fighting such adversaries often in large high density urban environments. But how can Army better prepare its forces to cope with the cognitive demands of the future? In this paper, some of the cognitive implications of the future operating environment are explored. It is argued that emerging computer-based simulation technologies will be central to improving our understanding of the cognitive demands of future warfare. This will be achieved by increasing the richness, realism and immersion of simulated military scenarios in ways that align with Army’s view of the future operating environment. DSTO, in partnership with industry and academia, has embarked on a multi-year program of simulation-based research that also involves the development of a simulation environment better suited to the evolving character of conflict. A large urban virtual battlespace is being developed that will create substantial cognitive demands for military participants in our research. Whilst this simulator is intended for research, it may have utility for Army’s requirements in cognitively preparing its personnel for future operations. We therefore invite discussions with simulation developers and researchers with a shared interest in developing simulation technologies closely aligned with these cognitive capability building requirements.

INTRODUCTION

The Future Land Warfare Report (FLWR) 2014, prepared by Army Headquarters, articulates the nature of the operating environment now and into the future [1]. The future land operating environment is expected to be crowded, connected, collective, lethal and constrained. Operations will predominantly occur in highly populated urban settings. Our forces, adversaries and other actors in the battlespace will be highly connected through advances in information and communication technologies (ICT). Addressing threats will entail cooperation with a variety of parties including coalition partners, as well as non-military organisations as part of interagency operations. The effectiveness of weapons will increase, as will the capacity of adversaries to develop improvised weapons via dual use technologies. Such developments will unfold in the context of domestic economic and demographic factors placing constraints on acquisition of new equipment and recruitment and retention of personnel.

Operations in urban environments already place substantial physical and cognitive demands on warfighters. They can be violent, unpredictable and difficult to control [1]. However, developments in ICT and associated societal changes are creating additional opportunities and challenges for friends and foe. In the military domain, a huge shift is underway as Armies move away from analog communications toward digital. Exploiting the capabilities of ICT whilst also mitigating against risks and issues will place substantial cognitive demands on operators. These demands are multi-faceted and characterised by both enhancements and decrements in a range of cognitive functions such as attention, memory, self-regulation, situation awareness, and decision making, which in turn are shaped by fatigue, arousal, training, tactics, teamwork, technology and organisational context.

One area of particular import is the effect of ICT on situational awareness (SA). SA is enhanced through Global Positioning System (GPS) enabled devices and functionality, such as automated position reporting of vehicles. However, SA is also potentially degraded by over-reliance on technology to support position-dependent tasks such as navigation, or through denial or masking of such technology. Warfighter capacity to appropriately exploit current and emerging technologies will be enhanced and degraded due to trust. Persistent use of technology is critically dependent on maintenance of an appropriate level of trust. Trust is enhanced when the behaviour and performance of a system is sufficiently predictable and useful. Trust is degraded when behaviour and performance are error prone or erratic [3], [4]. But how will an appropriate level of trust in ICT be maintained in technologically degraded and contested environments?

ICT offers up tools designed to support deliberate planning and plan execution. Such tools can enhance decision making through capturing key decision inputs as well as incorporating the inputs of key actors. Such tools may also degrade decision making through not supporting the types of necessarily quick decisions made in higher tempo operations, decisions characterised by choosing a course of action underpinned by pattern matching. How can personnel be trained to use ICT-based planning and execution tools in ways that are sensitive to operating context?

We rely on heuristics and biases to reduce the cognitive demands placed on us by the complex socio-
technical environments within which we are embedded. Some of these rules of thumb and short-cuts may enhance performance in future urban operations, such as heuristics for judging when information provided by a system can be trusted, whilst still others will expose warfighters to critical vulnerabilities, such as confirmation bias [2] – a tendency toward ignoring any new information that doesn’t accord with one’s preconceptions. How can we support personnel in recognizing when such heuristics and biases are adaptive and when they are maladaptive?

Warfighter choice may be enhanced and degraded by the organisational context and decision-making culture. Increased choice and freedom of movement may be supported by limited oversight and direction from higher Command, but may be constrained by higher Command seeking improved SA and oversight generated through advances in ICT and intelligence, surveillance and reconnaissance (ISR) assets. How can we prepare our forces to operate with sufficient autonomy but also to respond appropriately to strategic oversight by higher command?

There is a recognition of the need to develop personnel to have the cognitive edge [5]; to outsmart a lethal, agile, adaptable and well connected adversary, to cope with the inherent uncertainty and surprise of fighting such adversaries often in large high density urban environments. Army also needs to be organisationally positioned and supported to develop mindfulness, to learn and adjust through constructive reflection on near misses and failures without fear of sanction [6]. Personnel need to be technologically supported to deliver required effects in the battlespace, such as through digitisation of the land force. But how can Army better prepare its forces to cope with the cognitive demands of the future?

DELRIVING THE COGNITIVE EDGE

One of the key avenues of achieving the questions posed above is through training and education. Training and education sit at the nexus of people, organisation and technology. It is through T&E that Army develops and sustains its military capabilities, and it is through T&E that it will imbue its personnel with the required cognitive capacities. Computer-based simulation already plays a substantial role in assisting personnel to acquire the required skills, knowledge and attitudes (SKAs), and are likely to increase in prevalence. However, are current solutions sufficient to support development of the cognitive edge?

Computer-based simulation is used extensively to support a range of training needs in Army. Part-task trainers often support acquisition of cognitive skills that underpin use of particular sub-systems. The acquisition of such procedural skills, whilst important, does not support attainment of higher-order cognitive skills as use of the system is largely confined to simple instantiations of warfighting scenarios designed to readily demonstrate levels of competence in using the particular sub-system.

Mission-system trainers such as those provided for helicopter or tank training combine a high degree of physical fidelity (via realistic cabins and simulated motion) with representations of various military scenarios to support use of all of the various platform sub-systems to accomplish a mission. However, the scenarios are quite austere and the cognitive fidelity is further constrained due to having a limited number of real players in the scenarios.

The above constraints are in part addressed through use of virtual battlespaces within which tactical training can be conducted by a number of personnel training together as a small unit. Current virtual battlespaces provide a “sand-pit” within which teams can prosecute missions. They also provide a range of representations of various technologies, actors and environments to generate increased richness, realism and immersion. Such virtual battlespaces however do not adequately represent many of the conditions outlined in the FLWR. Whilst the lethality of various weapons is able to be reasonably well represented in such virtual environments, the current capacity to represent the crowded, connected, collective and constrained aspects of the future operating environment is limited, as is the capacity to readily represent exploitation of dual use technologies as improvised weapons.

The world is now more urban than rural. The increasingly crowded nature of future areas of operations requires the creation of large urban simulation environments that also include large numbers of intelligent agents travelling on foot, in cars and trucks and to a lesser extent in the air, and engaging in behaviours that approximate those of adversaries and non-combatants. Such environments can make it hard for warfighters to identify enemies, to filter out all of the background clutter. Current virtual battlespaces simply cannot support the creation of large high density urban environments, nor have artificial intelligence (AI) that is sufficiently realistic.

Being constantly connected is now a taken for granted feature of modern society. Advances in ICT are also facilitating increased economic and social linkages. However, competition will also continue in the cyber, electromagnetic and space domains due to inherent constraints, as well as through the actions of adversaries. Such competition will lead to land force operations that are “increasingly enabled (or disabled) by access to digital networks” (p. 11). The ability to represent the differential performance of digital networks in contested environments is also limited in current simulation technologies.

Joint land warfare entails combining together various land, air and sea based assets to deliver effects in the land battlespace, often with military and non-military partners. Such collective action is and will increasingly become a feature of operations. The need to coordinate efforts with other military forces, as well as non-military organisations will similar goals of responding to threats to the prevailing order, will require carefully integrated planning as well as an appreciation of the goals and methods of other organisations. Simulation is
already used extensively to support better integrated planning within and between the services, and between partner nations, and is underpinned by simulation standards that facilitate interoperability between different simulation environments, such as Distributed Interactive Simulation (DIS). Whilst DIS compliance is now widespread, full compliance cannot be assumed. Such joint land warfare also calls for simulations that represent the effects of various military capabilities provided by Air Force and Navy so as to appropriately prepare tactical level Army personnel for Joint land warfare. The capacity to emulate and simulate the performance of such systems is currently somewhat limited in current generation virtual battlespaces.

Budgetary pressures are constraining spending on Defence. In turn Defence is competing in a highly competitive labour market, and in a social context where society demands increasing accountability of its Defence forces and the employment of those forces in ways that are deemed acceptable. This constrained environment will demand more efficient utilisation of resources within Defence, including the time and cost associated with training and maintaining the capabilities of our forces. Simulation technology already generates substantial efficiency dividends for Defence, however, there remains much untapped potential, particularly in generating training solutions that maximise the learning value for personnel in the shortest amount of time, across a broad range of potential operational scenarios and with clear evidence of training value, as well as delivering such training in a way that motivates and engages personnel. Current virtual environments are slipping behind developments in the gaming industry, with potential consequences for trainee buy-in. The upshot of these limitations is that important features of the future operating environment simply cannot be represented in current generation virtual battlespaces, nor can these battlespaces create sufficient cognitive demands to support attainment of the cognitive edge.

Whilst it is argued that delivering the cognitive edge will require exploitation of advances in simulation technologies. It will also require the application of cognitive science focused on biases and heuristics, and rapid decision-making in real world settings. Klein’s [7, 8] work on naturalistic decision making is considered particularly relevant as is the work of Kahneman [2]. Such theories and models, extended through the research being undertaken in DSTO, not only enhance our understanding of cognition, but also support the identification of appropriate interventions for improving cognitive capabilities [9]. Investigating cognition will continue to rely on observational and performance data, pre and post cognitive assessment tools and cognitive task analyses. However, developments in dynamic biopsychological monitoring tools such as eye movement, heart rate and EEG can serve as reasonable surrogates of some cognitive phenomena, as well as providing insights about moderators of cognitive capacities, such as fatigue.

Improved capture and analysis of participant behaviours, as well as cognitive performance measures embedded within simulation scenarios are also improving our capacity to understand the dynamics of cognition in indicative future operating environments. Such developments in the methods and tools for investigating cognition in naturalistic settings also offer up opportunities for training programs customised for individual learners, through adapting the level of challenge presented to trainees based on dynamically assessing their behaviour, performance and relevant biopsychological indicators.

OPPORTUNITIES AND CHALLENGES FOR THE SIMULATION COMMUNITY

Preparing Army personnel for the cognitive challenges of the future is becoming a critical issue for Army. This presents many opportunities and challenges for the simulation community. It calls for simulation technologies, and associated training approaches, that can better support representations of cognitively demanding missions and scenarios that support the assessment and acquisition of cognitive skills suited to operating effectively in the future operating environment.

Land Division of DSTO is focussed on using simulation technologies to support the research and development objectives of the land force, with a particular focus on understanding the cognitive demands associated with the future operating environment described in the FLWR (2014). As a result, we have decided to explore alternative virtual environments to current in-service offerings, since the latter do not support key functional requirements associated with a crowded, connected, lethal and constrained future operating environment.

DSTO is partnering with industry to identify and develop best of breed simulation components that can be readily integrated, added to, upgraded and swapped. Such components will therefore be compliant with open standards, such as DIS. Such an open architecture approach will also mitigate against vendor lock-in and associated constraints on rapidly evolving the simulation environment to incorporate emerging simulation technologies. Low cost virtual reality and augmented reality are currently under consideration.

The core virtual environment will draw on a best of breed game creation system, Unity (http://unity3d.com). This will provide an enhanced game engine, as well as more user friendly game development tools, as well as improved capacity to integrate third party game development tools such as city builders.

Selecting a game engine that provides improved terrain resolution, which underpins improved trainee buy-in, through improved visual representations and more realistic vehicle physics and motion simulation.

Accessing online repositories of various military and non-military artefacts and modifying them, rather than building them from scratch.
The ability to represent the performance of key emerging technologies, not just kinetic weapon effects, but also ICT, ISR assets and vehicle behaviours.

The ability to readily integrate third party AI that provides: enhanced patterns of life, such as cars, people, and animals; and improved performance of military entities such as dismounted and mounted forces, adversaries.

The capacity to increase the number of neutral actors in the environment, who also respond appropriately to conflict situations, such that the ability to detect personnel of interest is more consistent with real world operations.

The facility to have a small number of simulation controllers directing a much larger number of agents in the battlespace and for the collections of agents to approximately tactically realistic behaviour.

The ability to incorporate emerging simulation technologies with minimal development cost such as virtual reality and augmented reality.

The ability to emulate key characteristics of digital networks in contested and degraded environments.

The ability to generate novelty and surprise, including representations of dual-use technologies such as remotely operated or (semi-)autonomous ground and air vehicles.

The ability to dynamically monitor and review psychobiology, behaviour and performance and to use the data to provide enhanced feedback to operators of their cognitive responses to challenging future scenarios and more timely and targeted feedback to enhance cognitive capacities. Such feedback would be provided alongside of widely available playback functionality used in support of After Action Reviews.

DSTO, in partnership with industry and academia, has embarked on a multi-year program of simulation-based research that also involves the ongoing development of a simulation environment with the elements described above. By the end of 2015 we will have created a virtual battlespace that moves us towards simulating an operating environment that represents the various features that will create substantial cognitive demands for our warfighters. Whilst this simulator will likely support DSTO research in 2016 and beyond, it is clear that Army will also need to draw on advances in simulation technology if it is to effectively represent salient features of the future operating environment. The simulation needs outlined in this paper can therefore be seen to potentially overlap with those of Army.

CONCLUSION

Simulation is already central to much of the training in Army. In parallel with the increasing prevalence of simulation in Army there is a growing focus on developing the cognitive capacities that underpin the “cognitive edge”. Additional developments in simulation technology are needed to support the acquisition and sustainment of the required cognitive capacities. DSTO, working with industry, is actively pursuing such developments drawing on best-of-breed component technologies. However, the development requirements are considerable. We therefore welcome collaboration, particularly in areas such as AI.

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Improving Air Force Operator Performance Through Synthetic Mission Rehearsal

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Abstract. To become fully combat mission ready, Air Force operators must develop the knowledge and skills required to act effectively as members of a coordinated force. Large-scale exercises such as Pitch Black in Australia and Red Flag in the United States provide learning experiences that can build these knowledge and skills. However, these exercises are expensive, infrequent, and subject to constraints related to safety, environmental, and regulatory factors. For these reasons, the tools and methods of synthetic collective training (i.e., networked simulators and associated support systems) are of great interest to the Royal Australian Air Force (RAAF). Since 2008, the Defence Science and Technology Organisation (DSTO) has partnered with RAAF as well as industry and research collaborators to conduct a series of four training research exercises called Exercise Black Skies (EBS). The overarching objective of these exercises was to provide an empirical basis for decisions about investments in future RAAF synthetic collective training activities and capabilities. Outcomes relating to the training impact of all four Black Skies exercises are presented for the first time together in this paper in terms of: (1) changes in participant behaviour over the course of the synthetic exercise, and (2) transfer of training benefits to subsequent live-flying missions. The outcomes show that the systems and methods used during Black Skies can lead to performance improvements and that these can transfer to live missions. However, opportunities to extract even greater benefits have been identified. While Black Skies has provided a solid foundation for development, addressing the identified shortcomings will enable RAAF to take the next steps in developing an effective and efficient training system that delivers an integrated, networked force.

1. INTRODUCTION
The ability of military operators to act effectively as members of a coordinated fighting force is an important determinant of success in operations. It is for this reason that collective training is regarded by the Australian Defence Force (ADF) as a fundamental input to defence capability (Department of Defence, 2012). According to ADF doctrine, collective training entails the simultaneous and sequential performance of related individual tasks to produce group outcomes under realistic operational conditions (Australian Defence Force, 2011). In the air domain, significant resources must be invested to provide realistic collective training using live assets. Exercises such as Pitch Black in Australia and Red Flag in the United States - which involve large numbers of personnel, airborne, and ground-based assets - can provide extremely valuable learning experiences. However, these exercises also have their shortcomings; for example they are expensive, they occur relatively infrequently, and they are constrained by factors such as environmental and safety considerations. For these reasons, the potential of networked simulators and associated support systems (e.g., performance assessment and mission replay tools) to provide collective training is of great interest to many air forces.

1.1 Evaluating Training Effectiveness
The Defence Science and Technology Organisation (DSTO) has recently supported the Royal Australian Air Force’s (RAAF) endeavours to leverage synthetic collective training (SCT) by hosting the Australian node of Exercise Coalition Virtual Flag. Over the next 5 years, DSTO will be assisting RAAF to define requirements for SCT capabilities of its own. These activities represent the continuation of almost a decade of research and development conducted by DSTO and its research partners in support of RAAF (e.g., Best & Burchat, 2006; Best, Jia, & Simpkin, 2013; Best, et al., 2009; Crane, et al., 2006; Stephens, Crone, Temby, Best, & Simpkin, 2011; Stott, Best, & Shanahan, 2011). An important component of this program of research has been the “Black Skies” series of exercises. Since 2008, Black Skies has provided synthetic work-up for RAAF operators prior to the live exercise “Pitch Black”. It has also served as a valuable research environment in which DSTO has evaluated the effectiveness and efficiency of various synthetic training tools and methods and trialed improvements aimed at enhancing training impact and affordability.

This process of iterative training effectiveness evaluation and improvement is central to the ADF Training Model (Australian Defence Force, 2006) and is critical to ensure that the greatest possible returns – in terms of human performance – are obtained from investments in training technologies.

The ADF Training Model (Australian Defence Force, 2006) highlights the importance of continuous improvement through iterative training analysis, development, execution, and evaluation for delivering effective and affordable training. In this model, training evaluation is used to identify gaps and shortcomings in the training outcomes provided by
existing training tools and methods and thereby to ensure that investments in new or refined training technologies or events are well targeted. There are numerous models available to guide approaches to training effectiveness evaluation (e.g., Bates, Cannonier, & Holton, 2013; Kirkpatrick, 1994; Kraiger, 2002). While these models differ in their complexity and scope, they typically include reference to (1) changes in knowledge, skills, and/or attitudes as a result of training, and (2) transfer of training to on-the-job performance, as important considerations for understanding training impact. These two factors were evaluated throughout the Black Skies series of exercises as a means of providing feedback to participants and of enabling evidence-based decision making about investments in synthetic collective training activities and capabilities. Two specific research questions relating to these factors were addressed:

- Did changes in learner behaviour occur during Black Skies?
- Did the training benefits of Black Skies transfer to the live environment?

The methods used to evaluate performance change during Black Skies and the transfer of benefits gained as a result of participation in the exercise to on-the-job performance are described in the Methods section below.

2. THE BLACK SKIES / PITCH BLACK EXERCISE SERIES

Black Skies was designed to serve as both a training research activity and a synthetic mission rehearsal for the live exercise Pitch Black. Pitch Black is held in August every two years and is conducted in the airspace of Australia’s Northern Territory with aircraft and personnel based out of Darwin and Tindal. It provides an unclassified integration training environment for international forces to develop combined tactics, techniques and procedures during large force employment of Defensive Counter Air, Offensive Counter Air and Offensive Air Support missions. Black Skies has been conducted prior to Pitch Black four times thus far; in 2008, 2010, 2012, and 2014. While personnel from a wide range of specialisations typically take part in Pitch Black, Black Skies has primarily been targeted at providing mission rehearsal for RAAF tactical command and control teams. Fast-jet pilots and Joint Terminal Attack Controllers (JTACs) also took part in Black Skies 2010.

2.1 Participants

Significant contributions have been made to the planning, execution, and analysis of Black Skies by large numbers of ADF personnel, DSTO staff, defence industry members, and international research partners. Specific details of these contributions are provided below.

2.1.1. Training Audience

The training audience for Black Skies has included a total of 8 teams, comprising 35 individuals, over 4 exercises. Individuals were drawn from operational communities of RAAF Air Combat Officers specialising in Air Battle Management, Air Surveillance Operators, and Fast-Jet Pilots, as well as Royal Australian Navy Fighter Controllers and Australian Army JTACs. Over the course of the exercise series, these individuals have comprised six Air Battle Management teams (a total of 31 individuals), and two Close Air Support teams (4 individuals).

RAAF Air Battle Management teams from both the ground and airborne environments have taken part in Black Skies. Ground-based Air Battle Management teams – operationally referred to as Air Defence Ground Environment (ADGE) weapons teams – have been drawn from Surveillance and Response Group’s 41 Wing. ADGE weapons teams generally consist of an Air Battle Director, a Tactical Director, two Weapons Directors and two Picture Managers. One ADGE weapons team has participated in every Black Skies event since 2008. Airborne Air Battle Management teams – operationally referred to as E-7A “Wedge tail” mission crews – were drawn from 42 Wing within Surveillance and Response Group. An E-7A mission crew typically consists of a Mission Commander, a Senior Surveillance and Control Officer, two or three Surveillance and Control Officers, a Systems Officer and an Electronic Sensor Management Operator. One E-7A mission crew participated in Black Skies 2012 and 2014.

To explore the feasibility of providing complex, challenging and valuable close air support training, two Pilot-JTAC pairs participated in Black Skies 2010 (Stephens, Crone, Temby, Best, & Simpkin, 2011). Fast-jet pilots and JTACs were paired according to experience levels (i.e. the senior JTAC was paired with the senior pilot and similarly with the junior JTAC and pilot) and remained as teams for the duration of the exercise. The JTAC participants were drawn from 82 Wing within RAAF’s Air Combat Group and from Army’s Special Operations Command. The fast-jet pilots were drawn from Air Combat Group’s 81 Wing.

1 While the ADF Training Model explicitly cites Kirkpatrick’s popular “Four Level” evaluation model, the approach embodied in that model has been the subject of criticism by other authors (Holton, 1996).
2 During even-numbered years.
3 11 foreign nations participated in Pitch Black 2014.
4 For a detailed description on RAAF command and control, see AAP 1001.1 (Royal Australian Air Force, 2009).
6 Picture Managers were introduced into the ADGE weapons team for the first time during Black Skies 2012.
7 Systems Officers and Electronic Sensor Management Operators were utilised in Black Skies for the first time in 2014.
2.1.2. White Force

The Black Skies White Force team has consisted of personnel involved in planning, coordinating and executing training scenarios, conducting performance evaluations, overseeing research activities, and developing and managing simulation and support systems.

The White Force team is an essential asset in the coordination and execution of any complex training exercise. Lessons learned from previous exercises in the Black Skies series as well as findings from international research partners suggest that quality of training is, to a great extent, dependent on the knowledge and credibility of the white force (McIntyre & Smith, 2013). As such, military or ex-serving military members who are experts in air combat tactics, training scenario design and management, and exercise control must be part of the White Force team (McIntyre, Smith, & Goode, 2013).

Throughout the Black Skies series, Milskil Integrated Operations Solutions (Green Hills, NSW) have been contracted to fulfill the roles of exercise planning, coordination and execution (also referred to as exercise control; henceforth referred to as EXCON). All Milskil EXCON personnel are ex-serving military members and are subject-matter experts in their respective fields with extensive operational experience. The Milskil EXCON team for Black Skies typically consisted of one or two Exercise Directors, a Blue Force (friendly) Mission Commander and a Red Force (opposing) Mission Commander. The Blue and Red Force Mission Commanders each supervised a team of Simulator Pilots that consisted of trained personnel from the RAAF Surveillance and Control Training Unit and School of Air Warfare. Blue force typically consisted of 8 to 10 simulator pilots, while red force consisted of three or four.

In order to evaluate participant performance change during Black Skies and on-the-job performance during the subsequent live Pitch Black exercises, performance assessment was conducted by RAAF expert assessors, all of whom were senior operators with significant experience in training and assessment.

The DSTO science and technology team for the Black Skies series has, for each event, consisted of around 20 staff members from the Air Operations Simulation Centre and Human Factors group, within Aerospace Division. International research partners from the United States Air Force Research Laboratory and from the New Zealand Defence Technology Agency have also taken part in research during the Black Skies series.

As it can be seen, the White Force team has contributed a substantial footprint to the successful conduct of Black Skies. Over the series, an indicative ratio of approximately 5 white force training staff per member of the training audience has been required. For an organisation such as the RAAF, this presents a significant issue when planning for the future sustainment of such capability.

2.2 Simulation Systems

The simulation infrastructure for the Black Skies series was located within the Air Operations Simulation Centre (AOSC) at DSTO Melbourne. The AOSC is a rapidly reconfigurable simulation facility that can be adjusted to meet a range of research requirements. The core systems used during Black Skies included an ADGE Regional Operations Centre simulator; blue force and red force simulator pilot role player stations; an exercise control room; a briefing and after-action review area; and a visitor area from which to observe the exercise. Additionally, a JTAC partial-dome simulator and an F/A-18A “Hornet” 4-channel ‘cube’ display simulator was configured for the close air support component in 2010, and an E-7A “Wedgetail” mission system simulator was integrated for 2012 and 2014.

The backbone of the Black Skies simulation environment was the AOSC standalone 100Gb/s Ethernet network, comprised of optical fibre transmission media, routing systems and redundancy safe disk arrays. Simulation ground truth sharing and voice communications were achieved through the Distributed Interactive Simulation (DIS) protocol. Link-16 was implemented via Socket-J, and Internet Relay Chat was provided by the mIRC client application. High definition video and audio were streamed from various locations to the exercise control room and visitors’ observation area. During each Black Skies mission, all DIS voice and ground truth data was logged to support after-action review and post-exercise analysis.

To ensure the value of training and to maximise realism, maximum use was made of systems and interfaces that are used by operators in their day to day roles. The Raytheon Solipsys ADGE suite including the Tactical Display Framework and Multi-Source Correlator Tracker provided a realistic and familiar interface for the ADGE weapons teams. Likewise, the E-7A mission system simulator was developed using a release of software and hardware that is used in the aircraft’s mission system. In functional terms, these systems were practically indistinguishable from their real-world counterparts, with the exception of just a small number of nuances relating to software versions and limitations of the virtual environment.

In comparison to a Full Flight Simulator, as are used by crews for flight training, all of the simulation systems used during Black Skies were relatively low cost. The benefits, for example, of providing a motion base platform for the E-7A mission crew would be marginal and not cost effective. By adapting standard engineering principles of modularity and reuse, reconfigurability was ensured and costs were able to be reduced. An example of this was the voice communication software which was adapted in slightly different forms for all participants with the underlying architecture remaining relatively untouched.
2.3 Exercise Construct and Battle Rhythm

Each Black Skies activity was held in June or July of the year of their respective live Pitch Black exercise. Since Black Skies was designed partly to provide synthetic mission rehearsal for Pitch Black, it was important to schedule each exercise as close as possible to the live event without burdening the standard work-up training programs of the training audience. However, due to constraints on participant availability, each iteration of Black Skies was conducted a different period of time before its associated Pitch Black. Fortuitously, this provided the opportunity to study the robustness of the performance benefits over time (see Section 4.3 below).

Each Black Skies followed the same basic schedule, commencing on a Monday and concluding on the Friday of the same week. Day 1 provided participants with introductory briefings, systems familiarisation, mock-scenario practice sessions, and time to conduct team planning activities. During Black Skies 2008, this was conducted as a half-day, whereas in 2010, 2012 and 2014 a whole day was allocated for introductions and familiarisation. Days 2 to 5 each consisted of a daily mass briefing, two 90-minute missions, and a daily after-action review session. Planning sessions were provided prior to the commencement of each mission. Black Skies 2008 was the exception, with only one scheduled mission per day being conducted each afternoon with the mornings allocated to planning and briefing.

The Black Skies scenarios were designed to provide an operationally-realistic representation of the missions the training audience would encounter during the live Pitch Black exercise. Milskil staff generated and managed the scenarios during each mission with the aim of providing a realistic problem-solving environment. Scenarios involved large-force employment of combined air combat assets in hostile territory, engaging in Defensive Counter Air, Offensive Counter Air, and Offensive Air Support missions.

Approximately 30 blue and 20 red force entities were involved in a typical mission scenario. These were managed by the blue and red force simulator pilot teams, respectively. All mission products, including scenario scripts and intelligence briefings, were developed by Milskil.

Daily after-action review sessions presented the opportunity for EXCON staff and expert assessors to provide feedback to the training audience. Each session was supported by tools that allowed missions to be replayed and presented to the group on large projection displays showing synchronised 2D and 3D ground truth data, individual operator tactical display video captures, audio communications (from all available channels), and assessor comments and ratings.

3. METHODS

Data collection during Black Skies and Pitch Black was guided by models of training effectiveness evaluation (Kraiger, 2002) and team performance (Kozlowski & Ilgen, 2006). Important amongst the data sets that were captured were subject-matter expert assessments of the performance of the participating teams during mission execution in terms of: (1) their effectiveness against team mission objectives, and (2) the quality of their team coordination behaviours. The methods used to capture these data sets are described below.

3.1 Materials

3.1.1. Evaluation of Team Effectiveness

Separate sets of criteria were used to evaluate team performance against mission objectives for the Air Battle Management teams and Close Air Support teams involved in Black Skies. The mission objectives used to structure evaluations of air battle management team performance during Black Skies 2008 were specific to the defensive counter air mission. During Black Skies 2010, a second set of air battle management criteria were developed for assessment of the offensive counter air mission. There was substantial commonality between these two sets of criteria related to such activities as planning, briefing, review, communication within and external to the team, and management of information systems. For Black Skies 2012 and 2014, the air battle management objectives relating to offensive counter air and defensive counter air were included as components in a single hierarchy. In all cases, performance was evaluated using a 5-point rating scale based on one described by Spector (1992). Scores on this scale ranged from 1 = “Terrible” to 5 = “Excellent”. During Black Skies 2010, close air support team performance was evaluated using a rating form that included consideration of mission tasks, team member understanding, and mission effectiveness. Each item was associated with a brief description of the behaviours that should be considered by the expert assessor and was assessed using a 5-point rating scale ranging from 1 = “Very Poor” to 5 = “Excellent”.

3.1.2. Evaluation of Team Coordination Behaviours

As was the case for evaluations of team effectiveness, different sets of criteria were used to evaluate the quality of team coordination behaviours for Air Battle Management teams and Close Air Support teams. Expert assessor ratings of the quality of air battle management team coordination behaviours were captured using a form based on the Anti-Air Teamwork Observation Measure (ATOM) developed by Smith-Jentsch and colleagues (Smith-Jentsch, Johnston, & Payne, 1998; Smith-Jentsch, Zeisig, Acton, & McPherson, 1998). This form included four dimensions of team coordination: (1) Communication, (2) Information Exchange, (3) Supporting Behaviour, and (4) Leadership/Initiative. Each dimension was rated on a 5-point scale, with descriptors at the positive and

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8 The length of scheduled planning sessions were condensed relative to standard procedures for live operations in order to maintain a balance between training and research objectives (i.e., to achieve as many missions as possible during the week).
negative extremes. For example, the descriptor associated with the positive extreme of the Communication dimension read: “No instances of improper phraseology, excess chatter, incomplete reports, or inaudible communication”. The descriptor associated with the negative extreme on this dimension read: “Consistently demonstrated improper phraseology, excess chatter, incomplete reports, or inaudible communication”.

To align ratings of the quality of close air support team coordination behaviours as closely as possible with the nature of the mission, the close air support teamwork rating form contained a slightly different set of teamwork dimensions, these being: (1) Communication, (2) Situation Awareness, (3) Supporting Behaviour, and (4) Adaptability. Each dimension on the close air support form was associated with a rating scale that provided a detailed description of performance characteristics associated with each scale point. For example, the descriptor associated with the positive extreme of the Communication dimension read: “Very few/no instances of incomplete information, unclear/inaudible transmissions, excess chatter/irrelevant information and incorrect terminology”. The descriptor associated with the negative extreme of the Communication dimension read: “Very poor: very frequent instances of incomplete information, unclear/inaudible transmissions, excess chatter/irrelevant information and incorrect terminology” (for a more detailed description of the close air support elements of Black Skies 2010, see Stephens, Crone, Temby, Best, & Simpkin, 2011).

3.2 Procedure
During Black Skies missions, subject-matter expert assessors rated the performance of the participating teams using the instruments described above. After Black Skies, follow-up evaluations of the performance of a subset of the participating Air Battle Management teams were conducted during the live exercise Pitch Black. The purpose of these follow-up evaluations was to determine whether learning during the synthetic exercise (i.e., Black Skies) led to improved performance during live missions (i.e., Pitch Black). To provide a basis for comparison in this analysis, observers also evaluated the performance of similarly experienced ‘control’ Air Battle Management teams who had not taken part in Black Skies. During each Pitch Black activity, the performance of the Black Skies team and its associated matched control team was evaluated by the same observer/s and against the same criteria that were used during Black Skies itself. The inclusion of a matched control team represents an extension on previous research on transfer from synthetic collective training to large-scale, live-flying, air-combat missions (Smith, et al., 2007; McIntyre, Smith, & Bennett, 2002). By comparing the performance of the Black Skies teams with that of the control teams during Pitch Black, it is possible to confirm that performance advantages in the live environment are attributable to participation in Black Skies and not to other Pitch Black workup activities.

4. OUTCOMES
Previous results have been reported on the improvements in team performance in synthetic and follow-on live environments for Black Skies 2008-12, and associated Pitch Black exercises (Best, Jia, & Simpkin, 2013). The data presented below represent an update of those results to include the relevant team performance data collected during Black Skies 2014 and subsequently Pitch Black 2014. This is the first time that the outcomes from the entire series of exercises have been presented. With just 8 Black Skies teams and 4 Pitch Black teams, it is difficult to justify the assumptions of parametric statistical tests. Nevertheless, it may be possible to detect some large effects using non-parametric techniques (Shieh, Jan, & Randles, 2007). In the sections that follow, Wilcoxon signed rank tests will be used to evaluate repeated-measures effects, while Mann-Whitney tests will be used to evaluate independent-samples effects.

4.1 Performance in the Synthetic Environment
As per Black Skies 2008-12 (Best, Jia, & Simpkin, 2013), expert assessors provided ratings of team coordination behaviours and mission effectiveness during each mission of Black Skies 2014. A difference score was calculated on each of these dimensions for each Black Skies team by subtracting the scores obtained during the first mission of Black Skies from the scores obtained during the last mission. These difference scores were then expressed in terms of percentage of scale maximum for ease of interpretation. A positive difference represents an improvement in performance, whereas a negative difference represents a degradation of performance. The Black Skies 2014 difference scores were combined with those obtained from all previous exercises (i.e., Black Skies 2008-12) to provide a data set consisting of observations of 8 teams on two variables.

4.1.1. Team Coordination
The first column of Figure 1 shows the mean percentage difference of team coordination for all teams (n=8) across the Black Skies series (error bars represent the standard deviation). The data show that across the 8 teams there was an average increase in performance of around 20% of scale maximum in team coordination from first to last Black Skies mission. All difference scores in this sample were greater than zero and this change was found to be statistically significant (Z = -2.52, p < 0.05).

4.1.2. Team Mission Effectiveness
The mean percentage difference of team mission effectiveness across all teams in the Black Skies series (n=8) is shown in the second column of Figure 1 (error bars represent the standard deviation). The data show

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" Ratings were obtained from one observer during Pitch Black 2008, 2012, and 2014, and from two independent observers during Pitch Black 2010."
that there was an increase in performance, on average, of around 10% of scale maximum in mission effectiveness from the first to the last Black Skies mission. Once again, all data points in this sample were greater than zero and this change was found to be statistically significant ($Z = -2.52, p < 0.05$).

4.2 Training Transfer to the Live Environment

Follow-up observations were conducted by RAAF subject-matter experts during Pitch Black exercises in order to assess the level of training transfer achieved from the synthetic to live environments. Live data were captured from ADGE weapons teams during the Pitch Black exercises that followed Black Skies 2008, 2010, 2012, and 2014. Live performance assessments employed the same team coordination and mission effectiveness criteria that were used during Black Skies.

Expert assessor ratings were averaged across live missions to yield a single live performance score for each Black Skies team and matched control team on each of the two performance dimensions. Difference scores were then calculated by comparing the performance ratings of the four Black Skies teams (i.e., one per iteration of the exercise) with those of the four matched control teams. Each point in this data set (n=4) therefore represents the mean difference in performance between two teams – a Black Skies ADGE team and a matched control team (i.e. the ADGE team that participated in Black Skies in the same year compared to a team of similar experience levels and qualifications that did not participate in Black Skies) – with positive difference scores reflecting better performance in the Black Skies teams.

4.2.1 Team Coordination

The third column of Figure 1 shows the mean percentage difference score on team coordination between the Black Skies ADGE teams and the matched control teams, across all observed live Pitch Black exercises between 2008 and 2014 (n=4). The outcome shows that, on average, the teams that participated in Black Skies outperformed the control teams that did not participate in Black Skies by around 20% of scale maximum on team coordination. The statistical test conducted on this data yielded a marginally non-significant result ($Z = -2.02, p > 0.05$). Nevertheless, all data points were greater than zero, indicating a consistent advantage for the Black Skies teams. This non-significant test result is most likely a consequence of low statistical power resulting from the small number of teams available for analysis.

4.2.2 Team Mission Effectiveness

The fourth column of Figure 1 shows the mean percentage difference score of team mission effectiveness between the Black Skies ADGE teams and the matched control teams, across all observed live Pitch Black exercises between 2008 and 2014 (n=4). The outcome shows that, on average, the teams that participated in Black Skies outperformed the control teams that did not participate in Black Skies by around 10% of scale maximum on mission effectiveness. As with the previous data set, the statistical test of this effect failed to reach significance ($Z = -1.59, p > 0.05$). Nevertheless, this data set also contained only positive
values, which is suggestive of a consistent advantage for the Black Skies teams over the control teams.

4.3 Effect of Time on Transfer

Due to scheduling constraints and participant availabilities, the opportunity existed to examine the effect of the variability of timing of Black Skies prior to its associated live Pitch Black exercise. Across the four Black Skies/Pitch Black exercises, days between first observed Black Skies mission and first observed Pitch Black mission varied between 28 and 64 days. It might have been expected that the improvement in team performance gained through participating in Black Skies might decay over time to the point that a participant team would have no advantage over another team that did not participate in Black Skies.

To examine this, the individual difference scores used to calculate the results presented in Figure 1 (columns 3 and 4; n=4) were plotted as a function of time (in days) between the first observed Black Skies mission and the first observed Pitch Black mission for each live exercise. The data presented in Figure 2 show that in all four live exercises the Black Skies teams outperformed the matched control teams. While the size of the performance difference varied somewhat between exercises, no systematic effect of time was apparent.

5. DISCUSSION

In response to the need for Air Force to define future requirements for synthetic collective training (SCT) capabilities, the Black Skies series aimed to evaluate changes in learner behaviour as a result of SCT and the transfer of training to on-the-job performance. The findings from the study presented here will be discussed in two ways – in terms of training impact and fidelity of simulation systems.

Throughout each Black Skies activity and subsequent live Pitch Black exercise, changes in learner behaviour were evaluated in terms of team coordination and mission effectiveness by utilising subject-matter expert assessor performance ratings. Improvements in performance were observed within each participating team over the course of each Black Skies activity. Follow-on assessments in the live environment (i.e., Pitch Black) also showed that Black Skies teams outperformed teams that had not taken part in Black Skies. These performance advantages also remained relatively stable within a window of around 2 months post-Black Skies.

Apart from the robust nature of the performance benefits over time, it is reasonable to have expected an improvement in team performance as a result of SCT. However, there is relatively little empirical data reported on transfer from realistic air combat SCT to live operations involving qualified military operators and including comparisons with control participants that enables evidence-based decision making on investments in SCT activities and capabilities. Statistical tests of the data arising from the live exercises did not reach standard thresholds of significance. However, it is likely that this was due to the relatively small amount of data available for analysis. The collection of additional data during future exercises will address this problem. The observation of
universally higher performance ratings for Black Skies teams than for control teams during live missions reaffirms previous findings that synthetic collective training can lead to improved performance during live missions (Smith, et al., 2007; McIntyre, Smith, & Bennett, 2002) and supports the hypothesis that such performance advantages in the live environment can indeed be attributed to participation in synthetic collective training.

As described in Section 2.2, the simulation systems used during Black Skies were of a relatively low-cost design, yet were targeted towards stimulating the underlying cognitive and behavioural processes required for effective mission execution (i.e., system functions were designed to be as close to the real-world setting as possible). The clearly positive outcomes of this study demonstrate that although high physical fidelity systems aim to ‘close the gap’ between training and real-world tasks (and are suitable in some contexts), systems that have low physical fidelity but high psychological fidelity (Kozlowski & DeShon, 2004) can offer cost-effective solutions while delivering substantial performance benefits and maximising transfer. It should therefore be considered that, depending on the type of training, some dimensions of fidelity (e.g., psychological fidelity) should be regarded with greater importance than others (e.g., physical fidelity). This has important implications for the forthcoming development of synthetic collective training systems for RAAF.

Although this study provides positive results, further development will be required to extract the greatest possible benefits from investments in synthetic collective training capabilities. For example, the team performance data collected during Black Skies contained some variability (as seen by the error bars in Figure 1). This suggests that in some areas and on some occasions the current capability is achieving effective training. In other areas and on other occasions, only minor improvements in performance were observed. Further development may therefore be needed to maximise training outcomes. Also, the significant burden on personnel required to plan, coordinate and execute large-scale synthetic mission rehearsal activities such as Black Skies was described in Section 2.1.2. Over time as training needs increase in complexity, these demands on training resources, in particular on training staff such as White Force, may render the use of current tools and methods unsustainable. Further development will therefore be required to maintain and even improve training outcomes while reducing required staff levels.

6. CONCLUSION

The activities and systems described in this paper have all been owned and operated by DSTO. The findings of the Black Skies series have provided a solid foundation for RAAF to make evidence-based decisions about investments in future synthetic collective training activities and capabilities of its own. However, much remains to be done to transition activities like Black Skies from the research laboratory to the operational training environment. Development aimed at improving the effectiveness and efficiency of synthetic collective training can be described in terms of training tools and methods. Tools refer to the physical capability (i.e., hardware and software) and hence include various simulation and support systems (e.g., those used for after-action review). While these are clearly important, another aspect to consider is how those tools are used in order to ensure the training is effective yet efficient – that is, training methods. Training design in the future will require novel methods to realise the full potential of synthetic collective training capability. Addressing these issues through ongoing research and development will enable RAAF, and the wider ADF, to take the next steps in developing an effective and efficient training system that delivers an integrated, networked force.

7. ACKNOWLEDGEMENTS

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Examining the effect of simulator fidelity on task performance and training transfer with an ICT device

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Abstract. The introduction of new Information and Communication Technologies into mobile workplaces is becoming more common due to the various benefits they offer. One such technology is the Battle Management System (BMS), a digital, touch-screen device that supports command and control (C2) tasks. The Australian Defence Force is acquiring the BMS for use by military personnel inside moving vehicles. The use of this device under motion will be challenging for users, raising implications about the best way to deliver training. One potential solution is training in simulators with realistic levels of fidelity. At present, it is unclear whether training under higher levels of simulator fidelity, including the use of simulated motion, leads to better transfer of training. The current study was designed to address this gap by comparing performance on representative C2 tasks under different levels of simulator fidelity. Forty-six civilian participants (34 males, 12 females) aged between 21 and 63 years (Mean=36.0 years, SD=12.7) with no prior experience using the device took part in the study. Participants were randomly assigned to one of three simulator training conditions (low, medium and high fidelity) where they trained to perform four tasks (create line, create text, create unit, pan and zoom) using the device. The tasks involved input, retrieval, and creation of information, and performance was measured in terms of accuracy and completion time. Following training, participants completed equivalent tasks under real-world conditions to examine training transfer. Overall, the results showed no significant evidence that training under higher levels of simulator fidelity led to better training transfer compared with training under lower levels of simulator fidelity. The results are discussed in relation to previous research and the study’s limitations. Implications of the findings for simulation-based training are also discussed, and recommendations for future research are outlined.

INTRODUCTION

The introduction of new technologies into mobile workplaces is becoming more common. Mobile workspaces are typical in many industries including defence (e.g., military vehicles), health (e.g., ambulances), law enforcement (e.g., police vehicles), and road transport (e.g., train drivers). The use of technology in mobile workplaces can present challenges for users, such as motion, vibration, workload, and confined spaces. This in turn presents challenges for organisations to identify and implement the most effective training strategies.

One class of technology that many organisations are investing in for their mobile workspaces is Information and Communication Technologies (ICTs). These technologies provide users with many potential benefits including rapid information exchange, better situation awareness, and greater productivity. In the civilian sector, examples of such technologies are navigation devices such as Global Positioning Systems (GPS) and automatic license plate readers used by police and law enforcement agencies (Applin, 2015). In the military context, an example is the Battle Management System (BMS).

Battle Management Systems (BMS)
The BMS is a digital, touch-screen device which is currently being acquired by the Australian Defence Force. The BMS looks similar to an in-vehicle GPS system and will allow users to exchange and receive information to support mission planning and execution (Abedin, Demczuk & Judd, 2012). It is hoped that the introduction of the BMS will result in greater operational effectiveness. However, the BMS will ultimately be used in moving land vehicles which will present challenges for users and training implications.

While researchers have identified a number of strategies for training BMS users (Whitney & Vozzo, 2012), empirical evidence on the most effective training strategies is lacking. This paper addresses this gap and describes a study examining the effect of different levels of simulator fidelity on training transfer for representative BMS tasks.

The following sections briefly summarise relevant literature on training transfer, simulator fidelity, and motion effects on task performance. This is followed by a description of the study aims, methods, along with a discussion of the results and their implications for the simulation community. The paper concludes with suggestions for future research.

Transfer of training

A key factor determining the success of training is the degree to which the training is transferred to and applied on the job (Blume, Ford, Baldwin & Huang, 2010; Galanis, Stephens & Temby, 2013; Grossman & Salas, 2011). A major factor influencing this is the similarity between the training environment and the job environment (Baldwin & Ford, 1988; Grossman & Salas, 2011; Thorndike & Woodworth, 1901). If simulation-based training is used to train skills, this begs the question: How closely does the simulation environment need to match the real world to yield positive training outcomes? According to identical elements theory (Thorndike & Woodworth, 1901), the greater the similarity between elements in two different
environments, the greater the likelihood there is of training transfer. Conversely, where elements in one environment are not present in another, no or limited skill transfer should be expected. While transfer of training studies can be challenging to conduct, particularly in applied or military contexts (Salas, Milham & Bowers, 2003), they are a rigorous way of assessing the efficacy of different training methods.

**Simulator fidelity**

Simulation-based training is a popular method of training that is widely used in aviation, business, education, health and defence (Salas & Cannon-Bowers, 2001). Simulation-based training offers a number of benefits over live training methods, such as the ability to practice a greater range of scenarios, resource savings, and the ability to objectively measure performance (Goode, Salmon & Lenné, 2013; Whitney, Temby & Stephens, 2013). An important consideration when using simulators is the level of fidelity required for effective training outcomes. Fidelity is the degree to which a simulated situation replicates the real world (Greenberg & Blommer, 2011) and there are different types of simulator fidelity, including physical, psychological and functional fidelity. Of particular interest to the current study is motion fidelity, a type of physical fidelity, which is the degree to which motion matches that of the real world (Allen, Park, Cook & Fiorentino, 2007; Goode, Salmon & Lenné, 2013).

Previous research has generally found that higher levels of simulator fidelity result in more effective transfer of training (Salas, Bowers & Rhodenizer, 1998; Thorndike & Woodworth, 1901). However, the benefits that higher fidelity afford need to be weighed up against the extra costs associated with generating it. Indeed, high fidelity simulators are often more expensive, require more maintenance and planning (McFetrich, 2006), and when used inappropriately, can result in diminished training outcomes (Grossman & Salas, 2011).

**Effects of motion on task performance**

A typical C2 system is shown in Figure 1. The effects of motion on the use of mobile ICT devices, such as digital C2 systems, have been the focus of several studies. These studies have used simulators to explore the relationship between motion levels and task performance in the simulator and real-world. In summary these studies have generally found that:

- High levels of both simulated and real-world motion tend to degrade task performance, when compared with mild or no motion (Abedin et al., 2012; Metcalfe, Davis, Tauson, & McDowell, 2008; Salmon et al., 2011).
- Input tasks that require information to be entered are more affected by motion than information retrieval and creation tasks, with task accuracy generally more affected than task completion time (Abedin et al., 2012; Goode et al., 2012; 2014; Salmon et al., 2011).
- Tasks that require creating something (e.g., creating text, or creating a unit on a map) are more affected than simple button-pressing tasks (e.g., panning and zooming on screen).
- Practice effects (i.e., improved task performance over trials) are observed on some tasks but ceiling effects are observed on others (Abedin et al., 2012; Goode et al., 2014; Magdas, MacDouggall & Goonetilleke, 2014).
- Based on these findings, researchers have proposed that BMS-type tasks be trained under motion (Abedin et al., 2012; Goode et al., 2014; Lenné et al., 2010; Salmon et al., 2011) but no studies, to our knowledge, have addressed this suggestion to assess whether such training is beneficial. Therefore, whether training with motion for these types of tasks leads to better training transfer remains unclear.

Some studies have also found that users develop particular strategies for mitigating the impact of motion; for example, using the side of the touch screen device as a stabilisation point for hands (Goode et al., 2012; Salmon et al., 2011). However, it is unclear whether motion mitigation strategies used during training assist in greater of training. Theoretically, these strategies could reduce training transfer if seating positions or vehicle layout in the real world are substantially different to the training environment, and users are no longer able to adopt particular postures or strategies.

**The current study**

The current study was conducted as part of the first author’s Master’s thesis project (Brunner, 2014). It was also conducted as part of a larger research program in...
DSTO which is investigating the use of simulation for training vehicle crew. The study was motivated by the previously noted lack of research examining whether training with simulated motion leads to better training outcomes. Based on identical elements theory and previous research, it was expected that training under higher levels of simulator fidelity would lead to better performance in the real world (i.e., better transfer of training) compared with training under lower levels of simulator fidelity.

METHOD

Participants
Forty-six civilian participants (34 males, 12 females) aged between 21 and 63 years (Mean=36.0, SD=12.7) took part in the study. None of the participants had any prior experience using the device but nearly all used touch-screen devices and keyboards on a regular basis (e.g., smart phones, desktop computers). Due to the inclusion of motion in the study, volunteers were excluded if they were pregnant, had back problems, or a history of motion-related simulator sickness.

Study design and approval
The study used a 3 x 4 repeated measures design (simulator fidelity x task type) with randomised control. The independent variable was simulator fidelity (low, medium and high) and the dependent variable was task performance. Participants were randomly allocated to one of the three simulator conditions, and then performed equivalent tasks under real-world conditions to assess training transfer. The study was approved by the University of Adelaide Human Research Ethics Committee and DSTO Low-Risk Ethics Review Panel.

Materials

Simulation environments
Two simulation environments were used in the study:

A high fidelity simulation environment: this comprised a highly realistic cabin simulator with 6-degree of freedom motion and a wide screen field of view (see Figure 2). This is also known as DSTO’s Land Motion Platform (LAMP) facility.

A low to medium fidelity simulation environment: this comprised an open-vehicle style simulator with racing car style seats on a fixed-base platform with the option of 3-degree of freedom motion using D-box actuators, and an LCD screen for the field of view (see Figure 3).

Virtual Battlespace 2 (VBS2) software was used to generate motion, sound and visuals in both environments. To quantify the level of motion, the Root Mean Square (RMS) value of the vibration was measured. Three different levels of motion were planned for the study: 0.0, 0.3 and 1.1 m/s². An RMS of 0.3 translates to moderate discomfort and 1.0 m/s² is rated as uncomfortable (Griffin, 2006; Standards Australia, 2001). For technical reasons, the desired level of motion (1.1 m/s²) in the high fidelity simulator was unable to be achieved and the motion levels had to be adjusted; see next section.

Using the two environments, three different simulator fidelity levels were created as outlined in Table 1.

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<tr>
<th>Fidelity level</th>
<th>Simulator</th>
<th>Description of motion</th>
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</thead>
<tbody>
<tr>
<td>Low</td>
<td>Racing car</td>
<td>No motion. RMS=0 m/s²</td>
</tr>
<tr>
<td>Medium</td>
<td>Racing car</td>
<td>Default VBS2 motion profile. RMS=0.18 m/s²</td>
</tr>
<tr>
<td>High</td>
<td>LAMP</td>
<td>Toned down recording of motion profile from road in transfer phase. RMS=0.3 m/s²</td>
</tr>
</tbody>
</table>

BMS emulator
An emulator version of a BMS was used in the study. The emulator was created using Java-based software and run on an 11.6-inch touch-screen tablet (Toshiba Z10T) with an attached keyboard (as shown in Figure 3). The emulator allows users to perform representative BMS tasks (see next section) and was designed for research purposes to explore general principles
underpinning device use. The emulator is not intended to be a high fidelity replication of the BMS being acquired by the Australian Defence Force.

Tasks and performance measures
The four tasks completed by participants and associated performance measures are described in Table 2. The primary measures were task completion time and task accuracy. Accuracy was measured as the number of typing and button errors for create text and pan and zoom tasks, and pixel errors (i.e., the distance between designated and pressed coordinates) for create line and create unit tasks. Several hundred unique instances of each task were generated for use in the study.

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create line</td>
<td>Participants created a line by touching four different map coordinates</td>
<td>Time, pixel errors</td>
</tr>
<tr>
<td>Create text</td>
<td>Participants typed a series of five randomly selected five letter words</td>
<td>Time, number of typing errors</td>
</tr>
<tr>
<td>Create unit</td>
<td>Participants created a specific military unit by holding their finger on a particular set of coordinates</td>
<td>Time, pixel errors, number of errors</td>
</tr>
<tr>
<td>Pan and zoom</td>
<td>Participants were required to pan a map up or down, left or right, and then to zoom in or out with touch-screen buttons</td>
<td>Time, number of button errors</td>
</tr>
</tbody>
</table>

Table 2: Description of tasks and measures.

Questionnaire
A questionnaire was administered to participants at the end of the study to assess their perceptions of task difficulty in the transfer test. The questionnaire asked participants to rate the difficulty of each task using the following scale: 1=very easy, 2=easy, 3=neither easy nor difficult, 4=difficult, 5=very difficult. Participants were also asked to list factors that they perceived adversely affected their performance in the real-world.

Study procedures
The study procedures are summarised in Figure 4. The following sections provide a detailed description of the procedures used in each session.

Recruitment and initial training
Following recruitment and informed consent, all participants undertook an initial training session to become familiar with the device and tasks. Participants were tested in groups of up to three. The session lasted for 15 minutes after which time all participants were comfortable with using the device. Following this, participants were instructed on how to best hold the tablet to minimise the effects of motion. Specifically they were instructed to support the side of the table with their non-dominant hand for three tasks, and to anchor the tablet in the lap using both hands when performing the create text task. These instructions were given to standardise the way that participants held the device and thereby control for this potential confound.

Simulator training
After familiarisation, participants were then randomly assigned to one of three simulator conditions: low, medium or high fidelity. Simulator training was conducted for 15 minutes. Participants were instructed to complete tasks as quickly and accurately as possible while sitting as a passenger in the co-driver seat. They completed as many trials (presented in random order) as they could in the time allowed. The number of tasks completed in this time ranged from 69 to 106 (SD=46). There were no significant differences between groups in the number of tasks completed.

Transfer of training
Following simulator training, participants completed a transfer of training test. This took place in a civilian vehicle driven on an unsealed public road, 10.75 km long with an uneven, bumpy surface including unavoidable pot-holes. The road surface was representative of bumpy terrain that might be encountered by military vehicle crews. The RMS value of the road’s motion profile was 1.1m/s². Testing was conducted with one to three participants, who were seated in the front or rear passenger seats. The vehicle
was driven by a member of the study team, who was instructed to maintain a constant speed of 60km/h except when it was unsafe to do so (e.g., when cornering or traversing potholes). During the test drive, participants completed several iterations of the four tasks (randomised in a different order to training) for approximately 12 minutes; the exact time was determined by driving speed. The duration was intended to roughly match the simulator training time of 15 minutes. Participants were instructed not to communicate with the other vehicle occupants during the drive. Driving conditions such as weather, traffic, and obstacles were comparable across trials and participants, so this factor did not adversely affect the results. At the end of testing, participants completed the task difficulty questionnaire and were asked to report any factors that they believed affected their performance.

Data analyses
Data were analysed using a series of ANOVAs and Kruskal-Wallis tests. All follow-up univariate analyses used a Bonferroni correction (α≤.01).

RESULTS

Task Completion Time
Training Phase
Mean task completion times for each group and task during the training phase are shown in Figure 5. Completion times were fastest for the pan and zoom task, followed by the create unit, and create line tasks, with the create text task taking the longest. This pattern was consistent across all groups. However, there was a significant difference in task completion times across groups (F(8,80)=2.56, p=.02, Wilk’s Λ=.63, η²=.20). Participants in the high fidelity training group were significantly slower on the create line, create text and create unit tasks than the other two groups. This suggests the higher level of motion had a significant impact on this group’s performance.

Figure 5: Mean task completion times for the three groups during simulator training.

There were very few errors made on the create text, create unit, and pan and zoom tasks by the three groups. Overall, there were no significant differences in task errors between the three groups for pixel errors (F(4,82)=.29, p=.88, Wilk’s Λ=.97, η²=.01) and typing/button errors (F(6,80)=.64, p=.70, Wilk’s Λ=.91, η²=.05). These findings indicate that task accuracy levels were similar across the three groups during simulator training.

Transfer Phase
Mean task completion times for each group during the transfer phase are shown in Figure 7. A similar pattern of results to the training phase was found (Figure 5). That is, completion times were fastest for the pan and zoom task, followed by the create unit and create line tasks, with the create text task taking the longest. When comparing group performance on each task, there were no significant differences in completion times between any of the groups (F(2,42)=1.87, p=.10, Wilk’s Λ=.77, η²=.12). This finding indicates that the performance of the three groups was comparable on each task, regardless of the simulator training they undertook.

Mean task errors for each task and group during the transfer phase are shown in Figure 8. When comparing group performance on each task, the only significant

2 Data from the pan and zoom task for the high fidelity training group was excluded because it was unreliable.
A difference was observed for pixel errors on the create unit task ($\chi^2(2)=9.23$, $p=.01$, $\eta_p^2=.25$). Post-hoc analysis confirmed the high fidelity training group performed better on this task than the low fidelity training group. All other differences between groups were not significant ($p>.05$). These findings suggest that training under higher levels of fidelity may have led to better performance on the create unit task in the real-world.

**DISCUSSION**

The primary aim of this study was to examine whether training under high levels of simulator fidelity produces significantly better training transfer relative to training under lower levels of fidelity. During simulator training, participants in the high fidelity condition took significantly longer to complete creation tasks (namely create line, create text, and create unit) compared to the other two groups. This finding suggests that the higher level of motion degraded this group’s performance relative to the other conditions. During the transfer phase (real-world), however, participants in the high fidelity condition performed significantly better on one task (create unit) than the other two groups. This finding suggests that training under higher level of fidelity did support better transfer of training. However, given the small effect size associated with this result ($\eta_p^2=.25$), and that no other performance differences were found between the groups in the transfer phase, the results suggest that the higher fidelity training had no significant benefit on real-world performance. On face value, this implies that training with high levels of fidelity may not be necessary for these types of tasks. However, this result may have been due to the motion in the high fidelity condition not being realistic enough to support better training transfer. Ideally, based on identical elements theory (Thorndike & Woodworth, 1901), the motion level should match that of the real world.

In this study, input tasks were more affected by motion than information retrieval tasks in the simulator and real-world; this result was consistent with previous research (Abedin et al., 2012; Goode et al., 2012). In addition, task completion time was more affected than performance errors. This is contrary to findings from previous research (Abedin et al., 2012; Goode et al., 2012; 2014; Salmon et al, 2011) and suggests the participants in the current study favoured accuracy over speed, despite the instructions being to perform both quickly and accurately. It is worth noting that task completion times in Salmon et al (2011) ranged between 7 and 18 seconds, which is comparable to the current study (between 5 and 14 seconds). The road surface in the real world had intermittent large bumps, and therefore it is possible that participants waited for a smooth section of road before completing tasks, delaying their response time. Taken together these findings indicate that the tasks were relatively easy and performance was able to be maintained from the simulator training to the real-world, most likely by exerting more effort and through error mitigation strategies (e.g. waiting for smooth stretches of road before completing tasks). This is consistent with Abedin et al (2012) who commented that the tasks were not demanding enough of participants to observe any systematic influence of motion albeit only in the simulator. This may have implications for training.
ICT-related tasks, as even if the tasks are simple, training under motion may not be able to ameliorate the effects of large unexpected bumps on task performance. Overall, it remains to be seen whether using more realistic motion when training these tasks actually leads to better training transfer. However, given the participants’ ratings of task difficulty, together with the low error rates in this study, it is possible that limited real world training may be sufficient to train tasks of the nature used in this study.

Limitations and Future Research

There were a few limitations with the study which are now discussed, along with suggestions for future research to address them.

Firstly, as already noted, we were unable to generate motion levels that matched the real-world. The highest level of motion used (0.3 m/s²) was well short of the real-world motion (1.1 m/s²). Such methodological limitations can preclude finding genuine effects where simulated motion is concerned (Boldovici, 1992). To examine whether the findings are valid, future research would need to use motion levels that are more representative of those in the real-world.

Secondly, the device was operated by participants in two different positions during training (i.e., mounted) and transfer (i.e., in lap). In the real world, the device would be mounted inside the vehicle, which was not possible in this study. This difference in position may have contributed to the study findings including reducing the beneficial effects that higher fidelity simulator training may have afforded. Future research should ensure that training and real-world conditions are matched in this regard to reduce potential confounds. Notwithstanding this, it is possible that holding the device in their lap muted the effect of motion on task performance, as their legs may have absorbed some of the vibrations. Also, in this study, motion mitigation strategies were not examined in detail. While participants were given instructions on how to hold the tablets to mitigate the effects of motion, it was observed that under the higher levels of motion in the real world, participants altered the way that they supported the tablet with their hands. For example, participants rested their fingers on the back of the tablet so digital buttons could be pressed with the thumb rather than with a finger. Future research examining different methods of managing the motion may assist researchers to find the most effective motion mitigation strategies. Related to this point, research looking at optimising the design of the device may serve to minimise or even eliminate human error altogether (e.g., using speech to text functions). One way to enhance the design would be to enable the device to be detached from the dashboard and held in the lap as the user’s legs may assist in mitigating effects of motion. This solution would need to consider safety issues; in the event of an accident or kinetic event untethered devices can be safety hazards to vehicle occupants.

Thirdly, the study looked specifically at the effect of simulator fidelity on task performance in a controlled manner. While this afforded control over possible confounds, it was not entirely representative of how the tasks would be performed in a real world military context (although as discussed later, we believe the findings can in principle generalise to other contexts). Rather, operators would be performing other roles, such as, communicating with other vehicle crew members. As a result, future research might examine task performance in the context of carrying out a sequence of operationally relevant tasks (e.g. C2 on the move).

Fourthly, no control group was used in the study. This was a limitation associated with recruiting sufficient numbers of participants into the three simulator conditions. Having a control group that completed initial training only (followed by the transfer test) would have allowed inferences to be made about the effectiveness of simulation for training BMS-type tasks compared with more traditional instruction methods, such as on-the-job training.

Finally, a sample of civilian participants was used in the study. This may limit the generalisability of the findings because military personnel are likely to have prior experience using equipment under motion, and hence be able to more readily transfer these skills. Future research looking at the effects of motion on BMS task performance with more realistic elements such as real military vehicles, real equipment, in real scenarios (e.g., C2 on the move) would extend the current research and improve generalisability.

Lessons

We believe there are several lessons from this study for researchers and practitioners in the simulation community.

Firstly, a key lesson is that with adequate planning and resources, transfer of training studies are possible, as we have shown. Such studies have a significant role to play in informing investment into, and the use of, simulation-based training. Consequently, we would encourage the simulation community to invest more effort in this area because of the insights that can be gained, despite the challenges involved.

Secondly, the findings are broadly applicable to other in-vehicle ICT devices where motion is a factor. Indeed, the results are likely to be relevant to simple perceptual-motor tasks involving input, creation and retrieval of information. The generalisability of the findings to more complex tasks is an area for further research, as high fidelity simulator training may be more effective in these cases.

Thirdly, another lesson is that high levels of motion fidelity may not be necessary to achieve good training outcomes. Even though we cannot rule out the
possibility that ‘less than realistic’ motion levels limited the study outcomes, the results showed that the group that trained without motion committed very few task errors overall. This highlights that the tasks were fairly easy (which is supported by task difficulty ratings) but also implies that users may be able to adapt to their environment quickly using error mitigation strategies. Therefore, a key lesson here for researchers is to focus on the complexity of tasks to be trained, and operator behaviour, not just simulator fidelity.

Finally, we believe the approach taken and results from this study will be of interest to researchers, practitioners and industry who are interested in better understanding the relationship between simulator fidelity, task performance, and training outcomes.

CONCLUSION
This study has extended previous research into the effects of motion on task performance. It is the first study, to our knowledge, to explore the effects of different levels of simulator fidelity on training transfer for BMS-type tasks. Overall, it was found that higher levels of simulator fidelity during training did not lead to significantly better training transfer. This suggests that higher fidelity simulations do not necessarily provide better training outcomes for BMS-type tasks than lower fidelity simulations. However, these results are based on tasks that were fairly easy, and under training conditions that did not match real-world levels of motion. It is suggested that future research examine task performance under more realistic operational conditions, including higher levels of motion to investigate whether the current findings are replicated under these conditions. This study has also highlighted a number of lessons which we believe will be of interest to the wider simulation community.

ACKNOWLEDGEMENTS
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What Went Wrong? Debriefing Human Factors, Heuristics & Cognitive Biases

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Overview.

No longer do we only look at Crisis Resource Management principles and clinical skills when debriefing a simulation. There are so many other factors influencing our clinical decision making. A heuristic is a mental shortcut that allows people to solve problems and make judgments quickly and efficiently. These rule-of-thumb strategies shorten decision-making time and allow people to function without constantly stopping to think about their next course of action. Heuristics are helpful in many situations, but they can also lead to biases.

In the clinical arena these heuristics and biases can lead to adverse patient outcomes. This workshop will introduce the concept of heuristics, cognitive biases and human factors and how to incorporate them into simulations and debriefing. The topic is then given relevance to healthcare simulation and patient safety with participants analysing a Root Cause Analysis (RCA), writing a simulation and debriefing a simulation - all based on heuristics and biases.

It is anticipated that participants will:

- Appreciate the impact heuristics and biases have on patient safety
- Demonstrate the development of simulation scenarios from RCA reports
- Integrate heuristics and biases into debriefing of simulations as a human factors influence.

A short presentation will introduce the concepts of heuristics and biases, including System 1 versus System 2 thinking and common diagnostic biases. Participants gain valuable knowledge in ways of de-biasing decision making and provided with tools to help others avoid biases.

In small groups, an RCA (where a death of a patient was the end result), is analysed and a simulation is developed. In the essence of time, a trigger video, of a simulation based on the same RCA is shown. With the workshop facilitators acting as the staff in the trigger videos, participants will have an opportunity to debrief the simulation, incorporating the heuristics and cognitive biases witnessed.

The lead facilitator will enhance and direct learning opportunities for the participants.

The workshop will conclude with a discussion on the value of introducing the concept of heuristics and cognitive biases to clinicians, its value in simulation, education and patient safety.
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Modelling and Decision Support Systems - New Methodologies from Business Intelligence to Future Force Design

A Hybrid Simulation Model To Help Design The Future Force

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Abstract. Force planning activities are periodically conducted in order to ensure the best possible match between defence materiel acquisition and strategic planning imperatives. Due to the very large number of competing goals, possible actions and future contingencies, manual military planning processes are often unable to ensure optimal levels of completeness and robustness. It is thus desirable to augment these manual planning processes with appropriate models. We present here a hybrid simulation model that quantitatively determines Defence Element availability for a given force structure subject to the demands of a series of military operations. We use the concept of supply and demand to model the preparation of Defence Elements for deployment, and their subsequent deployment on military operations. We present the results of running an unclassified dataset through the model for verification purposes. We were able to demonstrate the level of demand for individual Defence Elements, and to measure the suitability of a force structure from a preparedness perspective. This work lays the foundation for analysis of official planning contingencies.

INTRODUCTION

The Australian Defence Organisation (ADO) periodically conducts whole of force planning activities such as the Force Structure Review, which we shall refer to as episodic reviews. The purpose of these episodic reviews is to assess the appropriateness of the planned future force against plausible future contingencies, which we shall refer to as vignettes. In order to conduct an episodic review, a range of future Defence Elements (e.g. the Joint Strike Fighter) and their associated preparedness levels need to be considered under the constraint of indicative ranges of strategic warning time and limited financial resources.

The preparedness concept describes Defence's preparation to undertake military operations, and comprises three key components - how ready we are for the task (readiness), how long the force has to get ready (warning time), and how well we can sustain the effort once committed (sustainability). Defence Preparedness Requirements (DPR) plans refined on an annual basis by the chiefs of the services define numbers and readiness level for all capabilities as the means by which preparedness is ensured.

To date the episodic reviews have relied on manual planning processes to determine Defence Element availability in order to focus efforts on assessing the suitability of Defence Element mixes against the vignette set. We propose to use a hybrid simulation model to quantitatively determine Defence Element availability in order to support a more rigorous assessment of the suitability of Defence Element numbers and associated preparedness settings. We use the concept of supply and demand to model the preparation of Defence Elements for deployment, and their subsequent deployment on military operations. Towards this goal, we present indicative modelling results for an unclassified force structure and DPR.

MODEL

In order to investigate the fitness of force structure and DPR options, a hybrid simulation model has been constructed. The model is based on the concept of supply and demand. The supply part is represented by the Defence Elements available or being available in the future, expressed in preparedness terms. The demand part is modelled by generated events. Associated with events are the requested resources. The required resources for these events are based on historical data or hypothetical future vignettes.

Preparedness levels are in a constant state of change, while events occur at discrete time points. The supply part is changing continuously on each simulation step, while the demand part is requesting resources discretely. This suggests the need for a hybrid modelling approach [6].

Supply Model

The supply model covers several aspects of preparedness such as personnel competency and platform availability which is affected by maintenance and deficiency. Our model uses statistical distributions to model maintenance and deficiency but personnel competency is modeled by the knowledge acquisition process.

The fundamental equation for knowledge acquisition is derived from the so-called 'ACT-R model' [1]. It encapsulates the power law of practice, the power law of forgetting and the multiplicative effects of practice and retention. The general expression formulated by Anderson & Schunn [1] is as follows:

\[ A \cdot N^r \cdot T^{(-d)} \]

where:

- \( A \) is a constant (scaling factor)
- \( N \) is the amount of practice
- \( T \) is time
\( c \) is the rate of learning
\( d \) is the rate of decay.

**Model of Learning**

The first part of the Anderson & Schunn model:

\[ A * N^t \]

can be substituted by the following differential equation with the initial condition of the decayed skill and the time when the transition from decaying to training takes place:

\[ e^c \frac{d\alpha(t)}{dt} + \alpha(t) = K * N(t) \]

where:

\( \alpha(t) \) is the skill level during learning.
\( \alpha(t_0) = \beta(t_0) \) is the initial condition for the first order differential equation for time \( t_0 \).
\( K \) is the knowledge gain.
\( N(t) \) is the step function.

The analytical solution is as follows:

\[ \alpha(t) = \beta(t_0) * e^{\frac{e^c}{c^2} - 1} + (1 - e^{\frac{e^c}{c^2} - 1}) * K * N \]

where:

\( c > 0 \) is the learning rate, as in the ACT-R model.
\( \beta(t_0) \) is the level of decayed skill when the learning process starts.

\( N \) is the amplitude of the step function and is usually equal to 1.

For a full explanation of the model, please see [5].

**Model of Decay**

The second part of the Anderson & Schunn model:

\[ r^{<c^2} \]

can be replaced by the following differential equation with the initial condition of the learned skills and the time when the transition from training to decaying takes place:

\[ d * \frac{d\beta(t)}{dt} + \beta(t) = \epsilon \]

Where \( \epsilon \) is the asymptote value of decay function, and where the initial conditions are:

\( \beta(t_0) = \alpha(t_0) \).
\( \beta(0) \) - is the skill level during decay.

The analytical solution is as follows:

\[ \beta(t) = \alpha(t_0) * e^{\frac{c^2}{e^c} - 1} + \epsilon * (1 - e^{\frac{c^2}{e^c} - 1}) \]

For a full explanation of the model, please see [5].

**Demand Model**

The demand model is based on the force generation cycle as a single-server queuing system supplying services to incoming events.incoming events are stored in a prioritzed input queue and matched against available resources in the supply model. If the system has enough resources to satisfy requirements, then an event is passed on to the next queue. Otherwise an event is held in the input queue until either resources become available, or the event expires. In our model there is only one input queue. We employ multiple internal queues in order to capture the state of events in the system. The movement of events between queues can be depicted as seen in Figure 1.

![Figure 18: Model Queuing Schematic.](image)

**Model Structure**

On each simulation step, one or more events may be generated. An event is associated with a particular vignette. The vignette defines the requirements for that event. Associated with each event are attributes such as the requested Defence Elements, their roles, quantities, readiness notices, event start time, duration, location and priority. An event type can be 'synchronised', in which Defence Elements must be deployed together, or 'asynchronised', in which this requirement does not apply. Each event 'travels' through the system from one queue to another based on the attributes of that event, and available resources.

The model queues (depicted in Figure 1) are outlined below:

**Input Queue**: all incoming events.

**Workup Queue**: events that have reached the workup stage.

**Deployment Queue**: events that are ready to be deployed.

**Travel to Theatre Queue**: events that have been dispatched to the theatre.

**Theatre Queue**: events that are now at the theatre and are ready to be engaged.

**Engagement Queue**: events that are currently engaged.

**Disengagement Queue**: events are moved to the disengagement queue after the end of the event.

**Travel to Base Queue**: events are moved to the 'travel to the base' queue after having completed the disengagement process.

**Reconstitution Queue**: events which are in the process of reconstitution, i.e. recovering in preparation for a return to the pool of available resources.

The model generates events with requirements for resources. Based on these requirements, the effective number of Defence Elements is calculated, taking into account the relationship between preparedness numbers, roles and preparedness levels. These requirements are matched with the existing pool of resources.
available resources (Defence Elements) such that events can effectively acquire these Defence Elements. This process takes place in the input queue. When the event’s requirements are met, the event is moved to the workup queue where its current level of preparedness will be raised to the operational level of capability.

When an event’s Defence Elements reach the required preparedness level, the event either remains in the deployment queue until all Defence Elements reach the required preparedness level (for synchronized events) or the event is immediately moved to the travel to theatre queue (for asynchronised events).

Based on the distance and the speed of Defence Elements, the event will at some point in time reach the theatre queue. The event’s start time attribute determines when the event is moved from the theatre queue to the engagement queue. The event’s end time attribute determines when the event is moved from the engagement queue to the disengagement queue. The event remains there for some time to recover from the engagement.

At the end of recovery period, events are placed in the travel to base queue. Based on the distance and speed, the event will at some point arrive at the base and is then placed in the reconstitution queue. After reconstitution, the event is removed from the reconstitution queue, recorded in the database for future analysis, and all Defence Elements are returned back to the pool of available resources.

There are three types of events:

- deployment event,
- rotation event,
- redeployment event.

Regular ‘deployment’ type events are the standard means by which Defence Elements are deployed on operations.

Rotation events are created when Defence Elements are due for rotation. Reinforcements are sent to the event, then, after a handover period, Defence Elements currently participating in the event return to their bases.

A redeployment event is created when Defence Elements are allocated to a new event from an existing event, rather than from their bases. For this to occur, the existing event must be in the disengagement queue, and within a given distance to the new event.

The algorithm which governs Defence Element travel is derived from the spherical law of cosines [7], and takes the following form:

\[
\text{bearing} = \arctan \left( \frac{\sin(\delta) \times \cos(\lambda_2) - \sin(\lambda_2) \times \cos(\delta) \times \cos(\lambda_1 - \lambda_2)}{\cos(\delta) \times \sin(\lambda_2) - \sin(\lambda_1) \times \cos(\delta) \times \cos(\lambda_2 - \lambda_1)} \right)
\]

Where:

- \( \lambda_1 \) is the current longitude in radians.
- \( \lambda_2 \) is the longitude in radians of the destination point.
- \( \delta \) is the current latitude in radians.
- \( \delta_2 \) is the longitude in radians of the destination point.

Whenever simulation time is incremented, the position of each Defence Element is adjusted. The bearing from its current location to its destination is calculated using this formula and the Defence Element is then moved some distance in this direction. The distance depends on a predefined speed at which that Defence Element can move.

**SIMULATION MODEL COMPONENTS**

Our model has two major components:

- a Simulation Engine,
- and a Simulation GUI.

**Simulation Engine**

The simulation engine is the core of our simulator. It drives the simulation loop and advances the simulation time. For each simulation loop, it calculates the position and preparedness for all Defence Elements in the system, as described above. As events are generated, they are accepted or rejected based on the limitations of the simulated system. If an event is accepted, its start time is calculated in relation to the most recent event of the same type, and it is placed in the input queue. The input queue is sorted by the arrival time of intelligence. This is the time at which information on an upcoming event becomes available.

There are two system parameters that affect the acceptance or rejection of generated events: the total system capacity and the input queue capacity. If an incoming event cannot be accepted due to the system capacity limit, but has a higher priority than one or more events currently in the input queue, it will replace the lowest-priority event.

Events which linger for too long in the input queue without obtaining the required resources will expire and be removed from the system. Events which secured resources in the input queue are moved between the queues based on their internal parameters such as location, start of event, duration, etc.

**Simulation GUI**

The Simulation GUI (Graphical User Interface) gives a high-level view of the current state of the system, including both supply and demand models.

Interaction between the simulation engine and the GUI occurs through an event-driven interface. There are two types of events fired from the simulation engine to the GUI – the update event and the increment event. Note that ‘event’ in this context means something quite different to an ‘event’ as used in the context of the model itself.

An update event is fired to the GUI when a simulation event changes state in some way. For example, an update event might be fired when a deployment event moves from the deployment queue to the travel to theatre queue.
An increment event is fired each time the simulation time is increased. It contains sufficient information for the GUI to represent the current state of the system.

Figure 2 shows the GUI during simulation. It can be seen that the GUI is divided horizontally into three main sections. Each section relates broadly to a particular aspect of the simulation. At the very top is a toolbar for interacting with the simulator.

The top section relates to the supply model. It shows the preparedness of Defence Elements currently in the pool of resources. There are three tables to the left of a graph. The tables show - from left to right - Defence Elements, Roles and Preparedness Levels. The graph shows the current preparedness levels for each role.

The middle section is similar in function to the top section, but relates to the demand model, in that it shows forces currently allocated to events. The four tables show - from left to right - Events, Defence Elements, Roles and Preparedness Levels. Again, the graph shows current preparedness levels for each role selected in the tables.

The bottom section shows more information relating to events. The world map at the left shows the locations of forces and events. The table in the middle gives more detailed information on the currently selected event. The graph at the right gives a timeline and visualisation of the forces contributing to each event currently underway.

VERIFICATION
To verify modelling assumptions a series of experiments were conducted using an unclassified data set. The model was populated with DPR plans represented in tabular form. Independently, research results of collective learning and skill retention in the Canadian Defence Force, US Army Research Institute and Naval Postgraduate School in Monterey California were incorporated into our model [2,3,4].

Behavior of the model was analysed from a concurrency point of view. For each number of concurrent events in the system (as an independent variable) 30 simulation experiments were executed to ensure statistical significance. Each simulation run covers a 30 year period. The simulation results were analysed by using SQL scripts and then statistical analysis was performed. A single factor ANOVA (significance level $\alpha = 0.05$) was employed to test the null hypothesis that there is no difference between the means of the response variables for all different numbers of concurrent events trialed. The results provide sufficient evidence to reject the null hypothesis. The alternative hypothesis that results are due to the variability of an independent variable (number of concurrent events in the system) is justifiable.

RESULTS
The performance metric has been defined as the ratio of successful events divided by failed events to the total number of events during the simulation period. Events are judged to be successful or failed on the basis of their level of resourcing and the timeliness of the resourcing. System success as a percentage was measured by the number of successful events during 30 years of simulation time compared to the total number of events over this period and averaged out over 30 simulation runs. The system failure rate was measured in an equivalent manner.
Figure 3 clearly demonstrates that there is a point above which the number of failed events will exceed the number of successful events. Lack of resources in the appropriate time frames due to the spread of resources across different events will cause more failures than successes. We now have two ways to assess the performance of a force structure: we can monitor the success or failure of key events, and we can monitor the system failure to success ratio. Figure 4 shows the success and failure trend as a function of the number of concurrent events.

In Figure 5, we can see that deployment of Defence Elements becomes increasingly delayed (on average) with more concurrent events (Sq10 to Sq1000). It is clear that higher demand results in more stress on some Defence Elements although there are others that are not affected at all such as airports, bases or infrastructure (e.g. De217). Since such Defence Elements are reusable and immobile, their throughput is effectively unconstrained in our model as measuring individual Defence Element throughput is outside our scope.

CONCLUSIONS
We have applied a hybrid simulation model of defence preparedness for the purpose of analysing force structure options from a preparedness perspective in support of the defence episodic review process. Working with an unclassified data set, we have confirmed we can analyse a force structure conducting...
concurrent operations and identify the over and under stressed Defence Elements. The results presented verify our modelling approach and lay the foundation for analysis of official planning vignettes.

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Managing Complex Multiple Simulation Exercises

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Abstract. Australian Defence is an example of an enterprise that is managing complex simulation requirements. Typically these are grouped as a named exercise, such as *Talisman Indigo 2015*. The synthetic environments must be planned, designed, developed, tested and supported during the production period of the exercise execution. With multiple exercises being run each year, over the planning horizon of two to three years, this can become a significantly complex management area. How to manage complex multiple simulation exercises is the simulation industry issue that this paper addresses. This paper presents a high level design for a management system to control the progressive development and execution of simulation exercises.

**MANAGER’S DASHBOARD**

The starting point for the management view is the manager’s dashboard showing the exercises in date order down the left and the stages across the top, with colour coding as to their current status. Each cell is a drill down link into more detail about the status of that component.

![Manager's Dashboard](image)

Each coloured cell can drill down into a component list and individual status. For example, Production Support may have the elements:

- Area of Operations defined
- Participating simulators configured
- Networking configured
- AoO Data loaded

This drill down report is illustrated below:

![Elements of Progress Tracking](image)

The data to support these visualisations is drawn from the underlying project management system which defines and structures the dimensions of the reporting tree structure. Setting target dates within that system enables the visualisation to build a coherent view across the simulation exercise space.

Status updates can be sourced from a variety of systems, including the real time operational support of the network to give a manager’s view of network and system overall up or down status.
The benefits for the management of multiple simulation exercises include:

A rigorous definition process of the steps required to execute a simulation exercise, which ensures that all steps are captured and reported.

Early management focus on those components of the exercise preparation that have not been completed on time, through the use of the Green-Yellow-Red traffic light visualisation of the exercise components.

Provide a geospatial view into the Area of Operations for different exercises. Data loading is one of the complexities of exercise management and the system can provide progressive detail on the conversions required and how they are being accomplished to ensure that all simulators in a simulation will receive their base data in the format that they need.

For an exercise in progress, the IOC portal can be configured to redisplay the various operational screens to provide oversight into current operations.

IBM Intelligent Operations Center provides a system for storing appropriate procedures and activities that are associated with events involved in the preparation and setup of simulation scenarios. For example users can track the progress of procedures, and monitor or update the status of activities that are assigned to them.

**IBM INTELLIGENT OPERATIONS CENTRE**

**Features**

IBM® Intelligent Operations Center provides measuring, monitoring and modelling facilities that can integrate underlying systems into one solution. This improves the operational efficiency, scenario planning, and coordination of multiple simulators.

IBM Intelligent Operations Center is a GUI-based product that provides role-based access to data for an organisation and underlying domains. It has event management and integrated mapping capabilities. The solution can supply and track the appropriate procedures and activities in preparation for and response to events. It also has key performance indicator reporting (KPIs) and collaboration capabilities for improved effectiveness. These features provide users with the ability to integrate domains for improved cooperation and decision-making.

**Event and data management**

IBM Intelligent Operations Center provides an event reporting and data tracking mechanism to enable identification and understanding across underlying domains. It can manage predicted events, planned events, and current events as they evolve.

An integrated geographic information system (GIS) or location plan maps events visually. For example, managers can gauge the impact of events through interactive mapping and scenario analysis. Users can filter information about events that are based on date and time, location, and other categories that you define. Filtered information can be either highlighted on a map, or listed in a table. The information is easy to access when and where needed.

**Response and activity management**

IBM Intelligent Operations Center provides a system for storing appropriate procedures and activities that are associated with events involved in the preparation and setup of simulation scenarios. For example users can track the progress of procedures, and monitor or update the status of activities that are assigned to them.

**Status monitoring**
IBM Intelligent Operations Center provides a tool for creating and displaying KPIs. The KPIs can be updated as underlying data changes. This means the following tasks can be accomplished with minimal effort to monitor the progress of exercises in various stages of development:

- Summarise executive-level status for a single domain or across domains
- Highlight issues and identify problems
- Investigate further by drilling down into the KPI details

![Image of Dashboard Example](image_url)

**Figure 26:** Dashboard Example

**Instant notification and messaging**

IBM Intelligent Operations Center provides a workspace that can maintain notifications for matters that need attention. This workspace can be used to monitor KPIs.

**Viewing reports**

The IBM® Intelligent Operations Center is designed for personnel who are involved with operational control in organisations and the management of simulation exercises: executives, supervisors, and operators.

Having access to meaningful data is only of use if the information can be presented in a meaningful and timely fashion. IBM Intelligent Operations Center gives all the advantages of tailored summaries and graphical presentation where reports can be viewed graphs, tables, or pie charts. Users can filter the information that is displayed in the reports that are based on date and time, location, and other categories that can be used to collect and present the information that is most useful on an up-to-date and regular basis.

**CONCLUSION**

In summary, the IBM Intelligent Operations Centre solution provides a foundation for the coordination of multiple concurrent exercises in various stages of development, with visualisation of management status.
Investigations Into Transient Simulations Of Thermal Propagation During Laser Pan-Retinal Photocoagulation

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Abstract. Ophthalmic laser treatment has been the standard of care for diseases such as proliferative diabetic retinopathy since the early 1970’s. It is less invasive and more cost effective than treatment with anti-VEGF (vascular endothelial growth factor) pharmaceuticals and has demonstrated a longer lasting clinical effect. Studies have tried to optimise the effectiveness of laser procedures by manipulating treatment parameters such as spot size, pulse duration and laser power. Recent investigations use computer models to simulate the laser procedure, the results of which are then compared to animal trials. Previously, investigations into optimization of the pan-retinal photocoagulation (PRP) procedure have focused on the adjustment of individual parameters; however this does not recognize the mutual dependence of the clinical outcome on these parameters. A finite element, time domain COMSOL based simulation model has been developed to optimize treatment conditions relating to pan-retinal photocoagulation. Such simulations can be used to determine more effective treatment conditions.

Keywords: Photocoagulation, diabetic retinopathy, laser therapy, thermal propagation, retinal sparing.

INTRODUCTION

Laser pan-retinal photocoagulation (PRP) has seen wide spread acceptance since its introduction in the early 70’s, and remains the standard of care for treating eye diseases such as proliferative diabetic retinopathy (PDR) [1]. This study uses a finite element, time domain COMSOL based model, simulating three dimensional heat transfer in retinal tissues. The objective is to investigate different laser profiles and treatment parameters to optimise delivery of laser energy to confine tissue coagulation within the retinal pigment epithelium (RPE) layer.

The neural retina, which precedes the RPE along the path of the incident light ray, contains photoreceptors and damage of these layers results in a loss of visual acuity in peripheral and night vision [2]. Heat diffusion into the choroid proceeding the RPE can cause pain and discomfort during PRP. Containing thermal energy specifically to the RPE layer will reduce recovery times and destruction of surrounding tissue layers. A reduction in the thermal diffusion will also result in less patient discomfort during the procedure and decreased patient recovery times [3].

Models based on dosimetry can produce inaccurate results due to widely varied pigments and absorption properties within the different eye tissues of patients. In practice, the laser power required to achieve appropriate levels of coagulation is a factor which is completely subjective to the individual. A difference in race, age or ethnicity are some of the determining factors in the degree of pigmentation of the RPE and the choroid and hence the absorption characteristics of the tissue layers. A patient with a non-pigmented choroid (NPC) requires different treatment parameters to one with a heavily pigmented choroid (PC).

This study considers the effects of changes to laser treatment parameters, including their influence on the subsequent thermal diffusion into surrounding non-irradiated tissue. Variations in patient tissues have been considered in the modelling which requires adjustment of parameters to maintain consistent coagulation areas. Confining the ED50 threshold (the point of confidence for 50% of cell death in irradiated tissue) and its corresponding tissue temperature within the RPE layer can reduce the pain response of the patient caused by thermal penetration into the choroid. More importantly any reduction of collateral damage to photoreceptors in the neural retina will improve patient recovery times and minimise loss of visual acuity and night vision, side effects that can be associated with this procedure.

Photocoagulation in the retina has been documented to be achieved when the tissue is raised to a temperature of 60°C, however the clinical requirement of cell death is represented by the ED50 threshold. In laser photocoagulation this is defined as irradiation of the RPE layer to reach or exceed 63°C [4]. This latter value has been confirmed by calculations and measurements of peak temperatures [5].

METHODOLOGY

The original model was built as a representation of the complete human eye, 24 mm along the pupillary axis, and 23 mm along the vertical axis [6]. Investigations with this model found marginal temperature rise within the vitreous humour of the eye and it has been confirmed by [6] showing no significant temperature rise of the tissues preceding the neural retina. The lens and its absorption of laser power were not included in this part of the study as the focus is on the energy delivered to the retinal tissue.

Consequently, the model geometry was truncated to a size that produced faster computational times, without influencing the results in the region of interest. The axial symmetry of the represented single incident laser beam was also utilised to simplify calculations and highlight the cross section of interest. Two variations of the retinal model, representing the extremes of
pigmented choroid and non-pigmented choroid, were created using the parameters defined in previous studies [6]. Both the PC and NPC variants showed results consistent with those of the published data.

It is accepted that the therapeutic effect of PRP is triggered by denaturation of the proteins in the retinal pigment epithelium (RPE), caused by raising the temperature of the melanin granules in the RPE layer to 60°C or greater [7]. The ED50 represents the effective dose for 50% of cell death in the tissue. Any other tissue destruction (i.e. surrounding tissue reaching or exceeding 60°C) is considered collateral damage and should be avoided to reduce the side effects of treatment. The main effect of the denaturation of surrounding tissue layers is the destruction of photoreceptors, causing degradation in the quality of the visual field in the periphery of vision. Input parameters were modified to analyse the resulting change in peak and average temperatures and the thermal dissipation through the surrounding tissue layers.

For this study, parameters (laser power, spot size etc.) were adjusted to produce a coagulation (ED50) area coincident with that of the laser spot that provides the energy source. Knowing that the lesion will only expand to the targeted area gives the surgeon added confidence in the procedure. This would be desired in practice, regarding the fact that visual recognition of the tissue denaturation can have a substantial time delay.

Using the simulator, parameters can be found that result in optimising ED50 conditions of the irradiated tissue. Parameters of the model were modified to achieve optimal results with the finest resolution. Tissue characteristics utilised in the model were taken from published data [6]. The number of mesh elements changed with model variations; we used a variable size triangular mesh, with a minimum of 5,900 mesh elements on the simplest (axially symmetric, NPC) model. Laser pulse durations were based on current treatment modalities, and time steps were interrogated at 1 µs intervals with a relative tolerance of 10⁻⁵ and an absolute tolerance of 10⁻⁶ degrees.

Once the models of retinal tissue are created in COMSOL it would be easy to change parameters and analyse the resulting thermal characteristics, significantly reducing the cost of prototyping. Systems utilising beam shaping technologies are difficult and expensive to manufacture and require significant tooling to change the spatial profile of the incident laser beam. Modelling provides a pathway for the optimisation of parameters that can be tested with a degree of confidence and the reduced need for numerous variations of the prototype.

An assumption for the model is that melanin granule distribution can be ignored as it has been shown that this distribution is negligible for laser pulses exceeding 1 ms [5]. Blood perfusion within this time period has also been shown to have a negligible effect on convective cooling through the choroidal tissue [8].

**RESULTS**

**Typical treatment conditions**

Initial studies aimed to model thermal conditions by utilising parameters typical of currently accepted therapies. Figure 1 shows the axial cross section of retinal tissue for an eye with a NPC. In this case the laser beam (diameter at the retina 500 µm, power 106 mW and 100 ms pulse duration) is represented as a thin disc heat source within the highlighted area within the RPE layer. All figures are temperature contour plots, symmetrical about the vertical axis coinciding with the line of symmetry of the incident laser beam. Figures show (A) Neural retina (B) RPE (C) NPC and (D) PC.

**Figure 1:** Temperature distribution in retinal layers of a human eye with a non-pigmented choroid.

Figure 2 shows a cross sectional contour plot of a PC, with 50% of the incident laser power absorbed in the RPE and the remainder in the PC. To achieve the same ED50 area of coagulation, the PC required a 22% increase in laser power compared to the NPC.

**Figure 2:** Temperature distribution in retinal layers of a human eye with a heavily pigmented choroid.

Both models showed similar thermal diffusion in the neural retina, but as expected the absorption of energy...
in the PC causes higher temperatures in the choroidal layer. The results for the PC displayed a 7% lower peak temperature but 40% deeper penetration into the choroid than the NPC. The volume encompassing the desired ED50 threshold (63°C) was similar for both tissue compositions.

**Beam shaping**

A promising method to restrict coagulation to the retinal layer is to shape the spatial profile of the delivered laser beam. This has been simulated in previous studies using a rabbit model [9] which was based on limiting the peak temperature using Probit analysis. The simulations used in this study have used the ED50 threshold as the limiting factor, producing favourable results. Figures 3 and 4 represent optimisation of the inner diameter (ID) of an annular laser beam with fixed outer diameter (OD) of 500 µm.

**Figure 3:** NPC using an annular beam of 176/500 (ID/OD).

**Figure 4:** PC using an annular beam of 195/500 (ID/OD).

In this case the outer edge of the ED50 was restricted to coincide with the outer edge of the incident laser beam, then ID and power level was adjusted until the ED50 condition was realised at the centre of treatment area. Spatially modifying the laser beam shifted the peak temperature from the radial centre of the laser beam to a ring of diameter approximately half that of the outer diameter of the laser beam. For an annulus with a 500 µm OD (outer diameter) and a NPC, optimal results were achieved with a 120 µm ID (inner diameter). The PC variant required an 11% larger ID and 20% more laser power to achieve the same conditions when compared to the NPC.

In comparison to their respective traditional parameters, both annular beam variants demonstrated significant reductions in ED50 areas for tissue surrounding the RPE. The PC required 9% less laser power and achieved a 12% reduction in peak temperature, with the NPC also needing 7% less laser power and achieving a 10% reduction in peak temperature.

**Short pulse parameters**

To enable the use of scanning lasers, pulse durations are reduced to deliver a sequence of pulses within a manageable treatment period, nominally 500 ms. Using a shorter pulse duration requires an increase in delivered laser power to maintain a fluence (energy per unit area) level sufficient for photocoagulation. In order to eliminate unwanted side effects caused by the increased power density, such as microbubbles or cavitation, smaller spot sizes are used. Figure 5 demonstrates the large area of tissue that is approaching 100°C within the RPE of a 500 µm spot. This temperature increase will likely cause significant amounts of pain, and can be mitigated by reducing the spot size to 200 µm.

**Figure 5:** PC, 20 ms pulse and 500 µm spot.

Using this smaller spot size with the longer (100 ms) pulse is not ideal, as the thermal spreading is almost spherical using these parameters. Using a shorter (20 ms) pulse and spot size retains an elliptical thermal profile, showing greater confinement within the RPE. The short pulse using a 200 µm spot size has a similar peak temperature to that of a long pulse with 500 µm spot size, reaching 91.4°C and 91.8°C respectively in a NPC. The PC also demonstrated 92°C and 93°C peak temperatures respectively.
Short pulse with annular beam profile

The thermal characteristics of the irradiated tissue under short pulse conditions were also analysed for the effects of an annular beam profile. For a NPC, short laser pulses and a 200 µm spot the optimal size of the annulus was achieved with an ID 38.5% of the outer diameter. When compared to traditional parameters (long pulse, large spot and homogenous power distribution), the short pulse with a spatially modified beam (shown in Figure 6 & 7) demonstrated an 11% reduction in peak temperature.

CONCLUSION

Using COMSOL simulations of thermal conduction dynamics enables investigations into surgical procedures to be performed with minimal expense and reduces the risk to patients by analysing the resulting tissue reactions prior to clinical trials. This process hastens the speed at which surgical treatment systems can be produced and improved. Simulations show that shaping the spatial and temporal profile of the treatment laser beam is an effective way to restrict the thermal propagation of the coagulated area. This in turn will improve the treatment procedure and its side effects by reducing the damage to the photoreceptors and tissue layers surrounding the RPE.

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Figure 6: NPC, 20 ms pulse, 77/200 (ID/OD).

Figure 7: PC, 20 ms pulse, 80/200 (ID/OD).

The most significant results were seen in the reduced volume of collateral damage to tissue layers surrounding the RPE, while satisfying ED50 conditions within irradiated zone of this layer. Variants that combined spatial and temporal modification showed 10-15% reductions in peak temperature when compared to their respective traditional parameters. These modifications to the beam profile could have significant implications for improvements to the PRP procedure.
An introduction to conducting qualitative research in simulation-based education

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Presenter Details. Associate Professor Margaret Bearman has conducted many qualitative studies into simulation-based education, drawing from a range of methodologies including grounded theory and phenomenology. Professor Debra Nestel has an international reputation as a simulation-based education qualitative researcher, including notable qualitative studies of simulated patients. Together with Dr Kristian Krogh, Debra and Margaret have recently conducted a qualitative study of expert debriefing practices in Australia. All three presenters are highly experienced workshop facilitators in the area of simulation-based education and educational research.

Overview. This workshop introduces participants to the basics of qualitative research methodologies with a focus on simulation-based education.

Expected Outcomes. At completion of this workshop, it is expected that participants will be able to:

- Differentiate between qualitative and quantitative research
- Formulate a qualitative educational research question relevant to simulation-based education
- Outline qualitative data collection tools
- Describe the experience of conducting a basic level of qualitative analysis.

Detailed Description. Research in simulation-based education is increasingly drawing on qualitative approaches to understand how learning and teaching occurs within simulated environments. In general, qualitative research is a rigorous and systematic approach to collecting and analysing data in order to better understand complex social phenomena. This workshop is aimed at novices to qualitative research. It provides an introduction to the concepts underpinning qualitative research approaches, using practical activities and examples from simulation-based education.

Evaluation. In addition to a simple evaluation survey, a learning needs analysis approach will be used to frame the session, providing both proactive and outcome evaluation data. The participants will complete a learning needs form pre and post the session, exploring their understanding of the topic domain and asking them to frame their learning goals.

Timeline.

- Introductions & learning needs analysis (10 minutes)
- Differences between qualitative and quantitative research paradigms (20 minutes)
- Framing the research: writing qualitative research questions (20 minutes)
- Qualitative data collection tools and analysis (40 minutes)
- Summary and learning needs analysis (5 minutes)
Rural Educators For Rural People

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Aims. To increase clinical skills levels of the rural health workforce using local knowledge and resources.

Background. Easy access to regular clinical skills training in rural and remote areas of Australia by health professional staff and for students on clinical placement is limited, with many training activities occurring in metropolitan or large regional centres.

The Greater Green Triangle University Department of Rural Health (GGT UDRH) Simulation Program delivers simulation activities across regional South Australia (SA) and south west Victoria (Vic) with a distributive training model that utilises local educators based in health services in local country towns. This study was to determine if locally based educators are able to deliver quality simulation workshops in fundamental clinical skills effectively and efficiently, lessening the need for travel to and from larger centres.

Methods. Registered Nurses (RNs) and Registered Midwives (RM)s already working in local health services were employed as clinical educators on a casual basis to deliver simulation training activities to health professional staff and students. Educators were based in district hospitals at Mount Gambier, Murray Bridge, Gawler, Port Pirie, Port Augusta, Whyalla, Tumby Bay, Roxby Downs and Ceduna in SA, and Hamilton, Portland, Warrnambool and Colac in Vic.

All workshop activity, such as number of participants, the date of the training, the health discipline/profession of the participant, the simulation modality and the number of training hours were recorded for each workshop. Workshop evaluation forms were provided to all students.

Individual semi-structured interviews of clinical educators were conducted during the early months of 2015. The informant interviews were recorded using digital voice recorders and these recordings transcribed verbatim. Transcriptions were subsequently read and coded by Sarah Boyd and Sandi Elliott with emerging themes being defined within key data clusters using a grounded theory approach.

Result. During the project term, (July 2013 – December 2014), rural clinical educators delivered 713 workshops across 46 towns to 3,411 professional entry students and 1,554 rural health professional staff for a total of 10,467 training hours. In all, participants were from 72 public and private health services, including Aboriginal Cooperatives and 19 educational training providers. Disciplines of those attending workshops were Aboriginal Health, Dentistry, Dietetics, Health Sciences, Human Movement, Medicine, Midwifery, Nursing, Paramedicine, Pharmacy, Psychology, Social Work and Speech Pathology.

Key themes that emerged included:

1) Easy access - staff had access to training without having to have extended times away from the workplace reducing cost and backfill of staff.

2) Training relevant to workplace practice - previous training ‘off site’ was not always a true reflection of current workplace practice. Staff benefited as they could practice clinical and communication skills in their own workplace with educators who worked in relevant clinical conditions.

3) Improved patient care - upskilling in rural workplaces resulted in higher educated staff therefore improving patient care and treatment.

4) Education and training of educators - educators themselves gained valuable educational skills through the provision of regular workshops.

5) Enrichment of rural clinical placements – students had more opportunities to access simulation training resulting in increased interactions with local health professionals and other students.

Conclusions. This teaching model utilises knowledge and skills of already placed health professionals in rural areas to deliver simulation activities across country areas that are relevant to curriculum requirements, competency levels and the rural environment. Local health professional staff and students were able to access training on a regular basis and the number of workshops delivered and training hours represented a significant increase. Whilst providing flexibility of education requirements around staff availability, and student placements, the activities were designed for relevance to workplace practice. This suggests that using rural based educators in country areas increases participation and training of rural health professionals, subsequently limiting the need for travel to metropolitan areas for education and training.
Adding ‘Life’ To Rural Emergency Disaster Management Training

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Aims. To enhance education and training in emergency disaster management in rural areas and increase active engagement through the provision of trained simulated patients (SPs) in large scale disaster training exercises.

Background. All certified airports in Australia are required to run an emergency exercise every two years as part of Civil Aviation Safety Authority compliance regulations. In rural South Australia (SA) and south west Victoria (Vic) these exercises have been limited by a lack of realism and have not involved local hospitals or transport of casualties. We wanted to determine if SPs altered the way emergency responders interacted with this activity and whether their presence influenced policy and practice in emergency disaster management.

Methods. GGT UDRH in collaboration with SA Police (SAPOL), SA Ambulance Service (SAAS), SA Metropolitan Fire Service (SA MFS), SA Country Fire Service (SA CFS), Mount Gambier and District Health Services (MGDHS), State Emergency Service (SES), Mount Gambier Airport, Glenelg Shire Council, Victoria Police, Country Fire Authority (CFA), Ambulance Victoria, Sharp Airlines, Portland Airport and Portland District Health (PDH) participated in two field exercises (N=125 participants). The exercises involved a simulated plane crash resulting in multiple injured persons, where emergency responders would follow incident management and recovery arrangements with the view to exercising Airport Emergency Plans, Limestone Coast Local Service Area Disaster Plan and Standard Operating Procedures (SOPs) for their respective agencies. SPs were recruited to play the role of victims and each trained in a specific scenario to enact out at the disaster site, en-route to the hospital and upon arrival at the hospital Emergency Department (ED). All SPs had moulaging applied to reflect injuries and contained case cards to describe the initial situation and management, and progress en-route to the hospital (Mount Gambier, 3 SPs were deceased at the scene, 5 critical and 5 walking wounded while at Portland 2 SPs were deceased and 6 triaged for ED). To complicate matters a non-English speaking person was portrayed at the Portland exercise and at Mount Gambier, a trained SP presented to the ED triage with chest pain at the same time victims were arriving from the airport.

A hot debrief on ‘lessons learned’ was conducted by Exercise Control for participating agencies (62 in Mount Gambier and 41 in Portland). Separate face-to-face debriefing sessions were also held within 3 months following the exercise. Notes were recorded from each meeting and responses collated.

Result. Compared with previous emergency exercises, all agencies agreed that they were more immersed in the exercise as the addition of moulaged SPs as victims and quality of injuries provided an excellent layer of realism that they had not previously experienced. Due to the authenticity of the exercise a number of organisations were able to trial policies and procedures not previously executed. For example;

- SAAS trialled a new triage system and were able to identify how long this process took in the mass casualty scenario.
- Local emergency and health services were able to practice patient extractions and triaging at the scene before transportation to the ED for activation and testing of hospital Code Brown responses.
- The addition of non-English speaking SPs allowed emergency crews to quickly identify communication barriers and practice their non-verbal gestures throughout the crisis.

Other feedback from participants included;
- Emergency processes were clearer with the use of SPs as they provided better understanding of current procedures e.g. Ambulance and Police personnel having to wait for fire services to declare the site safe before attending to casualties.
- Greater understanding by ambulance and hospital staff about field systems, timings and how the triage system worked.

As a consequence MGDHS and PDH will now undertake a full review of their Code Brown response and disaster triage.

Conclusions. The airport exercises provide agencies the opportunity to practice response and recovery, command, co-ordination and control functions during a large community disaster. The addition of trained moulaged SPs offers a more ‘life like’ situation resulting in a higher level of professionalism and supports stronger cohesion between agencies/personnel including medical responders, clinicians, public health professionals and emergency services. We therefore recommend that SPs be routinely used in rural airport disaster exercises to improve the training, education and trialling of emergency policies and procedures, potentially reducing casualties and strengthening partnerships, improving collaborations and teamwork between health and emergency services.
Deakin’s Rural IMMERSese Clinical School
“Virtual Clinical Setting” to Promote Equality of Student Teaching & Equity for Student Learning Outcomes

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Background Students enrolled in the IMMERSese (Integrated Model of Medical Education in Rural Settings) Program participate in a longitudinal integrated clerkship for their third year. The year’s academic teaching is based on six third year disciplines including Mental Health, Children’s Health, Women’s Health, General Medicine, General Surgery and Musculoskeletal Medicine via students being supervised from a general practice in a rural town.

During the IMMERSese program review concerns raised included:
- The equality of student teaching compared to the rest of the third year cohort based at the larger clinical schools.
- IMMERSese student’s believed they were disadvantaged as they didn’t have the clinical exposure of a number of common condition patients
- The larger clinical school students had multiple opportunities to see a large number of common condition patients

Aim The aim of the “Virtual Clinical Setting” Program has been consistent in;
- the simulated environment allows students to demonstrate their knowledge and to practice both clinical and non-technical skills without time pressure and / or risk of causing harm to ‘real’ patients or themselves. It will also provide equality of student teaching and equity in student learning outcomes as compared to the rest of the third year cohorts.

Methods Adopted. A “virtual clinical setting” was created to expose the IMMERSese students to a number of different patients with a variety of common medical conditions. Using the simulated learning environment, manikins and simulated patients were used to mimic real patient scenarios including; paediatric, women’s health, mental health, general medical, surgical and musculoskeletal medicine.

The IMMERSese students attended seven simulation sessions throughout their third clinical year. At each session the students work in teams to provide a treatment and management plans for four patients. In order to prepare the students for the session they are provided with pre-reading material and learning objectives.

At the completion of each simulation session all students completed an evaluation. The evaluation also asked students to document their four key learning points from the session.

Evaluation Data from the Program. Simulated learning environments have been used as a teaching method throughout university medical school curriculum. Students appear to have benefited from the simulation teaching modality, which allows them to practice performance as medical professionals in a safe environment which mimics the ‘real’ workplace. The student evaluations post attendance in the “virtual clinical setting” scenarios indicate they are more confident in treating and managing these patients and they felt more prepared to work in their rural country town clinics and hospitals.

The Program provides equality of student teaching including:
- IMMERSese students have a wider exposure to the common condition patients in all six year three disciplines by participating in the scenarios

The Program also provides equity of student learning outcomes including:
- The students have the opportunity to participate and repeat the scenarios
- The students are provided with learning objectives, references and debriefing notes to reinforce their learning to promote confidence, familiarity and knowledge to support the student in the ‘real world’ when faced with this kind of common condition patient

Conclusions and Recommendations for Future Use and Development. In conclusion the literature states the better the clinical placement in the medical student’s final years the smoother the transition for the medical student to progress to internship (AMA 2007; Gome, Paltridge & Inder 2008).
In our experience we have observed the virtual ward experience permits students to be taught in a safe simulated environment. This teaching program has provided our medical students with an appropriate foundation to build their professional careers (Goldacre, Davidson & Lambert 2003) preparing them for internship.

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The Coffs Harbour Clinician Airway Monitor Course
A Work in Progress

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Aim of the Education Program.
Approximately 300,000 episodes of procedural sedation occur annually in NSW hospitals. Much of this sedation is overseen by non-anaesthetist clinicians. While the majority of procedural sedation is administered to low risk patients and occurs without incident, there are consistent reports of poor patient outcomes from sedation and concern about failure to align the appropriate resources with patient need. Considerable variation in skill levels between nurses who care for sedated patients has been reported. (1)
The role of clinician airway monitor is specified in the NSW Health Clinical Procedure Safety Policy PD2014_036. (2) In the absence of an anaesthetist or credentialed sedation provider/sedationist, there must be a nominated Clinician Airway Monitor, whose primary role is to monitor the level of consciousness, airway and haemodynamics, and provide support and rescue (when necessary) to the patient receiving procedural sedation. The required level of knowledge, skills and behaviours, and the training appropriate for this role, has not been previously described. The Coffs Harbour Clinician Airway Monitor course was established to support safe procedural sedation, in line with the requirements of PD2014_036, and in concordance with the Minimum Standards for Safe Procedural Sedation described by the NSW Agency for Clinical Innovation. (3)

Methods Adopted.
The Clinician Airway Monitor course was designed to deliver the following educational outcomes:
Knowledge of rationale for patient assessment for procedural sedation, including which patients should be referred to the appropriate department of anaesthesia, fasting guidelines, general medical assessment, and risk stratification including ASA status and airway assessment, and recovery, discharge or transfer arrangements.
Knowledge of drugs used for sedation—including midazolam, ketamine, opioids, propofol.
Knowledge of equipment involved including oxygen delivery systems, bag and mask circuits, airway devices (Guedel, nasopharyngeal, laryngeal mask airway), cardiovascular and respiratory monitors including pulse oximetry and capnography, ECG and defibrillator.
Skills—ability to make appropriate patient risk assessment for conscious sedation, and to make appropriate referral to department of anaesthesia for higher risk patients.
Skills including provision of intravenous access, application of oxygen and monitoring devices, airway support techniques (chin lift, jaw thrust), insertion of airway devices detailed above, ability to provide bag/mask ventilation to an unconscious patient.
Behaviours—ability to function in a multi-disciplinary team, including in crisis management.
Behaviours—ability to provide timely and assertive advice to the proceduralist of any adverse effect to the patient of procedural sedation, especially a significant reduction in level of consciousness.

Evaluation Data from the Program.
This course has been delivered in pilot, and (with subsequent modification and improvement) throughout the Local Health District. Learner feedback was overwhelmingly positive. Objective testing has demonstrated early improvement in knowledge, and perception of skills retention.

Conclusions and Recommendations for Future Use and Development.
Further work will address the transfer of knowledge, and the potential for organizational change. Audience feedback is sought regarding the need for other learning outcomes or competencies, the availability of similar roles or training courses in other jurisdictions, the most appropriate assessment methods, and the potential for a national framework for the described role, or for the training underpinning this role.

References.
Development and Implementation of a Multidisciplinary and Cross-Sectoral, State-Wide Mechanism to Inform and Support Simulation-Based Education and Training in Victoria

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Introduction. In recent years, Victoria has embarked on a process of increasing its capacity to provide high quality clinical placement experiences for students. This process has enabled increased numbers of health students to access the clinical education and training necessary to provide high quality health care services to the community. Achievement of self-sufficiency in health workforce supply will require continuing increases in clinical placement numbers, as well as changes to the planning and delivery of clinical education and training. One part of the strategy to meet these challenges is the use of simulation-based education and training (SBET).

The Commonwealth and Victorian State Government have made a significant investment in simulation for Victoria over the last four years, with $23.5M of funding distributed via 38 projects through the Simulated Learning Environments (SLE) Program.

This investment has seen an increase in simulation resources across the state including simulation facilities, mobile simulation learning centres, educators and technicians, networks of simulated patients, equipment, and educational material.

The challenge now is to sustain and maximise the return on the investment made by State and Commonwealth governments.

Methods Adopted. To support the development of future strategic direction the department established an expert advisory group (EAG) that includes stakeholders from across Victoria.

The Simulation-Based Training and Education (SBET) Expert Advisory Group (EAG) is a multidisciplinary and cross-sectoral, statewide mechanism which has provided advice and guidance to the department to inform and support the development of SBET in Victoria.

The SBET EAG was established in September 2013. Members of the SBET EAG comprise project leads from each of the 2013-14 SLE Program projects and representatives from Clinical Training Networks where there was no SLE project in that area. Industry representation was also included with a Victorian Simulation Alliance representative participating in the group.

Results. Working together, the department and the SBET EAG identified three priority focus areas:
1. Ensuring sustainability of simulation.
2. Widening the simulation community of practice (CoP).
3. Developing an evidence base supported by research and data.

Throughout 2014, the EAG met monthly, and held five workshops to develop a simulation sustainability action plan for Victoria.

A workshop in February 2015 resulted in the development of a model of success for SBET in Victoria, which aims to embed simulation as a tool for education and training and to increase the recognition of simulation as a modality that provides broader benefits to an organisation, particularly in relation to risk reduction and patient safety improvements (see Figure 1).
Further workshops looked at how sustainability of simulation in Victoria could be supported through collaborative models.

Other initiatives to support sustainability and the simulation community of practice include: the development of a resource outlining the benefits of simulation to health services/organisations; a literature review looking at the links between simulation and patient safety; recommendations for a research agenda; networking and showcase events; and liaison with accrediting bodies.

**Summary.** The department, on advice from the EAG, are continuing to investigate collaborative ways to support sustainability of simulation in Victoria. Outcomes from this investigation will assist the department in establishing priorities for future investment in statewide capacity-building initiatives for clinical education, including principles as they apply to simulation, and will ensure that benefits from SBET are fully realised.

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Aim of the Education Program.

The SLiPAH program utilises simulated learning to enhance exposure to paediatrics for pre-entry level allied health students in Queensland. It develops clinical and non-technical skills and experience in assessment, measurement, goal setting and treatment of children, integrating SLE across the education continuum [1]. With the commencement of the program in 2013, simulation scenarios were introduced into curricula, with key constraints being scheduling particularly within established Program. Preliminary evaluation of learners’ reaction & self-perceived change was overwhelmingly positive [2,3]. Ongoing collaboration and analysis of training needs with university faculty, aimed to identify strategic entry points for learning and development of core skills throughout the curricula of each program. This in turn, would guide the overall structure, design and delivery of simulation in terms of number, frequency and timing of scenarios for each student cohort’s specific learning objectives and capabilities.

Methods Adopted.

Through a process of formal training needs analysis and faculty debrief, the Program identified standardised authentic evidence-based clinical experiences. Simulation scenarios were designed, and delivery methods were formulated specifically to provide deliberate practice according to the capability of the student cohort. The aim was to increase frequency of exposure as students approached clinical placement. Incorporating a combined approach of e-learning, skill acquisition was consolidated by simulation scenarios, which served to provide opportunity for development of curricula specific skills and knowledge.

SLiPAH subject matter experts (SMEs), all with intricate knowledge of current clinical practice were utilised in development and delivery to facilitate translation of research into clinical practice. The SMEs tended to move away from the ‘Part-task’ approach, favouring primarily ‘Pause & Discuss’ with a focus on non-technical skills. Ongoing pre-emptive communication with universities was vital to co-ordinate delivery. As the SLiPAH program utilises shared assets and expertise on a state-wide basis, a balanced approach to resource allocation and scheduling was developed to ensure optimal timing and frequency of delivery. The extent of each cohort’s exposure to SLiPAH was collated, as well as the applicability at time of delivery in relation to their course content.

Evaluation Data from the Program.

SLiPAH delivered simulation experiences to 14 Programs at 6 universities throughout Queensland. This consisted of 104 sessions with 18 of these in regional & remote locations. The total number of students who participated in SLiPAH delivery in 2014 was 2392:
1862 Physiotherapy,
377 Occupational Therapy,
115 Speech Pathology,
38 Interprofessional.
The students received a total of 3697.25 hours of simulated learning across multiple specialist areas of paediatric management. Participants were at varying stages of their university Programs and exposure varied between 1 and 6 sessions per student.

Qualitative feedback was significantly positive [3] across the board, but detailed analysis identified specific differences. When SLIPAH was integrated seamlessly into the curricula, with scenarios scaffolded from theoretical content into practical application, students’ response demonstrated a greater understanding. In contrast a session that delivered a clinical scenario that was not aligned with the curricula at that time; students identified the need for either smaller groups or for delivery to be scheduled differently.

**Conclusions and Recommendations for Future Use and Development.**

In 2014, SLIPAH attempted to find the balance in optimising allied health student learning opportunities throughout Queensland universities. It was clear from the constructive feedback and faculty debrief that the use of concurrent sessions must be aligned with the theoretical progress of the students. The introduction of SLE needs to be targeted to the knowledge level and skill of the students, to maximise learning. This can be achieved by embedding SLIPAH throughout the student journey, ensuring relevance and realism for the students. Therefore as the students’ progress there is a clear move towards scenarios requiring greater cognitive load, culminating in planned immersive experiences during clinical placements.

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Multidisciplinary Crisis Management Training – Value Adding To The ANZCA CPD Program

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Aims. To evaluate the acceptance of a simulation based multidisciplinary crisis management training program.

Background. In 2014, the Australian and New Zealand College of Anaesthetists (ANZCA) introduced a revised Continuing Professional Development Program (CPD) that encompassed three new categories including “Emergency Responses.” This was incorporated into the program to facilitate regular education in those emergency responses considered “core” to safe practice. Although considered core, these events are rare and Fellows are not likely to encounter these situations frequently (1).

One of the four activities is the management of a cardiac arrest, or Advanced Cardiac Life Support (ACLS). In the past, ACLS training has been either non-existent or performed each within the silos of the respective medical or nursing disciplines. Our department saw this as an opportunity to introduce mandatory simulation based multidisciplinary ACLS training; that included both senior and junior anaesthetists, as well as recovery and anaesthetic nursing staff, which goes beyond the requirements of the Australian and New Zealand College of Anaesthetists.

The focus of our program is on team performance and non-technical skills (NTS) as well as the understanding and application of the various Australian Resuscitation Council (ARC) algorithms.

Methods. Six participants were rostered to attend a 2.5 hour simulation session within the Royal Adelaide Hospital during working hours. Each group was made up of two consultant anaesthetists, two anaesthetic registrars, one recovery nurse and one anaesthetic nurse. The experience and skill mix of the participants in each session was deliberately engineered to replicate what may occur at any given day in a busy large tertiary teaching hospital’s operating suite.

A total of five scenarios were run over the course of the session. The first scenario was structured as not to assign specific roles to the participants. The subsequent debrief had a strong focus on team performance and NTS.

For each of the following four scenarios a different team leader was assigned. The expectation was that participants would apply the NTS discussed in the preceding debrief while applying the appropriate ACLS algorithm to safely resolve the patient’s clinical problem.

At the end of the session, each participant was surveyed with a questionnaire.

Results. As at the end of February 2015, 59 participants have successfully completed the multidisciplinary training (MDT) in emergency responses.

Trends from results to date show that, amongst other things, an overwhelming majority (over 90%) of participants found the experience of significant value, were likely to translate their newfound knowledge into their clinical practice, have a better appreciation of effective teamwork and see a strong need for regular ongoing MDT.

Discussion. Data to date confirms the high value placed on MDT in both technical and non technical skills. We have seen that familiarity and exposure to a simulation learning environment decreases anxiety and fear of losing face and achieves a greater acceptance of this training modality amongst both nursing and medical professions.

Both anaesthetists and anaesthetic/recovery nursing staff have accepted simulation based MDT as a valued and worthwhile training experience. Our long-term aim is to reinforce this perception and work to embed the culture of both regular simulation and MDT into our work environment. This has the potential to improve quality of care, healthcare provider morale and ultimately improve patient outcomes.
Future research would be useful to evaluate the extent to which participants have utilised their learning experience into a clinical context, in their own clinical work environment.

**Conclusions.** Although this program started as a CPD exercise for anaesthetists, results to date have shown that both clinicians and nurses have found the training and experience invaluable and are likely to translate learning into clinical practice.

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“They’re Not Just Little Adults!” Paediatric Emergency Response – Organisational Response To The Closure Of Mater Children’s Hospital

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Aim of the Education Program.

Mater Health Services (MHS) is a complex tertiary level teaching health service operating 3 hospitals at South Brisbane campus incorporating private and publically funded beds. In 2014, the landscape of paediatric services changed in Queensland, resulting with the closure of the Mater Children’s Hospital (MCH) and subsequent movement of the majority of paediatric services to Lady Cilento Children’s Hospital (LCCH) which is co-located at South Brisbane. The risk for MHS with this major change was that some Paediatric services continue, including paediatric presentations to both the private and public adults’ emergency departments. The questioned that remained for the MHS was “How do we adequately prepare staff with a significant knowledge and skill gap in paediatric emergency management for the ‘paediatric unknown’?” Paediatric Life Support (PLS) is a simulation education program that aims to ensure participants are adequately equipped with the skills and knowledge to respond to a paediatric emergency. The PLS program ensures that clinicians are accessing appropriate education on a yearly basis, and in conjunction with the Pop-Up Recognition of the Deteriorating Patient simulation program, their newly acquired skills and knowledge can be maintained through regular point of care (insitu) practice.

Methods Adopted.

Training of all members of the emergency response team in PLS commenced prior to the closing of MCH. Adaptation of the HWA funded PLS program was undertaken to enable an ALS refresher course to address clinical rostering requirements. All staff attending PLS were required to complete both PLS core and advanced e-learning modules prior to attending the course. This annual course was followed up by Pop-Up paediatric simulations in the clinical environment, reflecting educational theory pertaining to skill retention. MHS also worked closely with LCCH to run regular point of care (insitu) simulations that required a dual response from both emergency management teams. There was ongoing consultation and bi-directional feedback between Mater Education, Clinical Safety and Quality Unit (CSQU) and the resuscitation committee to ensure simulations met organisational need.

Evaluation Data from the Program.

The TEAM tool developed by Cooper et al., (2010) was used to evaluate team members’ leadership and communication skills in both the PLS and Pop-Up simulation programs. Post simulations participants along with faculty, evaluated teamwork skills using the TEAM tool. Post simulation participant survey was also conducted to evaluate learner reaction. Initial program data demonstrates an increase in teamwork skills and staff confidence within a paediatric deteriorating patient scenario. Further descriptive and statistical data will be analysed in July.

Conclusions and Recommendations for Future Use and Development.

The PLS simulation program has enabled those participants who do not have the background knowledge and training in paediatrics, an opportunity to develop skills and knowledge around the

References.


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Innovations and Emerging Trends - Situational Awareness and the New Cyber Challenges

Cyber Situational Awareness Challenges And Simulation’s Value

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Abstract: The cyber battlespace is increasingly dynamic and challenging. The volume of information available to decision-makers is increasing. The uncertainties about the state of cyber space, whether due to cyber attack, miscommunication, mechanical fault, or other problem, prevents rapid, effective, informed decision-making. The mere application of “big data” technologies cannot address the scope of the challenges. Therefore, assessing and comprehending the state of friendly cyberspace in near real-time (NRT) is a challenge. A few of the factors that impede NRT cyberspace situational awareness include network activity, data volume, network routing, software activity, software faults, analysis of bandwidth consumed, malware activity, and assessment of accuracy/reliability of data. The volume of information combined with the detail, and the speed of change of the data points to the need for situational awareness assistance for decision-makers in cyberspace. To address the situational awareness challenges in cyberspace, intelligent agents can be employed. The need for NRT assessment of data in conjunction with the need for rapid action in response to events produce a requirement for intelligent agents for situational awareness assistance that can assist humans in cyber state determination, activity detection, data assessment, data validation, and response.

In this paper we describe the technical challenges obstructing cyber intelligent agent development, the challenges posed to SA in the cyber battlespace, and the shortfalls to be addressed. The paper discusses the roles that simulation should play in order to research, develop, and integrate battlefield intelligent agent technologies into operational practice in cyberspace. We discuss the challenges of situation awareness and the roles that intelligent agents can play in addressing SA challenges. We discuss the uses of simulation to develop improved SA and intelligent agents. The paper concludes with a summary and future work.

1. Introduction

Situation understanding and adaptivity are the hallmarks of the modern information enhanced battlespace. However, the improved decision-making promised by information systems has not materialized. The problem and challenge arises from the vast amount of information that is available, uncertainty of information, difficulty in determining where to focus attention, and the rate of change of information coupled with the unvarying human capabilities for information assimilation and comprehension. A person’s brain is very difficult to change, but the manner of information presentation and the tools provided to assist each individual can maximize personal abilities for information assimilation and comprehension. Decision support systems are not equal either in their ability to convey critical information to users in support of specific decision contexts or in the degree that the decision support system is compatible with basic human information-processing abilities.

To overcome inherent human limitations in information acquisition, information understanding, and situation assessment, decision support systems have to be built with user limitations in mind as well as provide capabilities for minimizing taskload. In information intensive environments, humans can benefit from the availability of intelligent assistants to achieve improvements in situation awareness and decision-making. One of the most challenging decision making environments is the cyberwarfare environment because of both the volume and pace of data change. The challenges faced by humans in the information intensive cyberwarfare environment are exacerbated by the lack of tools to support situation awareness. The paucity of tools for cyber situation awareness calls for the development of intelligent decision aids to assist humans in understanding and acting within the cyber warfare battlespace.

The need to identify and diagnose attacks in cyber space is increasingly important. Cyber attacks continue to be successful and our current approaches to cyber defense do not seem to be having a noticeable impact on the permeability of cyber defenses to attack. Current cyberdefenses do not work for the life of the system they protect or even for an appreciable length of time after deployment of the system because new malware and cyberattack vectors are employed daily. The cyber defense’s problem is compounded by the generation of many false positive attack indicators using current cyber defense technologies. The large number of false positives requires active human monitoring, assessment, and response in order to identify and counter even rudimentary attacks. As a result of the need for active human assessment of cyber activity, subtle cyberattacks can be missed despite the investment in human monitoring. The challenges to situation assessment in cyber space arise from the large volume of data, the presence of uncertain and conflicting data, and efforts made by the cyber attacker to deliberately corrupt data.

Cyber attacks’ continued success demonstrates that our current approach to cyber defense is not effective and new approaches to cyber defense are needed. The press of events and the speed that data can be
exfiltrated or destroyed coupled with the continued success of cyberattacks results in pressure to decrease the amount of time that elapses between the beginning of a cyber event and its detection as well as between the detection of event and its termination. To decrease the amount of time that elapses during these two critical time periods, the cyber defenders require improvements in situational awareness concerning activities in cyber space as well as decision support system(s) that aid them in analyzing and understanding the importance of the activities that are detected.

The challenge faced by decision support system designers lies in ensuring that they provide useful, adaptable, and transparent support for situation understanding and decision-support despite rapid change. Intelligent agents have been a significant research topic for decades but the technology is not yet useful within cyberspace. In addition to being useful, the cyber intelligent agents must be robust, resilient, and able to withstand cyberattacks that target them in addition to shielding the users’ cognitive activities from attack [1-10]. As a result, the cyberspace intelligent agent must not only be able to distill and present data relevant to the user, the agents must continuously assess the information in order to determine if the data or the data acquisition environment have been compromised. Achieving this combination of goals is beyond the capability of traditional intelligent agent systems.

The use of intelligent agents to enhance situation awareness (SA) and decision-making in cyberspace cannot relieve the user from the need for acquiring deep, situational-oriented understanding and acting upon the situation as they understand it [11]. In general, situation awareness (SA) begins by perceiving information about the environment and coupling that perception with comprehension of the meaning of the information in light of the user’s goals. SA requires more than merely being aware of all of the data in an environment or all of the most pertinent pieces of data. SA requires developing and maintaining a mental model of the situation. Maintaining a mental model of the situation requires estimating the likely future state(s) of the environment and developing a model of the progression of the situation toward those projected state(s). In a complex environment, SA is difficult to achieve without training to prepare the user for both the breadth of the situations as well as the pace of change in the situations. Even given intelligent aid assistance, situation awareness-oriented training must focus on training operators to identify prototypical situations associated with different types of cyberattacks and cyberthreats by recognizing critical cues and what they imply. Decision-makers must also learn in the course of the training that situation awareness is not a passive process. Decision-makers must actively seek out and comprehend the information they require. Training in SA development can help decision makers to acquire the situation recognition and behavioral skills they need as well as complement the activity of intelligent agents. Because of the challenges that decision-makers face, intelligent agents must be designed to support user situation awareness development and maintenance.

The situation awareness (SA) challenges faced by cyberspace decision-makers are complicated by the characteristics of the cyberspace environment within which they operate. Cyberspace is dynamic and uncertain; therefore, the autonomous agent requires the capability to reducing the user’s workload by providing integrated observing, interpreting, communicating, planning, and decision-making techniques. In the dynamic cyber battlespace, momentary lapses in SA can have catastrophic repercussions. Additionally, a lack of operator knowledge and preparation or lack of procedures will result in system failure in the face of unexpected system conditions despite the best technologies for acquiring and distributing data. Conversely, procedures, training, and preparation cannot overcome failures in technologies for acquiring data, displaying relevant data, and/or failures to develop accurate shared situation awareness. Because of the complexity of cyberspace and the challenges faced by humans within it, the necessary intelligent agent knowledge bases are complex and difficult to develop.

In this paper we discuss cyber space intelligent agents and simulation’s role in bringing about their next generation. The paper introduces the technical challenges obstructing cyber intelligent agent development, the challenges posed to SA in the cyber battlespace, and the shortfalls to be addressed. The paper discusses the roles that simulation should play in order to research, develop, and integrate battlefield intelligent agent technologies into operational practice. In the next section we discuss the challenges of situation awareness and the roles that intelligent agents can play in addressing SA challenges. In the third section, we discuss the uses of simulation to develop improved SA and intelligent agents. Section four contains a summary and future work.

2. Background

The goal for cyberspace intelligent agents is to improve situation awareness and help users attain information dominance. The presumption is that intelligent agents will permit a faster response to cyberthreats and cyberattacks by reducing human response time and reducing the complexity of the data to be analyzed. The intelligent agents should help the user to identify critical information, help the user to acquire critical information and prioritize response to cyberattacks. The intelligent agents should also increase user awareness of an opponent’s activities in cyberspace, increase awareness of an opponent’s likely goals in cyberspace, help the user to identify profitable actions to be taken in cyberspace in order to dominate and exploit it, and, finally, reduce user stress. However, exploiting information dominance may be difficult due to the scope and success-rate of cyber attacks, which can adversely affect situation awareness. To improve SA, even during a cyber
attack, the intelligent agents must behave in a manner that enhances development and maintenance of situation awareness, allow users to concentrate on significant aspects of cyberspace and serves to minimize the user’s taskload. Before discussing these issues, a short discussion of SA in light of current technology is warranted [11-35].

Endsley [11,12] defines individual situational awareness (SA) as the following: the perception of the elements in the environment within a volume of space and time, the comprehension of the elements’ meaning, the projection of the elements’ status into the near future, and the prediction of how various actions will affect the fulfillment of one’s goals. Situational awareness is a rapidly changing, ephemeral mental model of an environment that must be assembled over time and continuously updated. Assembling the mental model requires knowledge of the current state of the environment.

SA arises by perceiving information about the environment and coupling that perception with comprehension of the meaning of that information in light of operator goals. SA does not refer only to static factors such as the knowledge of established procedures, doctrine, and skills; SA also refers to one’s perception of the dynamic state of the environment. SA requires more than merely being aware of all of the pieces of data in an environment, the significance of the elements (individually and in combination), or even all of the most pertinent pieces of data in an environment. SA requires development and maintenance of a mental model of the situation, including likely future state(s) of the environment as well as a model of the progression of the situation toward the future states. The challenge faced by the decision-maker lies in placing the elements of the environment into a meaningful, coherent pattern that yields a holistic picture of the environment that helps the decision-maker in comprehending the significance of objects and events. Because SA is time-dependent the individual must refresh their SA as the environment changes.

Endsley [11,12] identified four components of situational awareness: 1) perception (what are the facts in the environment), 2) comprehension (understanding the facts), 3) projection (anticipation based upon understanding), and 4) prediction (evaluation of how outside forces may act upon the situation to affect projections.) These components are not stages, but instead are interlocking cycles that progress in relation to each other. The factors that promote individual SA are both structural (semi-permanent) and situational (transient, ephemeral) and combine with information and training to give rise to SA as illustrated in Figure 1.

Structural factors include background, training, experience, personality, interests, and skill. Situational factors that affect SA include the mission that is being performed and the circumstances prevailing in the environment. Several factors can cause degradation of an individual’s situational awareness.

These factors include the following: 1) ambiguity (arising from discrepancies between equally reliable sources), 2) fatigue, 3) expectations and biases, 4) prior assumptions, 5) psychological stress, 6) misperception, 7) task overload (too much to do), 8) boredom (not enough to do on the tasks to maintain focus), 9) information shortage, 10) information overload, 11) information interruption, 12) irrelevant information, 13) mission complexity, 14) fixation/attention narrowing.
The core of the situation awareness cycle is perception, comprehension, future state projection, and action. Achieving high performance in this cycle is very challenging in the cyber environment because future state projection is difficult. The cyber state projection difficulties arise from the challenges posed by comprehension of a rapidly changing state of the cyber environment as well as the likelihood that unexpected cyberattacks (zero-day attacks) can be executed with no warning. The cyber environment is so large and complex that the unexpected must always be expected to occur. Furthermore, the four state cycle is affected by external factors. The factors include an individual’s goals, objectives, and preconceptions, which serve to make SA development complex and challenging. These same factors affect an individual’s decision. The decision, in turn, leads to action(s) that have an effect upon the environment; the effect must be conveyed to the individual in conjunction with the state of the environment in order to begin a new cycle of SA development, projection, decision, and action. A challenge is presenting relevant, critical, accurate information to the user so that the user can make timely decisions despite the complexity of the cyber environment, the press of events, and uncertainty concerning possible future cyber state.

3. Intelligent Agent Objectives and Using Simulation

Intelligent agents operate either as a decision support system to assist the decision-maker in mission accomplishment and to minimize the decision-makers’ taskload associated with accomplishing the mission in cyberspace. In our view, intelligent agents should aid the decision-maker in all phases of situation awareness development, 1) perception and comprehension of the situation, 2) projection of future status, 3) correlation of goals and objectives with the situation, 4) development of alternatives in light of the mission, 5) goals and objectives, 6) monitoring of the decision, 7) monitoring of actions, 8) assessment of actions, and 9) assessment of the environment reaction to the decision. The decision-maker’s perceptions, preconceptions, abilities, experience, and training should influence the behavior of the intelligent agents that are aiding the decision-maker. Additional confounding elements are that objectives and plans are affected by activities in the real-world and in cyberspace and by the interplay between the plans and their execution in pursuit of real-world and cyberspace objectives.

The decision-maker is the keystone; responsible for not only developing and maintaining situation awareness of the cyber and real-world components of the battlespace, but also for using the mission as the foundation for developing and maintaining objectives and plans for activities in cyberspace, the real-world, and in the intersection/interplay between them. The objectives and plans are affected by activities in the real-world and in cyberspace. After the user’s development of cyberspace plan, guidance and tasking for the intelligent agents can be developed, so that their activities support the decision-maker. Furthermore, the cyberspace intelligent agent uses its knowledge about the state and security of the cyber battlespace to inform the decision-maker about the reliability of the data they are using and thereby constrain the users’ data scope to the data that has the lowest probability of having been tampered or altered. The cyberspace intelligent agents are broadly tasked with determining the security state and data reliability of the decision-maker’s sources of information as well as for directing the activities of supporting cyberspace intelligent agents. The support intelligent agents act to secure data sources and to inspect the sources for indications of tampering, evidence of decreased data reliability, or inaccurate data.

One of the most critical tasks for the intelligent agents is to support development and maintenance of situation awareness by the decision-maker. Performing this task imposes many burdens on the intelligent agents. SA development and maintenance support requires help for the user to keep their SA model “current.” The intelligent agents should act to acquire data for the decision-maker, both in response to specific requests and in anticipation of needs. The intelligent agents should conduct analysis of data in response to specific requests and in anticipation of needs of the decision-maker. The cyberspace intelligent agents should maintain a watch for indicators of malware infestation and data corruption as well as act to insure data security, reliability, availability, and timeliness.

The cyberspace intelligent agents must be able to infer user intent, objectives, and changes in plans without requiring the decision-maker to actively engage the intelligent agent systems to alter their behaviors. The cyberspace intelligent agents should be capable of proactively identifying relevant collaborators in decision scenarios. The cyberspace intelligent agents must be capable of monitoring progress toward the decision-maker’s objectives and plans. Finally, the cyberspace intelligent agent must use its knowledge about the state and security of cyberspace to inform the decision-maker about the reliability and fidelity of the data they are using.

The intelligent agent’s portion of the decision-support system is comprised of intelligent agents that operate within a hierarchy to provide increasingly sophisticated support to the decision-maker. In the hierarchy, the lowest level agents have the least complex databases because they provide the least complex support to the decision-maker. The low level intelligent agents gather and analyze observable data. The higher levels of the hierarchy have more complex knowledge bases and provide more complex decision-making support that involves analysis of lower-level intelligent agent outputs as well as analysis of the activities of peer intelligent agents.

In our approach, we do not expect intelligent agents to learn automatically, they use a robust case-based reasoning system for decision-making. Building the knowledge bases required by all of the intelligent
agents is a significant challenge for many reasons, including the need to support a variety of users, variability in the operational environment, inability to test the agents within operational environments and the need to achieve high accuracy with the intelligent agent results immediately upon use. Simulation environments provide the realism required to develop intelligent agent systems with the capabilities required to assist decision-makers in developing situation awareness in real-world situations.

To develop intelligent agents for use to provide battlespace assistance, knowledge bases to support the operation of the cyberspace agents are needed. We refine each intelligent agent/knowledgebase pair iteratively by refining each pair in turn. The key to our approach is to use subject matter experts (SMEs) to develop rules for the cyberspace intelligent agents by involving them in creating the training scenarios, developing baseline knowledge bases, and in evaluating the performance of the intelligent agent after each training session. In the knowledge base development process, the intelligent agent hierarchy simplifies the database development process. The intelligent agents in the lowest levels of the hierarchy can be developed in parallel within the simulation environment because they have no interaction with other intelligent agents. Only at the higher levels of the hierarchy is it necessary to develop intelligent agents within the simulation environment one at a time, which is due to their requirement for inputs from subordinate and peer intelligent agents.

The first step in agent training is development of training scenarios that are described using UML and XML, followed by selection of an intelligent agent/knowledgebase pair to be refined. After selecting the pair, the training scenarios are modified based upon the intelligent agent’s task and the knowledgebase structure. The baseline knowledgebase for the intelligent agent is then assembled using SME expertise. We associate each SME-produced knowledge base with a single intelligent agent. Each intelligent agent/knowledge base pair is augmented in turn, the content of the knowledge bases for the other intelligent agents are frozen. To augment the content of the knowledge base, we insert the intelligent agent into a simulation environment wherein the intelligent agent specific training scenarios are executed.

By executing the scenarios within a simulation environment, we obtain maximal fidelity and complexity in intelligent agent training scenarios content with a minimum of additional development and minimal risk of exposure or compromise due to a real-world scenario mishap. We enhance the knowledge bases using successive refinement based upon the performance of the intelligent agents within simulation environment based test scenarios. Refinement of intelligent agent performance is accomplished by repeatedly presenting the knowledge base and intelligent agent pair with training and test scenarios. The performance of the intelligent agents is evaluated by the SMEs. If the evaluations indicate unacceptable performance, the scenarios are executed again to further refine the knowledge base. Once the performance for an intelligent agent and its knowledgebase is satisfactory, the intelligent agent is available for deployment. In our approach, we can successively refine each intelligent agent and we can deploy an intelligent agent once its performance is adequate. By improving scenarios over time, we can improve the performance of the intelligent agents and of the decision support system. The decision support system can be improved by the addition of additional intelligent agents to perform analysis of observable data as well as to analyze the output of other intelligent agents in the hierarchy.

The challenges posed to SA and decision-support cannot be addressed solely by assisting humans without assessing the human being helped. The amount of data to be assimilated and assessed, even after intelligent agent analysis, must of necessity be vast, which usually precludes intensive scrutiny by a human. The unknown number of false negatives and false positives present in the data as well as the wide range in speed of infiltration by malware can also serve to confuse the human, disrupt focus, and distract the user from important but transient data. Furthermore, an individual’s SA is affected by many factors, including short-term, ephemeral factors such as emotional state and degree of concentration/focus of the human. Some progress in automatically assessing human user state and intent has been made [36-40], but much remains to be done. Fortunately, current work indicates that the human assessment need not be precise; determining the approximate state of the human appears to be adequate. We do not use the human assessment to influence the analysis performed by the intelligent agent hierarchy, instead the assessment is used to determine if the user’s focus of attention has wandered and if the user appears to be focused on the less significant events within cyber space.

4. Summary and Future Work

Intelligent agents are a technology that can improve situation awareness and decision-making in cyberspace. However, an approach to the development of the complex intelligent agent knowledge bases is needed. In this paper we presented the requirements to be addressed by an intelligent agent system that can aid users in decision-making, situational awareness maintenance, and information dominance maintenance in cyberspace. We propose that simulation be used to present the intelligent agents with scenarios that can be used to develop knowledge bases and to evaluate each intelligent agent’s operation. The approach supports successive refinement of intelligent agent performance as well as testing of the performance of intelligent agents systems in their support of decision-maker SA in cyberspace.

In future work we plan to extend the situation awareness and decision-support capabilities provided by intelligent agents by investigating their use to develop and maintain group situation awareness in cyberspace. A second research avenue that we plan to address is improving training and test scenario
complexity and yield so that useful intelligent agents are produced at a faster rate.

REFERENCES


Abstract: Protection of critical infrastructure from cyber attack is an increasingly important cyber security issue. Electrical power grid (EPG) critical infrastructure is composed of some of the most advanced, large-scale technology for power generation and distribution in the world and yet the EPG infrastructure is fragile and vulnerable to cyberattack. The EPG critical infrastructure protection challenge is further compounded by the fact that the EPG is a tempting target due to national dependence upon electrical power and the cyber attackers’ ability to affect society on a large-scale via the compromise of a few components of electrical power infrastructure. The scale of the EPG also raises challenges for human decision-makers who must develop situational awareness about the EPG in order to analyze cyberattacks and respond to them. In our research we have been investigating means for assisting humans in developing situational awareness for the large-scale aspects of the electrical power grid and for determining if the EPG is experiencing a cyberattack at large-scale. In this paper we propose a foundation for a solution to the situational awareness and decision-support problems encountered when the EPG is attacked. The proposed approach involves the use of remote sensor systems, simulation to determine the expected EPG overall response and well as component response to current actions, and an environment that promotes situational awareness development and maintenance using a combination of intelligent agents and visualization.

1. Introduction
People desire rapid delivery of accurate information. Conversely, inaccurate information or slowly arriving information yields frustration. Couple the frustration with frequent significant changes in information content may yield poor decision-making and counter-productive actions. If the information addresses an area of grave concern, such as critical infrastructure or people, tolerance for slow information delivery, inaccurate information delivery, or frequent changes in information decreases and the pressure to make a decision increases. Critical infrastructure is an arena ripe for exploitation of the problems and challenges produced by information disruption and confusion. However, to date little has been done to address information delivery issues or to improve situational awareness for decision-makers or for affected individuals. In this paper we present a foundation that can be used to address information delivery issues at national and individual scales.

To date, and contrary to expectations, the improved decision-making promised by more expansive and powerful information systems has not materialized. The decision-making and situational awareness (SA) difficulties have arisen due to the vast amount of information that is available, the uncertainty associated with information, the rate of change of information, and the perceived costs associated with an incorrect decision coupled with the unvarying human capabilities for information assimilation and comprehension. These difficulties are compounded by the fact that the human brain’s capabilities are essentially semi-fixed and cannot be changed. The only tool available to improve decision-making and situational awareness is to improve information presentation. Information presentation can be improved using visualization technologies and intelligent agent systems. The manner of information presentation and the intelligent agent systems can maximize personal abilities for information assimilation and comprehension by highlighting critical information.

Clearly, all decision support and SA systems are not equal in their ability to convey critical information to users in specific decision contexts. The best systems overcome inherent human limitations in information acquisition, information understanding, and situation assessment because they are built with user limitations in mind and provide capabilities for minimizing taskload by using intelligent assistants. In light of human information processing limitations, one of the most challenging decision making environments is cyberspace because of both the volume and pace of data change. The challenges faced by humans in cyberspace are exacerbated by a lack of tools to support situation awareness in a distributed cyber environment. The general paucity of tools for cyber decision-making and situation awareness is worse in the critical infrastructure related portion of cyberspace, due no doubt to the lack of computing power in the elements of the critical infrastructure systems and the relative lack of bandwidth between the infrastructure elements and central control nodes. The importance of critical infrastructure coupled with the lack of tools to assist decision-makers calls for the development of tools and technologies to assist humans in understanding and acting within the critical infrastructure portion of cyberspace. We propose and describe a secure solution to both the tools and technologies problems.

In our approach, we use simulation technology in conjunction with real-world system activities to
determine if electrical power distribution system(s) have been compromised by a cyberattack. The paper is organized as follows. In the next section we present background information relevant to our research. In Section Three, we discuss our approach. In Section Four, we present a summary and suggestions for future research.

2. Background

Electrical power generation and distribution is a complex task, a task that has been addressed over many years and resulted in a complex system composed of a variety of parts of various ages and capabilities [1-19]. As illustrated in Figures 1 and 2, electrical power generation and distribution, typically called the electrical power grid (EPG), is an extensive and even continent-spanning undertaking, consisting of electrical power generation facilities as well as high-voltage electrical power transmission lines and voltage transformer stations. Electrical power distribution requires the generation of electricity at power plants, transmission of the electrical power from the generators to substations using high power transmission lines. The transformers at the substations change the high-voltage electrical power to medium or low power that serve the customers. The substations are unmanned and contain equipment to monitor and control distribution quality [1]. The problem posed by the size and scope of the electrical power grid (EPG) is determining what is happening if a problem arises; a skilled cyberattacker will attempt to corrupt any data that would serve as an indicator of an attack during and after the attack.

Figure 1: Main US Electrical Power Grid
Data from remote units situated at substations are used to manage electrical distribution over large geographical or service areas, which includes the scheduling of systems for power production and insuring that demand is met. Programmable logic controllers (PLCs) are used to manage the operation of the systems they directly control, such as managing electrical power generation output of the local device and the consistency of operational performance of the device that the PLC manages. Achieving situational awareness, let alone making timely decisions, across these large, rapidly changing systems poses a challenge that can be addressed using intelligent agent systems and visualization systems in conjunction with simulation environments.

The goal for cyberspace intelligent agents [20-29] is to improve situation awareness and help attain information dominance. The presumption is that intelligent agents will permit a faster response to cyberthreats and cyberattacks by using information dominance to reduce human response time and to reduce the complexity of the data to be analyzed. The intelligent agents should help the user to identify critical information, help the user to acquire critical information, prioritize response to cyberattacks, increase awareness of an opponent’s activities in cyberspace, increase awareness of an opponent’s likely goals in cyberspace, help the user to identify profitable actions to be taken in cyberspace in order to dominate and exploit it, and, finally, reduce user stress. However, exploiting information dominance may be more difficult than expected due to the scope and success-rate of cyber attacks, which will, in turn, adversely affect situation awareness. To improve SA, even during a cyberattack, the intelligent agents must operate in a manner that enhances development and maintenance of situation awareness, allow users to concentrate on significant aspects of cyberspace and not on the intelligent agents, and serves to minimize the user’s taskload. Before discussing these issues, a short discussion of SA in light of current technology is warranted [9-33].

Endsley [27,28] defines individual situational awareness (SA) as the following: the perception of the elements in the environment within a volume of space and time, the comprehension of the elements’ meaning, the projection of the elements’ status into the near future, and the prediction of how various actions will affect the fulfillment of one’s goals. Situational awareness is a rapidly changing, ephemeral mental model of an environment that must be assembled over time and continuously updated. Assembling the mental model requires knowledge of the current state of the environment. SA arises by perceiving information about the environment and coupling that perception with comprehension of the meaning of that information in light of operator goals. SA requires more than merely being aware of all of the pieces of data in an environment, the significance of the elements (individually and in combination), or even all of the most pertinent pieces of data in an environment; SA requires an understanding of the situation, which equates to developing and maintaining a mental model.
of the situation, including likely future state(s) of the environment and a model of the progression of the situation toward the future states. The challenge faced by the decision-maker is placing the elements of the environment into a meaningful, coherent pattern that yields a holistic picture of the environment that helps the decision-maker in comprehending the significance of objects and events. Because SA is time-dependent, the individual must refresh their SA as the environment changes. SA does not refer only to static factors such as the knowledge of established procedures, doctrine, and skills; SA also refers to one’s perception of the dynamic state of the environment.

Endsley [27,28] identified four components of situational awareness: 1) perception (what are the facts in the environment), 2) comprehension (understanding the facts), 3) projection (anticipation based upon understanding), and 4) prediction (evaluation of how outside forces may act upon the situation to affect projections.) These components are not stages, but instead are interlocking cycles that progress in relation to each other. The factors that promote individual SA are both structural and situational and combine with information and training to give rise to SA. Structural factors include background, training, experience, personality, interests, and skill. Situational factors that affect SA include the mission that is being performed and the circumstances prevailing in the environment. Several factors can cause degradation of individual situational awareness including the following: 1) ambiguity (arising from discrepancies between equally reliable sources), 2) fatigue, 3) expectations and biases, 4) prior assumptions, 5) psychological stress, 6) misperception, 7) task overload (too much to do), 8) boredom (not enough to do on the tasks to maintain focus), 9) information shortage, 10) information overload, 11) information interruption, 12) irrelevant information, 13) mission complexity, 14) fixation/attention narrowing, 15) erroneous expectations, and 16) lack of experience.

The core of the situation awareness cycle has four components: 1) perception, 2) comprehension, 3) future state projection, and 4) action for the cyber environment. However, the cycle is affected by external factors that serve to make SA development complex and challenging. SA development is affected by the individual’s goals, objectives, and preconceptions. These same three factors affect the individual’s decision. The decision, in turn, leads to action(s) that have an effect upon the environment, the effect is supplied to the individual in conjunction with the state of the environment in order to begin a new cycle of SA development, projection, decision, and action.

3. Toward Protection of the Electrical Power Grid

In the research reported here, the goal is not to assist humans in the management of the frequency and voltage aspects of electrical power delivery, we rely upon existing and future control systems to perform these essential functions during normal operation [19]. Instead, our goal is to assist human in determining if an electrical power generation and distribution system is experiencing a cyberattack, assessing how well the system is responding to the cyberattack, determining if any human intervention is required, and determining the appropriate human response. We focus our efforts on the large-scale cyber security aspects of electrical power delivery status assessment, situational awareness, and decision support because others [2,3,4,9,10,11,13] are generally addressing the individual location aspects of cyber security for electrical power delivery or the challenges of national incident response [14].

Our overall approach to providing humans with the insight that they require is to acquire data about the status of the EPG from a variety of sensors, use simulation to determine what the sensors indicate about the state of the EPG, and allow humans to compare the simulated EPG state to the real-world EPG state. The size and complexity of the EPG make comparisons between the real-world state and simulation output state difficult to perform, as a result advanced decision aids are needed to support the humans in making the comparison.

For the purposes of our work, we assume one or more EPG cyber security management facilities wherein humans examine sensor data and compare them to the output from the simulation environment, as illustrated in Figure 3. As illustrated in Figure 3, data is acquired in real-time from the sensors during a data gathering time interval, then normalized and stored. Simultaneously with data storage, the normalized data is sent to intelligent agents for analysis and to the EPG simulation. The EPG simulation executes to compute expected EPG status for the current computational window, then this data is forwarded to the intelligent agents for analysis in conjunction with the normalized data gathered in the next data acquisition cycle. In essence, the use of the simulation outputs computed from past data allows us to compare current EPG state with expected state, thereby allowing the detection of anomalies in EPG performance.

Data acquisition for the EPG simulation is accomplished by using a mix of existing and special purpose sensors placed at substations. The cyber security purposed sensors are independent from the existing sensors used at the substation to manage voltages. The new cyber security purposed sensors would be different from the existing sensors so that one type of cyberattack could not disable all of the sensors at a substation. The newly emplaced sensors will require more memory and computational power than traditional sensors to accommodate the need to encrypt all data transmissions and to use certificates to authenticate each sensor source to the EPG cyber security management facility. The new cyber security purposed sensors serve an additional purpose: a cyberattacker must compromise two independent systems in order to execute a successful cyber attack against the EPG. Therefore, a critical requirement for the cyber security purposed sensors is that they be
completely independent in operation, computation, sensing, and communication from the existing EPG sensors currently in-place. While the new cyber security purposed sensors and supporting infrastructure imposes additional costs on the owners of the EPG, the additional security will be worth the cost. Fortunately, we can use the EPG simulation environment to determine placement of the new cyber security purposed sensors and thereby minimize the cost of the additional cyber security that the new sensors provide. A critical element of the proposed approach is the suite of intelligent agents and their training as illustrated in Figure 4.

Figure 3: Data Flow From EPG to Users via Intelligent Agents

Figure 4: Nominal EPG Intelligent Training Process
One of the most important issues to be addressed in the EPG cyber protection facility is the means for presenting the real-world status and simulated output in a manner that allows humans to rapidly acquire and maintain situational awareness for the EPG and to determine if the EPG has been compromised by a cyberattack. Clearly, the operators of the EPG security facility will require training in the use of the compromise detection systems available to them as well as training to provide them with an understanding of the operation and normal behaviors of the EPG. Two forms of training are needed so that the operators are able to detect cyberattacks upon the EPG, one to identify malfunctions in the sensor system(s) and the other to identify improper EPG response to unusual but not cyberattack related events in the EPG. We expect that the facility must be able to receive and present large amounts of data in near real-time, which can overwhelm the user with data and hinder the recognition of significant events in the EPG. To reduce the workload imposed upon the users in the facility, intelligent agents are used to examine the incoming data and simulation data to identify and highlight discrepancies between the predicted and actual data. Training the intelligent agents to detect meaningful anomalies is a challenge that we have considered, as illustrated in Figure 4.

Training the EPG intelligent agents requires data about the EPG, its performance and response to circumstances that are normal and not indicative of a cyberattack. Essentially, the false positive rate for the intelligent agents has to be low enough so that the alert rate is acceptable while insuring that actual events are identified. The training also must support multiple analytical time windows; the intelligent agents must be able to examine the incoming data and look for indications of a cyberattack that manifest over time periods of sub-seconds, seconds, minutes, multiple hours, and days. Humans are notoriously bad at identifying patterns across multiple, overlapping time periods; hence, the intelligent agents must perform the analysis.

Until the EPG cyber security purposed sensors are installed, the best data available is the record of EPG activity provided by its daily operation and heuristics provided by subject matter experts (SMEs). The real-world data and SME data can be supplemented by performance data acquired from training simulation systems used to train EPG operators to manage portions of the EPG. The data must be converted from any sensor specific format to a normalized data format in order to enable analysis across the EPG and to be harmonious with the new cyber security purposed sensors. By taking these two actions for agent training we minimize the amount of work required to re-train the intelligent agents as the cyber security purposed sensors are deployed and allow the intelligent agents to operate while there is a mix of current and cyber security purposed sensors. A challenge to be addressed is building the intelligent agents so that they can automatically adapt to changes in EPG configuration, sensor placement and sensor operation.

The simulation environment component of our approach serves a number of purposes. The most obvious use is that the simulation output provides a baseline that can be compared against to the sensor data in order to detect anomalies and cyberattacks against the EPG. The simulation is also used in the development of the intelligent agents, as portrayed in Figure 4. The simulation also helps us to address several other issues that arise when trying to detect cyberattacks. One issue is how to provide the user with visual cues to indicate the occurrence of an anomaly that could indicate a cyberattack, the probability that the detected anomaly is an actual cyberattack occurrence, and the systems affected by the detected anomaly. The visual cue problem becomes increasingly acute as the number of systems and sensors increases. Without effective visual presentation of information, the user will become overwhelmed by the volume of information despite the use of intelligent agents for analysis and synthesis. The second issue is that the simulation can be used to generate data that can be used to develop “big data” analytical tools. The big data tools can be used to compute inputs for the intelligent agents as well as informational displays for the user that reduce the data volume from a huge dataset to one or a few numbers.

4. Summary and Future Work

The electrical power national infrastructure is a vulnerable and essential component of modern civilization. The EPG makes a tempting target for cyber attackers because it is essential to modern life, can inflict wide-area disturbance as a result of attacks at only a few points, and poses tremendous challenges for humans trying to determine the grid’s status. Therefore, in our research, we have been investigating means for assisting humans in developing situational awareness for the large-scale aspects of the electrical power grid and for determining if the EPG is experiencing a cyberattack at multiple nodes within the grid. In this paper we proposed the underpinnings for a solution to the situational awareness challenge across the EPG. The proposed approach involves the use of remote sensor systems to monitor the EPG independently of existing localized sensors, simulation to determine the expected EPG response to events and for assessment of individual EPG component responses, and an environment that supports situational awareness development and maintenance using a combination of intelligent agents and visualization. The combination of tools should be useful for managing and for determining the appropriateness of the response of the EPG to cyberattacks as well as component failures.

The remote sensor systems operate independently of current sensing systems within the grid and use alternative communications channels to report their findings to management centers for analysis. Because of the large amount of information sent to the management centers, intelligent agents are used to analyze and correlate data before visualization. Intelligent agents are a key component of our approach.
Intelligent agent systems are a technology that can improve situation awareness and decision-making in cyberspace. In our approach [30–33], simulation is used to present the intelligent agents with scenarios that can be used to develop the required knowledge bases and to evaluate each intelligent agent’s operation. The approach supports successive refinement of intelligent agent performance as well as for testing of the performance of intelligent agents systems in their support of decision-maker SA in cyberspace for the EPG.

Two open questions of major importance are the cost of the cyber security purposed sensors and the speed with which the additional sensors can be deployed. The cost should not be unreasonable, existing sensor systems can be used initially with two provisos: the sensors placement must result in a heterogeneous mix of sensors on every component of the grid and there must be sufficient computational and storage capacity at each sensor to provide the necessary encryption protection for sensor data in transit. In future work we plan to address the intelligent agent training problem in more detail and to investigate how to employ the proposed system to detect cyberattacks, to detect errors in local monitoring systems, and to develop tools that will allow humans to better differentiate between cyberattacks, large-scale monitoring failures, and large-scale EPG failures.

REFERENCES


SimART™ II: Adding Reality to Simulation

Jessica Stokes-Parish¹, Simulation Coordinator; Rebecca Marley², Simulation Coordinator; Jan Roche³, Director of Simulation

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Presenter Details.

Jessica Stokes-Parish, Simulation Coordinator, Chameleon, University of Newcastle; Hunter: Extensive experience in simulation. Keen interest developing moulage related to simulated patients, with a vision to see increased participant buy-in through simple solutions, leading to more realistic simulations, better educational outcomes and patient care.

Rebecca Marley, Simulation Coordinator, University of Newcastle, Manning: Using simulation both as a nurse and in simulation lab for many years. Experience in Special Effects for actors and enhancing simulations using Simulated Patients.

Jan Roche, Simulation Director, Chameleon, University of Newcastle, Hunter:
Using simple, effective and systemised moulage techniques to enhance student engagement and meet learning objectives.

Overview.

simART™ is one of the key tools utilised in suspending disbelief for those participating in a simulation scenario. Transforming manikins or simulated patients using simple effective techniques can seem overwhelming.

This workshop will present moulage & special effects techniques including illness effects, intermediate lacerations and first degree burns, easily applicable without extensive time or equipment. This session is designed to be interactive and experiential.

Expected Outcomes.

The participant will be able to identify and practice using makeup and equipment required to create these effects.

Upon completion of this session, participants will be able to:
1. Demonstrate ability to apply theoretical principles for using simART™ in teaching
2. Identify safe simART™ techniques using a variety of materials and methods to mimic patient states, wounds and pathologies
3. Design and create and implement a simART™ related to a simulated learning event.

Detailed Description.

The session is divided into five main parts:

1. Provision of safe practice environment, learning objectives and session plan with relevant reference material.
2. Faculty demonstration and participant practical experience.
3. Session for participants to practice simART™ techniques with facilitator available.
4. Participant involvement through team work to develop, apply and showcase simART™ techniques
5. Evaluation of the session
Evaluation.

The web-based response system mQlicker will be used to provide feedback from participant learning outcomes, the facilitators and equipment used. Using web based mobile devices the audience will be asked to participate in providing feedback.

A back up option of paper evaluations will be available.

Timeline.

Part 1 – 5 minutes
Part 2 – 10 minutes
Part 3 – 45 minutes
Part 4 – 25 minutes
Part 5 – 5 minutes
Finding the Balance of High and Low Fidelity Simulation for Authentic Midwifery Learning

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Aim of the Education Program. The BNSc/BMid program commenced at James Cook University in 2010. Since inception the teaching midwifery team has been focussed on finding authentic ways to teach midwifery theory and clinical skills that are innovative, engaging and authentic. During this period, our simulation strategies have also been evolving from unsophisticated task trainers to utilising high technology, high fidelity simulators such as SimMom. Whilst the advances in simulation methods have complemented our current teaching practices, it is apparent that merely having the equipment does not equate to creating an authentic learning experience.

To address this ongoing challenge, we have adopted the principles of design thinking and the ‘5 E Framework’ (Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook & Landes, 2006). This strategy promotes a journey of learning for midwifery students from pre lecture preparation to professional experience workshop (PEW). The goal for this educational strategy is that the learning is engaging; it facilitates learning that is student centred and it meets the individual learning needs of the student.

Methods Adopted. The design thinking approach focusses on empathy for the learner, their level of development and resources available to them. The teacher acknowledges that the learner has prior knowledge and experience, supports the students’ learning with activities that foster engagement, and assessment that is authentic. Similarly, the ‘5E Framework’ focuses on engaging, exploring, explaining, elaborating and evaluating the teaching and learning experiences (Bybee et al., 2006).

Adopting these principles can aid the teacher to identify how to balance the use of low and high fidelity simulation. In our program, we use low fidelity simulation to teach the art of midwifery care such as building rapport with the woman and foundational midwifery assessment skills. This correlates to the student being engaged in learning, exploring and explaining key concepts. Once confidence is attained in performing these cares, students are supported to use medium-high fidelity simulation to elaborate and evaluate their care. Importantly, the ‘5E Framework’ enables the student to reflect on their learning and revisit key concepts related to the birth continuum.

Evaluation Data from the Program. Since the co-utilisation of design thinking, the ‘5E Framework’ and simulation based education, midwifery students’ confidence levels have improved and they are better prepared for clinical placement. To further evaluate this program, more formal feedback is being sought in 2015 via the use of the ‘Y-Chart Graphic Organiser’ where students are asked to reflect on the learning experience each week by identifying what the learning experience looks like, feels like and sounds like.

Conclusions and Recommendations for Future Use and Development. Through experience we identified that equipping the clinical simulation laboratory with high fidelity simulators did not equate to creating an authentic learning experience. Instead, an authentic learning experience that balances low and high fidelity simulation can be accomplished using design thinking and the ‘5E Framework’. This approach is in its infancy but our preliminary findings indicate this is a more robust way of preparing midwifery students for clinical placement.

References.

Simulation in Undergraduate Nursing Programs: What is Holding Faculty Back?

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Aims. This study explored perceived barriers to and enhancers for the implementation of simulation as learning and teaching resource.

Background. The importance and effectiveness of using simulation as a teaching and learning resource within nursing education is well supported in the literature (Burns, O'Donnell, & Artman, 2010; Jansen, Berry, Brenner, Johnson, & Larson, 2010; Jeffries, 2008; Kardong-Edgren, Starkweather, & Ward, 2008), for the vital role it plays in preparing student nurses for the workplace (Nevin, Neill, & Mulkerrins, 2014). The literature also suggests there are many barriers to the adoption of simulation that impact on its successful implementation within teaching and learning (Abell & Keastler, 2012; Anderson, Bond, Holmes, & Cason, 2012; Jansen, Johnson, Larson, Berry, & Brenner, 2009). Teaching staff’s lack of engagement with simulation has been found to be one of the key barriers to adoption (Adamson, 2010; King, Moseley, Hindenlang, & Kuritz, 2008). Yet a fuller understanding of what is driving the reluctance of teaching staff to engage in simulation is lacking.

Methods. The study used a qualitative descriptive approach. Data were obtained from structured focus group interviews conducted across four campuses from a single university. A deeper understanding of 16 participants’ perspectives of simulation were obtained through categorical thematic coding from audio recordings and verbatim transcription recordings. Participants’ responses were coded with use of NVIVO under each of the following structured questions:

1) Please outline you understanding of what simulation is about.
2) What were the barriers to simulation?
3) What were the enhancers to simulation?

Result. Three central themes were illuminated during coding. These themes were educator anxiety, simulation resources, and enhancers to simulation. Following is a description of each identified theme.

Educator anxiety – This theme resulted from the disclosure by faculty staff regarding anxiety due to perceived student performance expectations of a simulation event and/or performance expectations that they placed upon themselves.

Simulation resources - A broad theme that encompassed a number of key issues identified about simulation resource management by participants included: administrators unrealistic performance and knowledge expectations of faculty’s ability to use equipment; lack of understanding by both administrators and faculty in required training for implementation of simulation and time needed for preparation and delivery.

Enhancers to simulation – A theme that incorporated the actions that participants perceived would lead to the successful and less stressful implementation of simulation into the learning and teaching space. Suggested strategies were coded as: mentorship, resource management and comfort.

Discussion. The key finding in this study is that faculty must feel comfortable with simulation to improve educational outcomes with simulation. Literature acknowledges comfort as a significant component to successful simulation implementation in nursing, but what defines the components of comfort for faculty appears to be lacking (Harder, Ross, & Paul, 2013; Jones & Hegge, 2007). This study demonstrates that simulation comfort for faculty encompasses more than technological skills and knowledge. Participants of this study defined features that would give them comfort as: faculty training in the pedagogical process of simulation; recognition of time that is needed for simulation in workload allocation and teaching sessions; the creation of mentorship support for simulation programs; structuring of simulation resources and the sharing of such resources.
Conclusions. To increase simulation usage and educational outcomes within the learning and teaching space in undergraduate and postgraduate nursing programs comfort for faculty staff must be created. What defines comfort for one Australian rural university has been shared through this research study. Further research is needed to broaden the definition shared so a comprehensive and cohesive strategy can be developed that will enable faculty teaching staff to feel comfortable and confident with implementing simulation within their teaching and learning.

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Determining Differences in Physiological Responses and Performance of Undergraduate Nursing Students during Simulations with Varying Patient Fidelity

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Aims

To investigate the extent to which patient fidelity impacts on students' stress in the simulation-based learning environment (SLE), and how these changes ultimately impact on performance.

Background

High-fidelity simulation works to maximise realism in clinical training scenarios with the aim of allowing students to 'suspend disbelief'—otherwise known as 'psychological fidelity'—to achieve authentic learning experiences. Measures of student 'immersion' in SLEs usually involves the use of subjective, self-reported questionnaires [1] or qualitative enquiry [2]. However, Tichon et al. argue that more accurate measures are possible through objective quantification of psycho-physiological factors [3]. Stress is one such variable of interest to many researchers seeking to objectively measure student 'immersion' in SLEs [4-6]. A number of studies have found heightened stress is associated with either decreased [5,7] or increased [4,8] performance in SLEs. Selye was the first to discuss the concept of 'eustress', being a controlled, manageable and motivating version of stress that does not lead to cognitive overload and ultimately leads to better performance [9]. Selye compared this to 'distress' that leads to cognitive overload and ultimately poorer performance. Consistently with this concept, adult learning theories such as the challenge point framework [10] and the cognitive appraisal theory [11] suggest a difficult, but achievable, level of challenge, eliciting an optimal level of eustress, is likely to promote peak performance.

An under-researched area of simulation fidelity is the influence of the simulated patient on student stress. Crofts et al. found live patient-actors prompted greater communication skills amongst midwives and doctors compared to computerised manikin patients [12]. Conversely, Gillet et al. found greater satisfaction with simulated patients compared to live-actors in a mass casualty scenario, although no quantifiable differences were found in critical actions [13]. To date no studies have investigated the impact of patient fidelity on participant stress in SLEs and how this impacts on overall performance. This project received funding from the Australian Government.

Methods

N=70 volunteer, stage-six nursing students were recruited from Edith Cowan University. Participants undertook a standardised clinical scenario involving a post-operative 35-year-old male in a hospital recovering from laparoscopic cholecystectomy. Students were expected to draw-up and administer a correct, second dose of a prescribed antiemetic (metoclopramide). A 'confederate' registered nurse supervised each student and respond to queries without prompting or redirecting participants away from potential errors. Students were randomly assigned to one of three patient conditions: (1) computerised manikin, (2) live-patient actor and (3) live-patient actor plus concerned relative.

Changes in stress were measured via analysis of saliva cortisol collected at baseline and immediately after the simulation. Students' actions were recorded via remote high-definition video cameras in the simulation suite and also by a camera strapped to the side of the registered nurse’s head. Performances were rated via a 16-item clinical assessment rating tool completed by two clinical nurse supervisors who viewed the video footage independently.

Results

No significant differences were found in between-group cortisol readings at baseline (p=.651) but differences were noted between groups immediately following the scenarios (p=.024). Specifically, students in the manikin condition had lower average cortisol levels after base-line compared to students in the live-patient actor plus relative group (-.0484 vs. .0900 respectively, p=.018) (see Figure 1). Statistically significant differences were found between groups for performance ratings (F(2)=3.802, p=.028). Post hoc analysis suggested this difference lay between the manikin and live-patient actor plus concerned relative groups with the latter performing significantly worse (12.95 vs. 10.67 respectively, p=.027).
Discussion

Heightened stress (as inferred by greater increases in cortisol from baseline to post-simulation) was found in the live-patient actor plus bystander condition compared to the manikin condition. Similarly, participants in the live-patient actor condition performed significantly worse than those in the manikin condition. This inverse relationship between stress and performance infers that for our sample, students being exposed to live-actor patients with an additional bystander were exposed to distress (as opposed to eustress) negatively affecting their performance over and above those in the manikin condition.

Conclusions

Some argue that unduly stressing students during clinical education is unproductive to the goals of inspiring confidence, fostering learning, enhancing students’ ability to self-monitor and driving self-assessment [14]. Our results suggest the use of real-life actors in SLEs is more likely to facilitate inhibitory distress amongst participants having a negative impact on performance than using simulated patients (i.e. manikins).

References

The Effect of Assessor Presence versus Absence during Clinical Competency Assessments

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Aims

To investigate the extent to which the presence or absence of an assessor in simulation-based live clinical competency assessments affects students' distraction, anxiety and performance.

Background

Clinical assessments using simulation-based scenarios are often used to gauge students’ ability to translate theory into practice. However, such experiences can be highly stressful for students [1,2] and may not provide a true reflection of clinical competency [3]. One method proposed to reduce student stress during clinical examinations is by removing in-situ clinical assessors. Quick and Ross found that in addition to the stress associated with simply being assessed, the presence of an assessor altered student behaviours and attentiveness through student-teacher discourse and a tendency for students to seek ongoing confirmation about their progress via ‘sideways glances’ to the assessor [4]. Conversely, the removal of an assessor from the environment decreased students’ sense of intimidation and self-conscious behaviours, and facilitated greater student ‘ownership’ of the scenario, allowing them to better focus on the clinical scenario itself. The authors concluded the presence of an assessor has the ability to disrupt the continuity of a scenario, potentially leading to poorer student performances, and ultimately detracts from the purpose of the assessment [4]. The generalisability of this study is limited by its qualitative nature so we sought to replicate the findings using a quantitative methodology in order to determine the extent to which assessor presence impacts upon students’ performance. This project received funding from the Australian Government.

Methods

Participants were 31 volunteer second-year paramedicine students from Edith Cowan University. Students were separated into groups of three as per the 'Physicians Model of Assessment' [5] undertaking a total of six distinct clinical scenarios (completed in random order); two as the 'delegator' responsible for clinical decision-making and delegating tasks, and four as the 'respondent' performing tasks requested by the delegator. Whilst acting as the 'delegator' students completed (in random order) one scenario with an assessor being present in the room and another with the assessor anonymously viewing scenarios from behind a two-way mirror. One trained live-actor patient was present in each scenario providing information to students about clinical symptoms and responses to medications and treatments. If students asked assessors in the ‘present’ condition for clinically relevant information about the scenario, assessors were permitted to respond but instructed to keep responses brief and provide minimal potential feedback to performance.

Video-recordings were used to quantify time-to-completion as well as interaction time and non-verbal glances towards assessors in the ‘present’ condition. Anxiety was inferred via continuous heart-rate (HR) data collected from delegators at five-second intervals during each scenario. Two expert assessors independently reviewed students’ video footage and rated their performances using a structured clinical assessment checklist.

Results

No statistical difference was detected between students’ mean performance scores in the assessor ‘absent’ versus ‘present’ condition (71.6% vs. 69.4% respectively, p=.496). However, the average time-to-completion in the ‘absent’ scenario was over a minute quicker than the ‘present’ condition (6.6 vs. 8.4 minutes respectively, p<.001). In the ‘present’ condition students spent an average of 61.4 seconds conversing with the assessor, accounting for 13% of their time-to-completion. This time was spent discussing clinically relevant information (43.4s), extraneous matters (17.9s) and non-verbal glances toward assessors (5.2s) an average of 2.8 times per assessment. Over the duration of each clinical assessment HR deviation from baseline remained consistently higher for students when the assessor was ‘present’ compared to ‘absent’ (see Figure 1). In the ‘absent’ condition, students’ average HR decreased by 9.1 bpm from baseline compared to only 4.3 bpm during the ‘present’ condition, a statistically significant difference (p=.040).
Discussion

In the assessor 'present' condition, our HR data provided a clear indication of heightened anxiety in students, disruptive time spent interacting with the assessor and significantly longer time-to-completions. In comparison, students in the assessor 'absent' condition performed just as well and significantly quicker. It appears that with an assessor present our students were contending with dual aspects of the scenario—clinical-decision making and the ongoing reminder that their performance was being judged. Removal of the assessor allowed students to narrow their focus to the patient.

Conclusions

If possible assessors should not be physically present when students undertake clinical assessments and alternative methods of observation, such as two-way mirrors or video-recordings should be considered. Doing so would be popular with students, likely decreasing their anxiety, and facilitating a more timely performance of clinical skills without adversely affecting overall performance.

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Developing An Effective Distributed Mission Operations (DMO) Training Environment

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Abstract. Distributed Training enables disparate systems to link together over short- or long-haul distances to operate simultaneously in a shared synthetic environment. This type of training is an invaluable tool in today’s fiscally constrained environment. Industry has made significant advances over the past 15 years, permitting warfighters to train in mission tasks that may be excluded from live operations due to safety, security, complexity or other real-world constraints. Distributed training allows warfighters to conduct “capabilities based” training, concentrating on mission essential tasks that require focused attention, while conserving precious resources for training events which can only be conducted during live operations. PLEXSYS Interface Products, Inc. has been a primary participant and industry leader in the development and operation of Distributed Mission Training/Operations (DMT/DMO) since its inception in the United States Air Force (USAF).

INTRODUCTION

This paper describes achievements and challenges that PLEXSYS Interface Products, Inc. has either experienced first-hand, or observed, as a key participant in distributed training operations during the past 15 years. It will identify, review, and analyze multiple aspects of a successful distributed training federation, and the architecture needed to support this type of persistent synthetic training. Focus areas include: the standards-based approach needed for establishing the federation, training environment considerations, distributed training benefits versus live training, and the organization/structure needed for a successful and sustainable distributed training system. Lastly, this paper will discuss lessons-learned and present concepts for standing up a distributed training capability.

DISTRIBUTED MISSION OPERATIONS (DMO) DEFINED

Distributed Mission Training (DMT) remains a critical element of the training toolkit for many militaries. DMT or Distributed Mission Operations (DMO) as it is called in the United States, is not a new training concept. This training scheme had its basis on reducing the cost of live training by using virtual and constructive environments to satisfy training requirements. But, in order to advance to the point where disparate training systems could routinely exchange information (talk to each other and exercise system interoperability), a significant amount of work needed to occur. Aside from the technical issues associated with connecting together different training systems made by different contractors, the issue of realism was a concern. Realistic training has been and will continue to be a key factor in determining whether or not war-fighters will use virtual and constructive training technologies. Conducting or participating in unrealistic training is not acceptable to the war-fighter, and inefficient training often leads to negative training. A key element in establishing a DMO training system is to define what is meant by DMO and define the intended training results. In defining DMO, an initial effort must identify the training requirements that can only be accomplished through live events. All other requirements, by definition, can then be accomplished synthetically, and some number of those requirements can and should be met through DMO.
DMO is defined by USAF Air Combat Command (ACC) as, “Warfighter training that utilizes the integration (networking) of live-fly, virtual (man in the loop), and constructive (computer generated) entities, systems, and environments to complete mission essential competencies required for a combat ready force. DMO focuses on individual and small team unit-level training, utilizing a unit’s organic resources to train assigned warfighters to perform their wartime tasks. It also expands a unit’s training capabilities and resources to facilitate Inter-team training among geographically separated and composite force teams to execute missions (or significant portions of missions) and mission rehearsal scenarios”. In the September 2011 ACC Instruction 11-213 DEVELOPMENT AND IMPLEMENTATION OF DISTRIBUTED MISSION OPERATIONS, the DMO end-state is described as, “The Distributed Mission Training (DMT, expanded in 2006 to DMO) initiative implements Commander, Air Combat Command (COMACC) 1996 Operational Requirements Document guidance to the ACC Directors of Operations; Plans and Programs; Requirements; and Communications-Computers Systems to implement linked, mission-level simulation training for the Combat Air Forces (CAF). End state is envisioned as high fidelity simulators at each wing for each Mission Design Series (MDS), linked to AWACS, JSTARS, RIVET JOINT, GTACS, C4ISR, and other simulators such as bomber and rescue MDS simulators as appropriate, as well as a dedicated set of adversary work stations that could present a manned threat”.

DEVELOPMENT OF THE COMBAT AIR FORCE (CAF) DMO NETWORK (DMON)

“Build it and they will come”. This phrase may work well in the movies, but it is not a good philosophy on which to build a training capability. Today’s warfighters must operate with limited/constrained training resources and every event/exercise must provide meaningful readiness training. No unit has the time to participate as a training aid to another, nor will it participate in a training event that does not fill specific training requirements. This was a major issue that the CAF DMO program dealt with for nearly ten years when first standing up the DMON.

Initially, daily DMO training events were left up to unit training officers to design, schedule, and coordinate between each other in order to plan and execute. Much like the “pull” concept for Close Air Support (CAS), unit training officers were forced to solicit support from other war-fighting units to help them fill training requirements. At that level of coordination, it proved difficult to schedule training events that would benefit all participants. This scheduling issue was a major factor that led some weapons system communities to lose confidence in DMO, and they became reluctant to participate in training events. Most units had minimum expertise in developing scenarios and operating the different environment generation software programs. The USAF began to develop solutions for these issues and a growing misunderstanding of the potential of DMO, resulting in a complacent attitude towards Distributed Training as a viable tool. These solutions eventually evolved into three functions, each serving a specific purpose and level of training across distributed networks. Together they provide robust DMO training options that fill a great deal of today’s Combat Air Force (CAF) training requirements. These functions are the Distributed Mission Operations Center (DMOC), Distributed Training Operations Center (DTOC), and Distributed Training Centers (DTCs).

3.1 Distributed Mission Operations Center (DMOC)

The DMOC provides virtual and constructive Large Force Exercise (LFE) training. It serves as the recognized USAF DMO center of excellence since the inception of DMO. Before the DMO Network was set up, the DMOC was primarily a C2&ISR-focused facility that took the lead in developing network protocols and standards that would permit disparate weapons systems to connect and train together over a distributed network. Training environments were provided through environment generation software such as the Advanced Simulation Combat Operations Trainer (ASCOT) developed by PLEXSYS Interface Products, which is an organic capability in the AWACS Mission Crew Training systems resident in the DMOC facility. As
Distributed Training technologies grew, and a significant network was made available. The DMOC began to develop Distributed Training events that involved more weapons systems. These events grew into what is known as the Virtual Flag (VF) Exercise, an event that is run four times annually to train and prepare hundreds of war-fighters to deploy. VF provides valuable training to many war-fighters employing disparate weapons systems, but the theater nature of the scenarios and operational level at which these events are run provide minimal training to the fighter community at best, and they are very reluctant to participate for that reason. VF exercises are LFE events, with joint and sometimes coalition participation. They require a significant amount of planning, and occur a limited number of times each year. Many units require training at the tactical and individual level that could not be scripted into a VF exercise.

3.2 Distributed Training Operations Center (DTOC)

The DTOC provides focused individualized training primarily for USAF Air Guard and Reserve Components (ARC). Many communities have specific, specialized training that cannot be accomplished in the live training environment alone. This is due to many factors to include fiscal constraints and lack of sufficient training assets among others. These requirements are also too specific for a VF event, and require unique training scenarios to accomplish. The Iowa Air National Guard (ANG) recognized a significant gap in this sort of training capability and stood up the DTOC in Des Moines, Iowa. Similar to the DMOC, the DTOC provides an operational environment for a virtual battlespace linking a wide array of high fidelity flight and mission crew simulators. Utilizing a manned constructive white force, the DTOC concentrates on frequent, small-scale, team and individual level tactical DMO training for the Joint Warfighter. The white force role-plays required mission entities with current and qualified warfighter skills. The DTOC is responsible for all network management, event control, scenario development, unit DMO scheduling, remote maintenance, remote instruction, and realistic threat insertion. In addition, the DTOC manages the distributed network called ARCNet. The Mission Training Engineering Center (MTEC), collocated with the AF Research Laboratory (AFRL), Mesa, AZ, coordinates technology programs with AFRL, and acts as the engineering focal point for the ARCNet to exploit and transition leading edge technology into hardware or software solutions.
PERSISTENT TRAINING CAPABILITY

On the technical side, one of the first steps is to determine if and how simulators can communicate between themselves. The two common protocols currently used are, High-Level Architecture (HLA) [IEEE 1516] and Distributed Interactive Simulation (DIS) [IEEE 1278]. Ensuring training systems adhere to one or both of these protocols is key. However, just because a simulator meets one of the IEEE standards does not mean the simulator will be able to communicate with other simulators. The best option is to establish a “federation” whereby simulators must pass rigorous testing and be IEEE compliant prior to being allowed to join the federation.

In concert with simulators meeting IEEE standards and becoming a member of the federation, a robust network must be available that connects the simulators to each other. The bandwidth of the network must be sufficient to handle the transmission of the data packets. Without an adequate network, DMO cannot occur. Although the bandwidth requirements are not substantial, a moderately sized network is required to support realistic synthetic training involving multiple units.

Along with establishing a robust network, security is an issue. Not only is the network to be encrypted, the network must consider restrictions certain simulators might have regarding the sharing of their special access information across all platforms. A “cross-domain solution (CDS)” is the term used to provide the domain or platform isolation. The CDS is a guard and rule set that determines the information shared between simulators. A cross-domain solution is not needed if all simulators on the network operate without program access restrictions.

Once the network is established, simulators meet IEEE standards, and a federation is established, DMO can begin. The key to successful DMO training is identifying the training requirements to be met, who can meet those training requirements, and how to build the exercise(s) and scenarios to meet those training requirements. The efficiency of DMO rests with the ability of platforms to be both a training vehicle for other platforms and receive quality training that fulfills platform training requirements. It is very inefficient for a platform to solely be a training device for another platform. It is also inefficient to have a large “white force” providing training “injects” when platforms could and should be providing realistic training inputs.

4.1 Standards

The weapons system trainers that participate in distributed training events must interoperate with each other consistently and reliably. The key factors that allow that to occur include:

Standards Compliance

All trainers must adhere to a common set of design and procedural standards. An example of the topical span of standards would be:

Networking Standards. Where system wide static IP address are assigned and managed. This provides ease of problem identification, and filtering criteria.

Security Standards. Provides technical, as well as procedural protections, which provides reasonable assurance that information presented by one training system will be protected when being utilized by another.

Common Models Standard. Ensures that each training system has the ability to create or interact with a common set of constructive models (simulated entities). This means that all entities present in a given scenario is “visible” to every training system and that the physical appearance and capabilities of these entities are properly interpreted by every system.

Event Control Standards: Provides detailed, mutually agreed upon procedural actions that allow distributed
training events to be accomplished with effective coordination and expediency on a routine basis. Synthetic Natural Environment Standards. Ensures that when a training event takes place, all players have the level of detail (e.g., geographic, visual) necessary to allow for effective training. This normally requires early establishment of common training areas.

Other standards that typically apply might be Threat Representation and the behavior of Computer Generated Forces (CGF), or DIS and HLA protocol standards.

4.2 Centrally Managed DMO Network Operations Center
A distributed training system should be managed centrally for consistent performance and control. A DMO Network Operations Center (NOC) staffed with technical personnel capable of managing a large and potentially complex network of dissimilar systems provides consistency and reliability necessary for persistent training to be accomplished.

4.3 Scheduling
A key is to make it simple on the user; if it takes more effort than flying a live mission, users, over the long term, will not participate. The key is to make the planning and scheduling as seamless as possible. A good analogy is to plan and execute every distributed and local training event using a DMO weapons system trainer exactly like you would an actual mission or sortie. In essence, when planning a monthly flight schedule, include the trainers and interact with external agencies. The use of existing centralized scheduling systems for live sorties has proven to be very effective in making sure that DMO missions are provided the same considerations as live missions.

4.4 Provide Relevant Training Events
Establish a training requirements matrix for each platform to ensure that scheduling supports each platforms training needs. This reduces the chance of making one training system serve as the training device for another and denying effective training for all platforms. It should be more important to focus on the training relevancy for each participant, and not focus on the number of participants. In other words, it is not practical to require all weapon system trainers to virtually participate in every event every time. In cases where the platform is merely “present and accounted for” in a given training scenario, use constructive entities such as those generated in ASCOT, and role players. The utilization of a training requirements matrix combined with a centrally managed scheduling system provides a venue for unit level input to the schedule forecast.

4.5 Fair Fight Conditions
Flight models and weapons parameters must be realistic and damage models accurate; unrealistic shots or maneuvers cannot be allowed; realism is paramount in order to assure realistic, effective training in the DMO environment. Because of the synthetic training environment, kill removal is “real kill removal” as opposed to during live fly when a killed entity must exit the area for a brief amount of time before reengaging. Any performance “dumbing down” of systems capabilities for the sake of security restrictions needs to be very carefully managed. In almost all cases this will require a separation of “crew” and trainer operators, whereas the crew sees exactly what they would see in actual combat, and the trainer operators see the “protected” data that creates the battle space. Essentially, crews see their perception of the world and the trainer operators may have access to all of the elements that make that world including those not perceptible by the crew.

CROSS DOMAIN INFORMATION SHARING (CDIS)
CDIS is an essential and requisite enabler to expanded DMO, where one or more mission participants are operating with different classification restrictions. For the purposes of brevity, this paper will limit its CDIS discussion to operations within one security level (i.e., SECRET, SECRET/REL, SECRET/NOFORN or SECRET SAR) vice multi-levels of security (MLS) which are a more complex problem set and less frequently required. CDIS is first and foremost a policy issue, with multiple and often competing elements. Cybersecurity policy, Information Assurance (IA), Accreditation and Authorization (A&A), Operations Security (OPSEC) and Risk Management Framework (RMF) all play out amongst a diverse group of stakeholders, e.g., nation(s), major command(s), acquisition program offices and training organizations/participants. It is policy that ultimately defines what Cross Domain Solutions (CDS) are possible and the timelines required to implement, not technology.

5.1 Technical Components
Each CDS must have two technical components.

5.1.1 An accredited transport CDS guard (H/W, middleware, and S/W). Currently, the Combat Air Forces (CAF) employ a proprietary guard within the SECRET/NOFORN Distributed Mission Operations Network (DMON) to support persistent and daily training, e.g. F-22 and AWACS. The success is attributed to strict adherence to CAF DMO standards and daily use. The Joint community is in the final stages of approving a government-owned CDS, i.e., Distributed Training Network Guard (DTNG). This guard is envisioned to support DMO across networks, such as Joint Training Environment
Network (JTEN), DMOC network, Air Reserve Component Network (ARCNet) with trusted coalition networks initially, and/or with DMON objectively.

5.1.2 A guard can and must run one or more S/W rule sets which satisfactorily filter, guise, or block the restricted information. When combined with appropriate rule sets, the security risk can be managed to an acceptable level to support Authority to Operate (ATO).

The combined result is DMO users can participate/interoperate in the same shared synthetic battlespace, while allowing individual participants to more fully operate their system capabilities and employ combat Tactics, Techniques and Procedures (TTP). The mutual goal being the greatest integrated combat readiness training, while managing security risks which occur in the physical domain and by way of inference.

5.2 Enclaves
An additional aspect of CDIS is managing the training enclaves created. Aircrew/mission crew participants may require read-in to an appropriate restricted security level to support the mission planning, briefing, execution, and debriefing process. This is not universal and will depend on the participants and networks being leveraged. Some examples are provided below:

5.2.1 Current CAF DMO mission on DMON. AWACS (Tinker AFB, OK) working with a 2-ship of F-22s (Langley AFB, VA) represent a training enclave where Air Battle Managers (ABM) are read into some elements of the F-22 program. The DMON contractor provides a CDS guard and rule sets to support DMO events.

5.2.2 Recurring Coalition VIRTUAL FLAGS (CVF). DMOC, DTOC and JTEN networks may connect with up to 25 participant sites to include UK’s Air Battlespace Training Centre (ABTC) and if connected to DMON will require a CDS guard, e.g., DTNG and rule sets to allow DMON participants to operate at the SECRET/NOFORN level while all other participants operate at the SECRET/REL level.

5.2.3 An AUS F-35 on DMON (or AUS DMON) in the future working with a US Joint Terminal Attack Controller (JTAC) will need a CDS guard and rule sets between DMON and DTOC, similar to the CVF above to support a SECRET/NOFORN training event. If the AUS F-35 training objectives require full system employment, a second serial CDS internal to DMON (SECRET SAR) would be employed prior to the CDS between the networks.

As you can see, CDIS is integral to realizing true integrated combat readiness training within and across DMO networks.

Briefings and debriefings are as critical for simulation events as they are for live training events. Mass briefs need to be focused on the training objectives and the execution of the overall mission scenario. Individual flight or single aircraft actions are section brief items that are covered in separate unit briefings. Realizing the macro problem, e.g., Eagle One targeted wrong group, is for the mass brief, the particulars as to why Eagle One targeted the wrong group is up to the unit brief. Mass briefings focus on the major points and use referees if independent judgment is needed. These referees however should not run the brief; the “Package Commander” should be in charge, just like a live-fly event debrief is run. Unit level debriefings are led by the flight leads and use detailed flight data recordings and controller notes, just as a live debrief would, but also aided with video recordings that can be captured during simulation events.

As previously mentioned, DMO events are briefed and debriefed as if they were live events. The advantages provided by distributed mission operations allow the participants to execute the simulation event from multiple locations around the world while still flying together in a common airspace and/or a common theater. This distributed execution also allows for distributed briefs and debriefs. This is made possible by using tools like video tele-conferencing and synchronized mission recordings that include audio, video and simulation truth, to analyze mission execution and document lessons learned for future missions. Many advances have been made over the years in synchronized wide area network After Action Review (AAR) for distributed mission operations. One of the most significant being a common protocol for allowing a single site to stop, start, fast forward and rewind disparate AAR systems. The Enhanced Mission Record and Review System (EMRRS) developed by PLEXSYS Interface Products is one CAF DMO-certified system that provides all these capabilities. The sections below will highlight the benefits of the aforementioned video and audio tele-conferencing and synchronized mission recording reviews.

6.1 Video and Audio Tele-Conferencing
Plan time to have “face to face” pre-mission briefs using modern video and audio conferencing technology. This allows for collaborative mission planning using shared briefing slides and other mission planning documents.

Plan time to have “face to face” mission debriefs. Using the same collaborative tools, debriefs are used to gather lessons learned from geographically separated event participants.

Participants should make use of the most modern collaborative tools to take advantage of network connectivity during mission briefs and debriefs.
Synchronized Mission Recording Reviews

Participants should record video and audio from the simulator that is the mission crew’s perspective of how their part of the scenario unfolded. This is accomplished by capturing video from sources at crew consoles and flight simulators along with audio capturing from the mic and headset of the individual crew member.

Participants should record simulation scenario “truth” data in the form of DIS and/or HLA for comparison to the individual mission crew member “perceived” video and audio recordings. This allows for analysis of the entire scenario against individual participant views. Truth data is displayed on a world view simulation engine such as the PLEXSYS ASCOT Environment Generation capability that will display all simulations interactions. Truth audio is monitored using DIS and/or HLA compliant radio simulation applications.

The use of a mission recording system that allows for multi-source, multi-site synchronization of mission videos and audio channels is paramount. All perceived audio and video along with truth DIS and/or HLA audio and entity interactions can and should be synchronized for centralized control of start, stop, rewind and fast forward functions.

The use of audio and video control software application that allows the display of several mission video and audio channels simultaneously on the same display allows for efficient review and sharing of recorded data.

CONCLUSION

Standing up a DMO capability is not a monumental task, but requires thought, and a systematic approach. It starts with connecting two sites and establishing persistent interoperability standards to support recurring training events. As the need for solutions to address live training shortfalls continues to grow, we believe DMO will mature even more to fill many of those voids. The concepts and capabilities presented in this paper have been operationally proven to enhance that training environment. Our hope in writing this paper is that the international training community will benefit from what we have experienced and implemented regarding an effective DMO training program.
Geospatial Layer Interoperability

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Abstract. Simulation is an area that requires the adoption of standards to allow the various simulation providers to interoperate. In particular, there have arisen a number of differing standards related to geospatial identification. Each of these standards has different benefits and different supporters among the industry vendors of simulation products. This has made it virtually impossible to agree and move to a single all-encompassing set of standards. Even if the hard work was done to obtain agreement to a single standard, the future is characterised by further rapid development in the digital arena, so the problem can be more accurately stated as how to build a conceptual model that allows disparate simulators to interoperate and allow for the introduction of new standards as they develop. This paper suggests an implementation model as to how that might be achieved.

INTRODUCTION

How is a particular physical location precisely defined? In an absolute sense, each place on earth is uniquely defined by its latitude and longitude coordinates, to a sufficient degree of precision. Of course this is further complicated by the concept of the objects height relative to the surface. The problem arises when various objects are placed onto the simulation landscape and slight inaccuracies lead to a misalignment of the object relative to the environment. This subject is generally discussed by Andreas Tolk (Tolk, 2012) and David Lashlee (Lashlee, 2012). These problems manifest themselves in the classic photo of a half-buried tank in a simulated environment.

Figure 27: Illustration of tank that is not aligned to its surrounding terrain

So, an initial model would suggest that there is an absolute location, which is described by a particular standard, which is used by particular simulators; in a one to many set of relationships.

Figure 28: Relationship of Standards Used by Simulators to the Position Represented

Next, let’s look at what can be present at the particular location described. We can think of this in two broad categories; the natural environment and man-made objects.

The natural environment can be illustrated as:

Figure 29: An Illustration of Components of the Natural Environment

As an example, the International Standard ISO 18025:2005; Information technology — Environmental Data Coding Specification (EDCS) specifies

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3 Photo source: http://www.strangemilitary.com/content/item/144069.html

4 http://standards.sedris.org/18025/
environmental phenomena in categories that include, but are not limited to, the following:

a. abstract concepts (i.e. absolute latitude, accuracy, geodetic azimuth);

b. airborne particulates and aerosols (i.e. cloud, dust, fog, snow);

c. animals (i.e. civilian, fish, human, whale pod);

d. atmosphere and atmospheric conditions (i.e. air temperature, humidity, rain rate, sensible and latent heat, wind speed and direction);

e. bathymetric physiography (i.e. bar, channel, continental shelf, guyot, reef, seamount, waterbody floor region);

f. electromagnetic and acoustic phenomena (i.e. acoustic noise, frequency, polarization, sound speed profile, surface reflectivity);

g. equipment (i.e. aircraft, spacecraft, tent, train, vessel);

h. extraterrestrial phenomena (i.e. asteroid, comet, planet);

i. hydrology (i.e. lake, rapids, river, swamp);

j. ice (i.e. iceberg, ice field, ice peak, ice shelf, glacier);

k. man-made structures and their interiors (i.e. bridge, building, hallway, road, room, tower);

l. ocean and littoral surface phenomena (i.e. beach profile, current, surf, tide, wave);

m. ocean floor (i.e. coral, rock, sand);

n. oceanographic conditions (i.e. luminescence, salinity, specific gravity, turbidity, water current speed);

o. physiography (i.e. cliff, gorge, island, mountain, reef, strait, valley region);

p. space (i.e. charged particle species, ionospheric scintillation, magnetic field, particle density, solar flares);

q. surface materials (i.e. concrete, metal, paint, soil); and

r. vegetation (i.e. crop land, forest, grass land, kelp bed, tree).

On the man-made scheme of things, we can overlay the natural environment with:

The man-made civil environment, such as buildings, roads etc Simulation objects that can interact with the environment and can typically move, shoot, be damaged or destroyed.

Typically there is a list of simulation objects that can move and interact. This list will need to resolve the simulator that is responsible for that objects movements and interaction. So an object such as a tank may have a location at a point in time, but also has a direction and speed. Thus the simulation landscape is a calculated representation at a particular point in time.

Next we need to consider how a simulator represents four issues:

The natural environment and static civil environment

The list of simulation objects

Changes to objects caused by their interaction resulting in damage or destruction

Collateral damage to the natural environment and static civil environment and how that is updated and represented

The natural environment and static civil environment

These environmental representations are characterised by being relatively unchanging, so that they can be loaded at the beginning of a simulation exercise as the “Area of Operations” for each simulator. This suggests that the general process would be one of Defence maintaining the gold standard of the world, from which the static representation of the Area of Operations is defined and provided to the various simulators using the applicable standards required by each simulator. This would result in each simulator in an exercise being able to commence with a preloaded view of the static natural and civil environment. This progression is illustrated in Figure 4.

The list of simulation objects

This is typically the list of man-made objects, such as those in the Order of Battle, that are then represented in the simulation landscape.

Changes to objects caused by their interaction resulting in damage or destruction

As the simulation progresses and weapons are fired, this can result in varying degrees of damage or destruction. So the properties of these objects need to be updated and then shared with all the simulators in the scenario, not just the ones inflicting and receiving the damage.

Collateral damage to the natural environment and static civil environment and how that is updated and represented

One example of collateral damage to the natural environment and static civil environment might be a tank firing shells at an opponent. For those shells that miss their target, there is still an impact on the ground or vegetation at the point of impact (trees might fall down, for example). A shell might hit a bridge and make it unusable, an important point to the fidelity of the war game and an important point that must then be shared with all simulators in the scenario.

An interesting point to note is that we're reaching the point where the level of granularity of the geospatial data captured and maintained for the real world and that of the synthetic world are becoming the same. Simulators are today better able to cope with the complex computing required for accurate environmental representation in the real time display of the simulator. The implications are that perhaps we no longer need to synthesise the environment, we can use
the real one in simulation and synthesis efforts shift to adding non-real world features we need for a simulation to a real world geospatial base.

A PROPOSED IMPLEMENTATION MODEL

The issue of which standards apply to the environmental representation is one which has never been resolved to settle on one exclusive standard. And looking forward, it is unlikely to be settled in favour of one standard only. Even if it was, there is the issue of the inevitable updating of standards to cater for new and improved simulation outcomes.

The need for interoperability between environmental layers is particularly relevant for the Joint, Live, Virtual, and Constructive (JLVC) 2020 Technical Architecture which represents the next generation of cloud-enabled modular M&S services that will improve flexibility, accuracy and reusability.

We can restate this issue as the ongoing need for being able to run a scenario in which groups of simulators (connected via a version compatible run-time instance of HLA/DIS) can each work with a particular version of environmental standards and yet share this information between the players in real time.

The Enterprise Service Bus supporting the Synthetic Backbone is a way to accomplish this. Each execution group of simulators is connected to the ESB and passes events to the backbone, such as damage to the environment or movement of objects in the simulation landscape. The backbone then mediates between each group of simulators and passes the event, in the right standard format to each group of simulators so that the objects move or reflect damage to them. In this way, a tank firing a shell at a bridge can have that damage reflected in other simulators that are not part of that action and may use a different environmental representation standard. That concept is illustrated below:

![Figure 30: Interoperability of Environmental Elements](image)

We can think of this as having a gold master for the world, from which is derived the specific exercise area of operations with that AoO being shared between the various simulator instances. The message events sent to the synthetic backbone enable each version of the AoO to be kept up to date as the action progresses in the game.

![Figure 31: Deriving the Area of Operations](image)

BENEFITS

The implementation approach outlined above allows for new versions of particular standards to be linked into the synthetic backbone and 'subscribe' to a particular exercise. The results of using new standards can be monitored and compared with the results obtained in the current production version of the game, without impacting on the outcome of the production version of the game.

Thus simulators may be in view only mode, subscribing to the appropriate data feed and receiving that data in the standard that they understand for display to the operator. The operator can see the result in the production version of the game and compare it in real time to the fidelity obtained by the new simulator. This approach provides a comprehensive way to test new standards while maintaining the production quality of existing versions prior to their deprecation and subsequent retirement. This will allow future standards as they develop to be mixed into existing simulation standards. It further provides flexibility to the hosting Defence force to ensure that all simulators can be accommodated with a broad range of supported environmental standards.

REFERENCES


The Tri-Service Open Platform For Simulation (TOPS)

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Abstract. Simulation has been established as a valid tool for medical instruction. The number and availability of commercial simulation platforms has grown rapidly. Many simulators are driven by a PC-type computer. Different procedures and vendors use computers with very similar in performance, yet each simulator includes its own computer. In an educational facility with many simulators, there is a proliferation of these computers. It presents procurement, maintenance, and cyber-security concerns. The Tri-Service Open Platform for Simulation (TOPS) seeks to develop an open interface standard for medical simulation devices. TOPS allows different vendor hardware products to run on the same PC-platform using a single unified driver and application programming interface. TOPS is intended to reduce redundancy, and facilitate the development of new medical simulation applications.

INTRODUCTION

Simulation has gained widespread acceptance within the medical community. There are a wide variety of computer based simulators addressing all levels of medical instruction. Examples include human patient simulators [1], laparoscopic trainers [2], and immersive medical team trainers [3].

Proprietary vendor configurations require a separate computer system for each simulator. PC-type computer hardware running a variant of the Windows operating system has become a commodity item. Because of their low cost, they are frequently employed in medical simulation products. Commodity PC systems have very similar configurations. They generally use the same commercial-off-the-shelf components for the CPU, and graphics processing unit (GPU). Memory and storage capacity are generally ample for supporting most medical simulation applications.

Maintaining a 1:1 ratio between simulators and computers is cost prohibitive in a large enterprise. As simulators generally employ fully-functional computers, the effort required to maintain software patches and updates increases. Ensuring cyber security becomes correspondingly more complex. Within the United States Department of Defense (DOD), there are more than 150,000 medical personnel at all levels. The number of simulators required to support this cadre is substantial. If the 1:1 assignment between computers and simulators continue, acquisition and maintenance cost will become unmanageable.

The Tri-Service Platform for Simulation (TOPS) seeks to develop an open interface standard for medical simulation devices. The objective is to reduce the unnecessary proliferation of PC-based computers without limiting the variety of procedures and instructional applications.

TOPS seeks to emulate the gaming platform paradigm. There exists a diverse range of games that can be run on a gaming console such as the XBox 360 [4]. Each game has a different objective, yet all are compatible with the same hardware console. In the same fashion, TOPS seeks to develop a standardized interface. It will allow medical simulation devices from different vendors to plug into the same computing platform.

METHODS

Development of TOPS was done using feedback from key stakeholders. Their concerns drove the design for TOPS. Specification of the TOPS protocol was done using these design principals. Implementation consisted of two components: the TOPS standards document, and a developer's toolkit. In this section, we describe each in more detail.

Stakeholder Input. Prior to defining a standard, input from the medical simulation community was sought [5].

The vendor community had multiple concerns. Intellectual property must be respected. Existing investments in engineering and software development must be preserved. Vendors were unlikely to accept a solution that required redesigning to their medical simulation devices.

Foremost among the end user community was the need for interoperability. Cost was another issue. Users were keep to preserve their original investment without incurring major expenses acquiring a TOPS-compliant system. Stability of the host computer system was desirable. Finally, the DOD medical simulation community had cyber-security concerns.

All computer-based systems needed to undergo the DOD Information Assurance Certification and Accreditation Process (DIACAP).

Design Principals. We designed TOPS using the following principals: TOPS will focus on standardizing hardware communication between the simulation device and the host computer. It will be designed to minimize product re-engineering from both the hardware and software perspective. The same driver architecture must be capable of driving all TOPS-compliant devices. Finally, it will co-exist with vendor proprietary protocols.

Protocol specification. The USB 2.0 Communications Device Class (CDC) was selected as the TOPS hardware link layer. The USB interface is ubiquitous on PC-type computers. Many vendor devices already
incorporated a USB interface. By further standardizing on the class of USB devices, all TOPS devices can be accessed uniformly using the same driver. Finally, some USB devices are already acceptable to DIACAP, simplifying the certification process.

TOPS communications is organized over data channels. A data channel allows data to be passed between the host and client. All TOPS devices support at least one bi-directional channel by default. This is designated as channel 0. Additional channels may be defined by the device manufacturer.

TOPS also provides a set of commands allowing the host computer to query an unknown device (e.g., device ID, number of channels supported, channel direction, bandwidth, and maximum speed). Vendor specific commands are supported by invoking the TOPS extension command.

TOPS-specific commands are communicated over channel 0. Other channels carry device data. No restrictions are placed on the nature and type of data supported by these channels. The vendor may choose to format them as required. However, the structure and purpose of this data must be documented and made available. The objective is to provide developers with sufficient information to communicate with the device, and to incorporate its capabilities into a medical simulation application. This documentation will be maintained as part of a definitive reference library for all TOPS devices. Work is ongoing to provide online access to the reference library.

This design philosophy permits TOPS to encapsulate existing vendor specific protocols. Once basic handshaking has been completed via TOPS, a dedicated channel can be established between the host and device through which the original vendor protocol can be used.

**Implementation.** To address vendor concerns regarding intellectual property protection and engineering costs, a developer's kit was created to specifically alleviate these concerns. It consists of a reference TOPS micro-controller interface design, associated firmware, a TOPS device driver and an Application Programming Interface (API). The former component integrates into vendor devices while the latter two components are to be used on the TOPS host computer.

The TOPS micro-controller serves as an interface for vendor devices. Together with its associated firmware, this component serves three functions: first, it implements the full TOPS protocol specification for the client device. Vendors need not dedicate any additional resources developing firmware for communicating with TOPS. The only effort required is integrating the micro-controller with the device's hardware.

This integration can be done in one of two ways. The micro-controller can be integrated directly with the device's internal system bus. Or, it can be implemented as a dongle that sits between the host computer and the device. In the latter configuration, the micro-controller primarily serves as a protocol translator. It receives TOPS formatted commands from the host computer. These commands are then translated to the native protocol before sending it to the device.

Implementation as a dongle has other benefits. No re-engineering of the vendor device is required. The TOPS functionality is provided as a standalone component that can be sold for an additional cost. Since the vendor controls manufacture of the dongle, intellectual property is preserved.

We have developed a TOPS device driver for windows. This driver has been tested under both Windows 7 and 8. It is also anticipated to run under Windows 10. Only a single unified driver is required on the TOPS computer. This driver will interface with all current and future TOPS compliant medical simulation devices. This capability addresses a number of stakeholder concerns. Since only a single driver is required, DIACAP certification need only be performed once. In addition, reducing the number of drivers simplifies software maintenance and upgrades.

The TOPS API provides software developers with a programming library for communicating with TOPS devices. It includes function calls to query for the existence of new TOPS devices on the USB bus and to open them for access. Other functions establish TOPS channels and manage data input and output. The TOPS API is written in Microsoft C++ and is intended for the Windows Operating System. Presently, Windows 7 and 8 are supported. Future support for Windows 10 is planned.

**RESULTS**

Through partnerships with industry, we have developed proof-of-concept TOPS compliant devices. Both commercially available products and development prototypes were chosen for conversion.

**Anthrotronix AccelGlove.** The AccelGlove is a glove that captures hand motion. It is a commercial product by Anthrotronix. The AccelGlove has applications in teaching sign language, and for recording dexterous motor skills performance during medical training.

The AccelGlove is a USB device. It incorporates a micro-controller that converts hand gestures into data that can be transmitted to the host computer. A TOPS compliant version of the AccelGlove was developed by incorporating TOPS specific commands into the firmware, then modifying the output data stream to use a dedicated channel. Since the AccelGlove already possesses all necessary hardware components (e.g., USB interface and dedicated micro-controller), no additional hardware re-engineering was required. Only an extension to the existing glove firmware was required.

**Digital Indigo Surgical Microscope Foot-pedal.** Digital Indigo assisted in the development of an eye surgery simulator. As part of the hardware
development, the company fabricated an interface to a popular foot-pedal typically used to control surgical microscopes. Digital Indigo developed a TOPS-compliant dongle that directly interfaced with the foot-pedal electrical connector. The company used the TOPS reference micro-controller design and firmware for this purpose. The only additional firmware programming required was the mapping of specific electrical signals to a data format to be sent over a TOPS channel.

**Juxtopia Blood Pump.** Juxtopia is a small, minority-owned business with a mission to provide opportunities for promising college students to work in technology development. Juxtopia developed a prototype TOPS-compliant blood pump. The blood-pump is intended to simulate traumatic bleeding when into a mannequin. Juxtopia used the TOPS developer's kit for this project. They extended the micro-controller firmware to control a small fluid pump based on inputs to the TOPS interface. The entire project was completed by a 2nd-year college student in six months.

**Laerdal 3G SimMan.** The 3G SimMan is the most advanced Human Patient Simulator (HPS) made by Laerdal Inc. It incorporates sophisticated physiological cues, such as breathing, pulse, and heart sounds into a life-size mannequin. The 3G SimMan incorporates a real-time physiology model that can vary life signs automatically based on the training scenario.

Digital Indigo developed a dongle that allows the SimMan to be TOPS compliant. It translates the TOPS protocol into the proprietary SimMan protocol. The dongle was built using the TOPS development toolkit. Since the SimMan is a complex device, only some of the mannequin's capabilities have been made TOPS-capable. They include the ability to control heart-rate, breath sounds (e.g., choking or coughing), and pupillary reflex. Developing the full set of capabilities is beyond the scope of the prototype.

**DISCUSSION**

The TOPS initiative seeks the following strategic goals: Standardization, Collaboration, and Cross-Fertilization.

Standardization is critical to the adoption of new technology. Without the TCP/IP protocol standard, development of the Internet as we know would have been impossible. Standards can be formally ratified by the relevant governing body. Standards can also be de facto. One of the most successful and widely adopted standards is the Intel x86 architecture and its corresponding instruction set. Based on Intel’s 8086 CPU developed in the late 70’s, better than 90% of today’s desktop computing systems still adhere to this standard. Machine language programs written for the original 8086 will still run on Intel’s latest Core i7 CPU.

TOPS aims to be the de facto standard for the medical simulation community. At this point, we believe that ratifying TOPS as a formal standard will limit TOPS’ ability to keep pace with technological developments. No comparable standard currently exists for medical simulation devices. The medical simulation market is largely driven by an interest in capturing market share. As such, a vendor driven initiative is unlikely to emerge. The military healthcare network is the United States' single largest employer of health-care workers. Collectively, the military services have considerable influence in defining product requirements. TOPS can serve as the basis of a common standard DOD-wide.

TOPS has achieved its goal to demonstrate that standardization across medical simulation devices is achievable. It has developed a suite of hardware, firmware, and software that will allow any vendor to adapt a medical simulation device for use with a TOPS compliant host computer. No modification to the host computer is required to support both current and future TOPS compliant devices.

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The Common Database (CDB) Specification – Roadmap To Standardisation

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Abstract. This paper briefly describes the process, recently undertaken, to bring the elements of the Common Database (CDB) specification into the formal standardization process of the Open Geospatial Consortium (OGC), an independent, international, consensus-based Standards Development Organization (SDO). It also briefly highlights the expected benefits of using the Common DataBase once it is a fully adopted and implemented OGC standard.

INTRODUCTION

The Common DataBase (CDB) is currently an industry-maintained, open, public specification for creating synthetic environment databases using Geospatial Information Systems (GIS) data and other sources. CDB was originally created by CAE, Inc., after a competitive award from the U.S. Army Program Office for the United States Special Operations Command (USSOCOM). Following the completion of the USSOCOM contract, the CDB Specification (Version 3.0) was made publicly available, and CAE, Inc. and its subsidiary companies agreed to maintain and continuously improve the public specification.

Multiple implementations of training and mission-rehearsal systems based on the CDB specification have been designed, built, delivered, and are in current operation around the world. In Australia, the CAE designed Australian Army Multi-Role Helicopter (MRH-90) Full Flight and Mission Simulator (FFMS) and MH-60R Full Mission Simulator (FMS) were delivered with a CDB compliant architecture, while the Royal Australian Air Force (RAAF) C-130J FFMS and AP-3C Advanced Flight Simulator (AFS) have recently been subject to an upgrade that included compliance with the CDB format for Synthetic Environment (SE) databases.

CAE, Presagis, FlightSafety, and multiple CDB end-users have been active in improving the specification, resulting in the release of Version 3.2 of the CDB specification in February, 2014.

This paper briefly describes the process, recently undertaken, to bring the elements of the CDB specification into the formal standardization process of the Open Geospatial Consortium (OGC), an independent, international, consensus-based Standards Development Organization (SDO). The paper will also briefly explore the expected outcome(s) if the Common Database becomes a fully adopted and implemented OGC standard.

WHAT IS CDB?

The Common Database (CDB) specification is an open Synthetic Environment (SE) data model format. It is an emerging simulation standard that defines data representation, organisation and storage structures for a synthetic representation of the world with the conventions necessary to support simulation. It was developed jointly by CAE and Presagis and is freely available from Presagis [Reference 0].

Databases built to comply with the CDB specification are portable across compatible simulators (application types, such as fixed or rotary wing; as well as host technology), and can be used as source data repositories for both off-line and run-time published architectures. CDB compliant SE databases enable reuse and support effective interoperability [Reference 0] among producers and consumers of SE data.

![Figure 32: Common Database Structure.](image-url)

The CDB folder / file system convention supports rapid access to non-proprietary file formats for concurrent use on multiple simulations and simulators and allows for simulation clients to modify data stores during execution. The CDB format is in use today in the US, Canada, UK, Germany, Israel, Turkey, Singapore, Brunei and Australia.
WHY TRANSFORM CDB TO AN INTERNATIONAL STANDARD?

There are a number of reasons for conducting the effort to ‘transform’ CDB from an industry-maintained specification to a fully developed and vetted international standard:

Interoperability. “Plug-and-play” interoperability among heterogeneous run-time simulation clients was one of the original primary use-cases for the development of CDB. In most competitive marketplaces, convergence on a standard is more rapid and more effective if the standard is approved and maintained by an internationally recognized, independent, consensus based Standards Development Organization (SDO).

Diversity. At the time of the original conception, CDB was intended to be further developed for wider use outside of the original use case in high performance mission rehearsal. The inclusion of interested members of communities outside the original use-case will foster increased utility of the standard.

Increased utility. The submission and conversion of a de-facto standard in a well organised SDO will, of necessity, bring the new work into the architecture, document templates, ontology, and organization of other, related standards, increasing the readability and use-ability of the work.

WHY CHOOSE THE OPEN GEOSPATIAL CONSORTIUM AS THE STANDARDS DEVELOPMENT ORGANISATION?

The Open Geospatial Consortium (OGC), founded in 1994, has 500+ members from industry, academia, government agencies, and individuals, and has produced more than 34 GIS-relevant core standards. The OGC Mission is to serve as a global forum for the collaboration of developers and users of spatial data products and services, and to advance the development of international standards for geospatial interoperability. In particular, the OGC has developed Web Services that have already been shown to very useful in extending access to CDB data stores through connected web clients and services in existing programs.

In addition to its well-known Standards Development program, OGC also has well established programs for standards compliance, interoperability experimentation, and communications/outreach [Reference 0]. Through these programs, OGC develops, releases and promotes open standards for spatial processing.

The compliance and interoperability programs at OGC, in particular, will serve to foster adoption and continuous improvement of the standards.

The OGC Interoperability Program is focused on increasing system interoperability while reducing technology risks. It provides vendors with confidence that a compliant product will be easier to integrate and to market, while providing buyers with confidence on the interoperability between compliant products irrespective of their development heritage.

The OGC Compliance Program is focused on increasing system interoperability while reducing technology risks. It provides vendors with confidence that a compliant product will be easier to integrate and to market, while providing buyers with confidence on the interoperability between compliant products irrespective of their development heritage.

The OGC Interoperability Program has conducted over 80 initiatives through public-private partnerships designed to accelerate the development of emerging concepts and drive global trends in interoperability through rapid prototyping of new capabilities.

Many existing OGC standards, such as GML, CityGML, IndoorGML, OGC Web Services, and others will be very useful additions to systems utilizing CDB for its current simulation and mission rehearsal users, as well as possible use in emergency management, disaster preparation and planning, modeling of complex environments with high performance rendering implications, and many others.

THE NATURE OF THE STANDARDIZATION EFFORT FOR CDB AT OGC

The progression of CDB through the OGC standardization process will involve multiple OGC Working Groups and bodies: an OGC CDB Standards Working Group (SWG), the OGC Three Dimension Information Management (3DIM) Domain Working Group (DWG), the OGC Technical Committee (TC), the OGC Architecture Board (OAB), and the OGC Planning Committee (PC) [Reference 0]. Since the effort of all the committees is consensus based, an estimate of the “timeline” for accomplishment of the
effort is, obviously, only notional. Nevertheless, the OGC standards effort is vigorous; there are well attended, week long, face-to-meetings four times a year and there are multiple collaboration tools available to progress the work between meetings.

In addition to the commercial industry members of OGC who may have an interest in CDB, any nominated CDB standards will be reviewed and voted on by all Technical Committee members, which include organizations such as the U.S. National Geospatial Intelligence Agency (NGA), the U.S. Army Geospatial Center (AGC), the United Kingdom Ordnance Survey (OS), the Defence Geospatial Information Working Group (DGIWG) and many others. The complete listing of current OGC members may be found at the OGC website [Reference 0].

At the time of the submission of this paper in February, 2015, a draft charter for the formation of an OGC CDB Standards Working Group is in circulation for comment within the OGC Technical Committee. The draft charter proposes commencement of the formal standards development in March, 2015, and further proposes a timeline of approximately 12 months to the milestone of consensus approval votes within the OGC CDB SWG forwarding recommended standard(s) products to the OGC Technical Committee.

**BENEFITS OF A CDB COMPLIANT SIMULATOR ARCHITECTURE**

Moving to a CDB compatible SE database format provides for significant benefits in terms of performance and savings in ongoing costs. These benefits have been proven over the last ten years through projects delivered by CAE globally, such as the U.S. Army Program Office for the United States Special Operations Command (USSOCOM) and on CDB compatible Full Flight and Mission simulators delivered in Australia such as the Royal Australian Air force C-130J and AP-3C, and include:

- Improved SE database generation timelines, of the order of months to days;
- Fully interoperable simulation-ready SE database;
- Improved client-device robustness/determinism;
- Runtime-Adjustable SE database correlation and fidelity;
- Increased SE database Longevity; and
- Reduced SE database storage infrastructure cost.

Additionally moving to a CDB compatible SE database format provides for economies of scale and scope, including:

- Consolidation/harmonization of database development facilities across supported simulation facilities;
- Simplification and consolidation of database management effort;
- Reuse of developed database assets across all compatible and authorized simulations;
- Minimisation of database deployment effort to all simulation facilities;
- Shortening of mission rehearsal timeline / access to developed databases across simulation facilities;
- Logical aggregation/distribution of simulators into one or more confederacies operating in real-time;
- Logical aggregation/distribution of tactical management centers; and

A CDB compliant implementation is “JP3035 ready” allowing for true re-use across ADF simulation assets.

**CONCLUSION**

CDB is an emerging simulation standard for an open Synthetic Environment data model format that defines data representation, organisation and storage structures for a synthetic representation of the world with the conventions necessary to support simulation. It was initially developed to meet the needs for effective interoperability and agility of update to meet mission rehearsal training requirements of the U.S. Army Program Office for the United States Special Operations Command. It was subsequently supported jointly by CAE and Presagis and is freely available from Presagis [Reference 1]. SE Databases built to comply with the CDB specification are portable across compatible simulators, irrespective of application type or host technology. CDB databases can be used as source data repositories for both off-line and run-time published architectures and enable re-use and support effective interoperability among producers and consumers of SE data.

CAE has initiated the process to bring the elements of the CDB specification from an industry-maintained specification to a fully developed and vetted international standard of the Open Geospatial Consortium. Establishing the CDB as an international standard will result in significant benefits from improved interoperability between heterogeneous run-time simulation clients and in re-use across CDB compatible simulators and simulations. It will foster diversity and increased utility through the inclusion of interested members of communities outside the original use-case.

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SimHealth

Posters - Curriculum Development

Designing Simulation For Authentic Learning: An Alternative Lens To Fidelity

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Aim of the Education Program. Increasingly, simulation in health education is being explored as a substitute for clinical placement. However there are few examples of simulation design using sound educational theory as the basis from which to design such extensive simulation experiences. Whilst debate continues in the simulation literature between the relationship between simulator / simulation fidelity and learning transfer (Bland, Topping, & Tobbell, 2014), the concept of authenticity is as yet relatively unexplored.

The Occupational Therapy Council (Australia and New Zealand) (2013) identify authenticity as one of five conditions to be addressed in the design of simulation activity intended to replace clinical placement hours. However, authenticity is poorly defined, with the term used interchangeably with fidelity and realism throughout the health care simulation literature (Bland et al., 2014). This presentation offers a representation of authenticity as a feature of simulation design that clearly distinguishes authenticity from fidelity and realism.

The aim of this education program was to design a simulated clinical placement for second year occupational therapy students employing Herrington and Oliver’s (2000) instructional design framework for authentic learning environments.

Methods Adopted. An Australian University designed a 40 hour block simulated clinical placement, located within the context of vocational rehabilitation. Herrington and Oliver’s (2000) nine guidelines for designing authentic learning experiences were employed to frame the design and implementation of the simulated clinical placement. The resultant simulated clinical placement engaged students in a range of authentic activities including interviewing, performing workplace assessments, review of clinical documentation, report writing and collaborating with healthcare professionals. Students were supported throughout by clinical supervisors. Authentic feedback and assessment strategies were employed.

Evaluation Data from the Program. Evaluation of the simulated clinical placement took the form of: Student Practice Evaluation Form – Revised (SPEF-R); facilitator evaluation of clinical placement; and Satisfaction with Simulation Experience Scale (Levett-Jones et al., 2011). Data obtained from the evaluation tools demonstrated successful outcomes from the simulated clinical placement.

Conclusions and Recommendations for Future Use and Development. This project demonstrated the value of designing simulation for authenticity, not only in context, but in terms of simulating the process of learning. Future recommendations include further alignment between learning theory of classroom and workplace to underpin simulation design to facilitate learning how to learn.

References.
Profession-Wide Collaboration To Embed Role-Play Simulation Into Australian Entry-Level Physiotherapy Courses.

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Aims. This project embedded a sustainable 5-day model of role-play simulation into 16 Australian entry-level physiotherapy clinical education programmes as a substitute for a proportion of traditional clinical placement training time. A coordinated collaborative approach was taken, with the aim of encouraging profession-wide support. The project aimed to provide each physiotherapy program with the physical resources, simulation scenarios, staff training, expertise and enthusiasm to enable simulation training to be a sustainable clinical teaching approach into the future.

Background. In an increasingly complex clinical environment, with limited capacity to provide comprehensive and effective training for the increasing numbers of health care professionals, simulated learning environments (SLEs) may offer a unique alternative learning experience. Simulated learning environments offer particular educational advantages over a traditional clinical setting. Simulation training maximizes learning by guaranteeing provision of learning experiences that can be written to suit specific educational needs. For example, scenarios can be scripted to focus on specific conditions using pre-planned learning strategies or can also be extended to include specific safety or emergency issues that may only occur infrequently in the clinical setting. Carefully planned simulation scenarios can also provide structure and a guarantee of equity of experience for all students. Health Workforce Australia (HWA) (an Australian Government organisation) funded a consortium of 16 Australian physiotherapy programs to undertake a project to embed simulation into physiotherapy clinical training across Australia in 2014 and 2015.

Methods. The project was coordinated and managed by staff from Curtin University (Perth, WA) and supported by the major Australian Physiotherapy national bodies. Throughout the project, senior academic staff members from each of the 16 Physiotherapy Schools participated in monthly teleconference meetings to discuss all aspects of planning and implementation. In the planning phase, smaller Working Parties also met to plan and report back on key aspects such as scenario development and evaluation methodology. Scenario development teams, with representatives from each of the states, developed 40 detailed scenarios for cardio-respiratory, neurological and musculoskeletal clinical areas, suitable for students at varying stages of training across Australia. This involved considerable discussion and some resolution of differing treatment approaches. A collaborative manual detailing how to set up and run clinical simulation units was developed, including detailed timetabling, set-up requirements and simulation teaching techniques.

Result. The project has been successfully implemented as part of 16 physiotherapy courses around Australia. By mid 2015, 1800 students will have participated in simulation-based placements with more than 13,000 days and 99,000 hours of simulation training provided across all 16 participating Universities. The response from students and staff alike has been very positive, with almost universal enthusiasm for clinical simulation as an effective clinical learning modality. The presentation will provide preliminary analysis from the data collected over the course of the project.

Conclusions. This national collaborative project has successfully embedded simulation into clinical training in 16 of the 19 physiotherapy programmes across Australia. The project has demonstrated both that simulation is an effective addition to traditional clinical training and also that a significant new teaching approach can be successfully implemented across a profession using a collaborative approach.
The Development of Key Clinical Learning Outcomes for Scenario Based Simulated Clinical Learning Experiences in New Zealand Undergraduate Nursing Programmes

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Aims.
To identify the key learning outcomes for scenario based simulated clinical learning experiences in undergraduate nursing.

Background.
A national nursing education forum was held in 2013 by the Nursing Education in the Tertiary Sector Aotearoa New Zealand [NETS] in response to national nursing workforce reports that identified by 2035 New Zealand will have a shortage of at least 15,000 nurses, due to an aging workforce (Nana, Stokes, Molano, & Dixon, 2013). The forum considered how nurse education programmes might use simulation as a clinical learning strategy to increase capacity and capability. It was recognised there was variance across the sector in relation to integration and utility of simulation and that national collaboration was desirable. NETS members agreed to commission several research projects to support the development of simulation as a clinical learning strategy in Aotearoa New Zealand. This study used a three phased E-Delphi consensus approach to develop an agreed learning outcomes framework in order to inform the development of nationally standardised and validated scenarios for clinical learning.

Methods.
First phase conducted was a national and international literature review, document analysis and key informants were interviewed to develop the key clinical learning outcomes for the first round of the Delphi technique in Phase Two, and to map learning outcomes to Nursing Council of New Zealand (NCNZ) competencies for registration.

In phase two a survey was distributed by survey monkey for participants to rate with five levels of agreement the key clinical learning outcomes.

In phase three participants were then asked to prioritize the top 15 learning outcomes by ranking them in order of importance.

Result.
The top three consensus learning outcomes related to Domain Two of the NCNZ competencies, with the top two focusing on clinical judgement and clinical reasoning. In total eight of the top 15 learning outcomes were linked to Domain Two, focussing on holistic care, physical assessment and the cognitive skills required. Five of the top 15 learning outcomes were related to Domain One, and were associated with professional and ethical behaviour as well as cultural safety. Only two of the top 15 outcomes came from Domain Three relating to communication, in particular therapeutic communication and inter-professional communication. No outcomes related to Domain Four were ranked in the top fifteen outcomes.

Discussion.
Clinical judgment and reasoning can be related to all the key learning outcomes that were identified as important by the participants and these learning outcomes have been recognised in the literature as being critical components of an undergraduate nursing programme (Kantar & Alexander, 2012). Additionally, Domain Two of NCNZ competencies covers a wide range of concepts in regards to nursing management this could explain why so many of the top 15 learning outcomes came from this domain. It was noted that crisis management, resource allocation and deteriorating
patient learning outcomes did not rank in the top fifteen. This is significant considering the research that supports the use of simulation for teaching these concepts (Beyea, Von Reyn & Slatter, 2007; Cooper, et al., 2011; McKenna et al., 2014). Five of the top 15 learning outcomes were related to Domain One, Professional Responsibility and two of the top 15 learning outcomes came from Domain Three, Interpersonal Relationships highlighting that respondents recognised the value of simulation in the development of professional behaviour and effective communication. This suggests that simulation is valuable for teaching the softer skills such as linking theory to practice, therapeutic communication, leadership and team work as well as the traditional skill acquisition (McCaughey & Traynor, 2010; Pearson & McLafferty, 2011).

No outcomes related to Domain Four, Interprofessional Healthcare and Quality Improvement ranked in the top fifteen. This was a surprise to the researchers as current literature points to the effectiveness of simulation in teaching leadership, direction and delegation, inter-professional communication and the use of evidence based practice (Endacott et al., 2010; Good, 2003, Weaver, 2011). As this is atypical with the international simulation community, development and understanding of simulation use in relation to teaching the principles of crisis resource management/human factors needs to be explored in relation to the current patient safety agenda. However respondents commented on the need for linking the learning outcomes to the stage of the programme as they felt that some learning outcomes were more suited to the final stages of an undergraduate programme. However the learning outcomes were developed so that they could be applied to all stages of an undergraduate programme.

Conclusions.

This research provides evidence of a high level of consensus across the sector regarding the value of simulation education for developing undergraduate nurses’ clinical competencies. Additionally there is a high level of agreement regarding the key concepts which form the basis of clinical education, clinical judgment and clinical reasoning. This research will now be used to inform any future discussions around simulation learning. Further research now needs to be conducted in developing authentic clinical scenarios that are based upon the agreed learning outcomes.

References.


Is Stress Similar During Simulation and Clinical Practicum?

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Aims. The purpose of this study was to compare acute stress experienced by physiotherapy students in simulation to that experienced during hospital-based clinical practicum.

Background. Clinical simulation is now a standard educational tool used in both undergraduate health student and health professional training. One aspect of simulation research that has recently been explored is the influence of stress on participants during simulation. Much of the literature suggests that simulation elicits stress levels comparable to those experienced in clinical practice. Accordingly, the impact of stress in simulation is an important concept, as simulation scenarios often directly reflect clinical practice. It is unknown however, whether stress experienced by undergraduate health students during hospital-based clinical education is similar to stress experienced in clinical simulation.

Methods. Thirty-six 3rd year undergraduate physiotherapy students participated in simulation and hospital-based clinical placements. Stress was quantified using psycho-physiological measurements of visual analogue scales (VAS) of stress (100mm scale), heart rate and saliva cortisol before and after a clinical assessment of a standardised patient in a simulation setting, and a real patient in the hospital setting. Two-way repeated measures ANOVA (stress variables and time) were used to determine differences in stress levels between simulation and hospital-based settings.

Result. The peak VAS stress (mean (SD)) during simulation was significantly elevated compared to hospital-based settings (45mm (23) vs 31mm (21) respectively; p<0.05). Average heart rate during the simulation scenario was comparable to the hospital-based settings (90 beats/min (16) vs 87 beats/min (15); p=0.89). Similarly, salivary cortisol levels before and after the patient assessments in simulation and hospital-based settings were not significantly different (1.5 nm/L (2.4) vs 2.5 nm/L (2.9); p=0.70).

Discussion. These results indicate that physiological stress elicited during simulation is similar to that in the hospital-setting in undergraduate physiotherapy students. In contrast, the psychological stress domain was reported as higher during simulation. This suggests that despite the safe learning environment created in simulation, self-perceived psychological stress was elevated in this environment, and this may have an impact on performance during simulation.

Conclusions. When devising simulated clinical experiences, educators should consider that learners may experience heightened psychological stress in clinical simulation compared to hospital-based settings.
Independent Simulation Based Medical Curriculum Development in China, a Pilot Study

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Aim of the Education Program.

Most medical schools in Asia carry Six-year medical education program including one year internship, and medical student come from high school graduation not college. Traditional six-year program is lacking bed-side teaching. As a pioneer of international medical education in China, Tianjin Medical University (Tianjin, China) developed an independent six-year systemic 500 hours simulation based clinical training curriculum, continually from start through graduation of medical program, the aim is to build up a simulation based integrated clinical ability training platform including knowledge, skill, and attitude.

Methods Adopted.

Tianjin Medical University had established a virtual hospital—SimHospital to provide medical student with clinical ability training. SimHospital is a copy of hospital setting in a 2000 square meters space, simulating the clinical environments and scenes. We had a complete set of 500 hours simulation based training curricula, textbooks, student should take a none-stop 500 hours of simulation based training during six year.

New simulation based curriculum had been implemented into the education program for four years. Curriculum includes four stages:

1. Early expose medical training on basic medical lecture stage (two and half year, 138 hours): training focus on basic clinical concept, basic clinical skill practice, medical ethics, art of medical communication, basic science related simple case study, and hospital visiting.

2. Clinical lecture stage (next two years, 122 hours): training includes clinical skill and teamwork with simple case. Students practice same content with simulator in simulation facility immediately after lecture. We named training as “Clinical Laboratory”.

3. Pre-internship stage: medical students concentrate 8 weeks, 200 hours clinical skill self-training in simulation facility before internship starting; including real clinical scenario based medical teamwork, behavior, writing and other clinical skills.

4. Internship stage: 40 hours clinical skill examination. Non-technical skill training was considerate in all of stages.

Evaluation Data from the Program.

Class 2009 which received new simulation curriculum training was the experimental group. Class 2008 was control group which without simulation training. Knowledge examination and internship performance were collected and analyzed; surveys were taken by faculties and students. Evaluation Data from the Program Experimental group was significant higher than control group in clinical skill examination and internship performance. The result of the survey of teachers and students shown: 94.2% of students approved that simulation based training can improve their clinical ability, and increase their self-confidence while facing real patients in clinic; 88.9% of faculties who are in charge of internship admit that student’s personal clinical skill and team work ability have significantly improved compared with previous classes of students who had not received simulation training.
Conclusions and Recommendations for Future Use and Development.

We tried to develop an independent simulation based curriculum go continually from the first year through final year, and become a major teaching subject in our school. Our mission is that integrate simulation curriculum with classic education, move partial of lectures to simulation facility, integrate different disciplines knowledge and skill based on case and scenario, and build up independence curriculum without extent teaching hours. Simulation curriculum is a comprehensive training platform with knowledge, skill, and attitude; these three components are unseparated and benefit each other. Simulation based training should be continually, gradually, repeatedly, and spirally systematic training. Simulation curriculum may build up medical student become a qualified physician more efficiency, and will be systemic major medical curriculum in the future.
‘My Caring Rules’: Preparing First Year Nursing Students For Clinical Placement Via Gaming

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Introduction. ‘My Caring Rules’ (MCR) is a tournament designed to enhance the acquisition of clinical skills and knowledge amongst our first year nursing students. This educational activity utilises simulated patient methodology to augment students’ experiential learning. This presentation will share the development, implementation and evaluation of what we feel is an engaging teaching and learning strategy.

Background. Prior to partaking in MCR, students work in teams throughout the semester to care for one ‘virtual’ patient utilising an unfolding case study. In this weekly activity, teams are required to plan, manage and evaluate the care of the person during their ‘patient journey’ (West, Usher & Delaney, 2012). Importantly, as new concepts are learnt throughout the semester, this content then becomes embedded in the unfolding case study creating the patient’s altering clinical picture.

MCR is held during the semester’s final practical session. During the tournament, the unfolding case studies are brought to ‘life’ with the use of simulated patients, with the student teams being required to provide individualised, person-centred care to several of the patients.

Aim of the Education Program. The aims of this educational strategy are to:
Prepare students for the realities of working in a dynamic and pressured clinical environment whilst on placement;
Facilitate the application of key concepts, knowledge and skills that are learnt by students during their first year of study, and;
Promote students’ understanding of how to link psychomotor skills to professional, non-psychomotor based skills when providing holistic nursing care.

Methods Adopted. The MCR tournament utilises a gaming methodology where students are engaged in three episodes (rounds) of care. Each episode of care represents either a morning, afternoon or evening shift in an acute medical ward. Working in teams, students must complete the necessary nursing cares within a specified timeframe. At the end of each ‘shift’, the simulated patients and teaching staff assess each team’s clinical proficiency, teamwork, communication skills and documentation using different coloured tokens. Bonus tokens can also be awarded by the simulated patient when teams demonstrate examples of exemplary care. At the end of the each round, the tokens for each team are collected and tallied by an independent auditor. The results are then announced to the class. At the conclusion of the three rounds, the team with the highest cumulative score is awarded with a group trophy and individual certificates.

Briefing plays a pivotal role in the success of MCR. Multiple sessions are held to inform the teaching staff, simulated patients and support staff regarding their specific roles during MCR as well as the game’s rules, expectations and schedule. Student briefings are also held prior to and on the day of MCR to outline the learning objectives of the session and the ‘rules of engagement’.

Evaluation Data from the Program. Student feedback regarding this activity has been elicited via subject feedback and student surveys. This qualitative data highlights themes such as “I feel better prepared for placement” and MCR “replicating real life” being cited by students.
Conclusions and Recommendations for Future Use and Development. The inaugural MCR was held at one of our five campuses in 2013. Following the positive feedback regarding this activity, the tournament was effectively introduced to the other four campuses in 2014. Due to the diverse nature of each our campuses which includes two remote sites, the successful implementation of MCR at each of these campuses demonstrates the flexibility and adaptability of this game.

The initial setup of MCR required significant resource development, however, now this foundational work is completed, the time required to prepare this activity is minimal. Consequently, this permits key staff to dedicate more time to briefing our simulated patients, thereby, promoting a more authentic learning environment to be created.

Reference.

Student Learning outcomes across Simulated, Virtual and Aged Care Clinical Learning Environments

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Aims.
This presentation aims to describe the results and implications of a research project investigating students’ communication knowledge, skill and confidence in interacting with elderly adults. Sixty two third year undergraduate speech pathology students were randomly allocated to a clinical placement where they interacted with either a nursing home resident, a trained patient actor in a simulated nursing home setting or an elderly male avatar in a virtual learning environment. Students completed surveys before and after their placement, rating their communication knowledge, skill and confidence as well as completing the Jefferson Scale of Empathy (2009). This study sought to determine whether students’ self-ratings improved following an aged care communication experience and, if so, which of three types of communication experience provides the most significant improvement. It was hypothesised that: i) students’ post-placement self-ratings of knowledge, skill, confidence and empathy will be significantly higher than their pre-placement self-ratings, ii) post-placement, the avatar and actor conditions will report equivalent ratings on these measures and iii) post-placement, the avatar and nursing home conditions will report equivalent ratings on these measures.

Background.
Speech Pathology students in Australia are directly assessed on their communication skills as a core generic competency within their clinical practice training (Speech Pathology Australia, 2011). There is a need for more explicit opportunities to be available for students to focus on and refine their communication skills, but in the current workforce and University climate, there is limited funding and capacity for additional clinical placements. Concurrently, there is an increasing amount of literature exploring alternative clinical training methods such as simulation and virtual learning environments, but there is limited research directly comparing these alternative methods of clinical training and the development of student communication skills within each.

Methods.
Sixty two undergraduate speech pathology students in their third year were randomly allocated to one of three alternate clinical placements where they interacted with either a nursing home resident (n = 21), a trained patient actor (n = 22) or an elderly male avatar in a virtual learning environment (n = 19). Each student had up to 30 minutes with their communication partner to have a general conversation and find out more about the patient’s interests and needs. Students also participated in small group debrief sessions on the same day of their experience.

One week prior to, and immediately following the placement, students completed a survey including the following components:
- Demographics (pre-placement only),
- Clinical communication knowledge (9 questions rated on a scale of 1 to 7),
- Clinical communication skills (9 questions rated on a scale of 1 to 7),
- Clinical communication confidence (9 questions rated on a scale of 1 to 7),
- Jefferson Scale of Empathy - student version (20 questions rated on a scale of 1 to 7), and
- Evaluation of learning experience (post-placement only)

Results.
Four hierarchical multiple regression analysis were conducted to explore the unique contribution that placement type had on evaluated changes in communication abilities after accounting for pre evaluations of skill, knowledge, confidence and empathy in communicating with older adults. This allowed determining the unique contribution of a given placement by observing the contributions of variables incrementally. Results of the study revealed that all participant groups self-reported significantly higher knowledge, skills, and confidence after completion of their respective placements. Effect sizes ranged from $d = .46$ to $d = .70$ (Median = .58). The nursing home group self-reported higher empathy post-placement ($d = .40$), but the other two groups did not (Median $d = .14$).

The change from pre- to post- placement did not vary as a function of group. Results indicated difference of post-evaluated knowledge ($F (2, 59) = 0.250, p = .780, \eta^2 = .008$), skills ($F (2, 59) = 0.162, p = .851, \eta^2 = .005$) and confidence ($F (2, 59) = 0.552, p = .596, \eta^2 = .017$) between the three groups was clinically non-significant. The
difference in reported post-evaluated empathy (JSE-HPS) between the groups was also clinically non-significant, $F(2, 59) = 1.534, p = .224, \eta^2 = .051$.

In their evaluation of the placement, nursing home participants' evaluations were significantly more positive than those of the avatar participants ($d = .89$), but not those of the actor participants ($d = .21$), specifically with relation to how realistic and natural the experience was and how engaged the student was in the experience.

Qualitative data gathered through open ended questions at the end of the post-placement questionnaire revealed a number of themes, including students perceptions that interacting with the virtual avatar was particularly challenging, the value of the clinical educator in the learning experience, and the difficulty in completing a task without a clear clinical focus.

**Discussion.**
This study investigated the validity of two contemporary simulated clinical education models; the virtual learning environment and the use of a trained actor, compared to a traditional clinical education model of direct patient contact in a community setting. The findings of this study highlighted that all students perceived improvements in their clinical communication and interpersonal skills irrespective of the practicum model used in their third year speech pathology placement. This preliminary validation supports the use of more sustainable and financially viable placement models in light of evidence that this is not compromising the student's learning experience.

The significant improvement shown in the students' self-rated improvement in communication knowledge, skills and confidence after only one short interaction experience highlights the need for ongoing investigation into the intensity and frequency of training required for developing communication skills. A common perception of community clinicians is that students require a number of weeks of experience interacting with elderly adults before their skills are deemed to be at an appropriate level. Future research should include objective measures of students' conversational skills to determine the optimum amount of simulated training required to ensure students enter future placements with the appropriate foundation communication skills.

The students' reflections regarding the lack of purpose to the task in the absence of a clinical goal (for example taking a case history) demonstrate the need for consideration as to the appropriate timing of introducing this placement into the curriculum. Third year students have already commenced and completed a number of clinical placements and are therefore likely to find it difficult to focus purely on rapport building and interaction skills. The value of the clinical educator in the experience as described by the students reinforces a common finding in the use of simulation in clinical education, that is, that the use of simulated learning environments still requires the ongoing support of a clinical educator to guide the students' learning and this cannot be compromised.

Further efforts are required to reduce the anxiety students' reported feeling during the avatar condition. Future use of this technology will include longer preparation and discussion time immediately prior to engaging with the avatar, and an opportunity for students to have a second experience with the avatar after receiving direct feedback on their interaction.

**Conclusions.**
Students reported essentially equivalent changes in the areas of communication knowledge, skills and confidence post placement. Given the ongoing costs associated with using actors in clinical placements and the difficulty in sourcing aged care sites able to take increasingly large numbers of students, the avatar is felt to be the most cost effective and sustainable placement option for developing students' interaction skills and empathy.

**References.**
Developing World Leading Network Centric Warfare Training Through A Spiralled Upgrade Partnership Between Defence And Australian Industry

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Workshop Summary.

The Air Combat Officer Training System (ACOTS) is an intensive emulated training environment utilised by the RAAF’s School of Air Warfare (SAW) for the ab-initio training of ACO’s.

In advance of the delivery of the final training solution under AIR 5232, the interim ACOTS is in use and being developed, via a spiral upgrade process, under Air Force Minors 1002 and AFM 1029. This spiral development has required a close and effective engagement between Defence and Australian industry to ensure the currency of the training capability and responsive adaptation to change. The engagement structure serves as a model for other simulation training system developments, and will be explored during the workshop.

In particular, the manner in which training needs are translated into engineering requirements through both formal systems engineering and informal workshop mechanisms is emphasised as a key factor in generating practical outcomes for the training end users.

Intended audience. Defence end users of simulation systems, defence acquirers of simulation systems and industry suppliers of simulation systems.

Workshop size. Up to 24.

Communication requirements. Laptop with projector.

Format.

The workshop would commence with short opening statements from both Defence and Australian industry (i.e. Cirrus Real Time Processing Systems) personnel on the engagement model, followed by an open forum question and answer session.

Expected Benefits.

Many defence forces are seeking to expand the utilisation of simulation technology for training purposes. For such technology to be introduced in an effective manner, the process by which the client and supplier engage must appropriately balance training outcomes, fidelity requirements, technical reach and the commercial risks borne by the parties. Workshop participants will gain an understanding of one engagement model that has been successfully attaining these balances for the parties concerned, and will be in a position to apply the engagement model to other simulation training system developments that may be undertaken in the future.
Flight Simulation – Teaching An Old Dog New Tricks

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Abstract. The training and mission rehearsal capability landscape is ever-changing, which places increased demands on existing training systems. When compounded by limited budgets for both acquisition and sustainment, it makes for a compelling case in teaching old dogs new tricks. In the theme of this year’s SimTecT, this paper highlights the successful obsolescence treatment of the visual sub-system on the Royal Australian Air Force (RAAF) AP-3C Orion Advanced Flight Simulator (AFS). Specifically, how the upgrade has now enabled greater capability potentialities on the AFS in the areas of synthetic environment commonality, and mission rehearsal in order to achieve greater training outcomes.

INTRODUCTION

The AP-3C Orion performs a variety of roles which include land maritime surveillance, anti-submarine and anti-ship warfare, naval fleet support, as well as search and rescue operations. The RAAF AP-3C fleet saw a significant capability upgrade by way of Project Air 5276 which commenced early 1995. This multiphased project included the acquisition of the AP-3C AFS in Phase 3.

The AFS is located at RAAF Base Edinburgh, and forms part of the 292 SQN training complex. It is used to train a range of flight crew roles including Pilots, Flight Engineers and Maintenance personnel. The AFS was designed and manufactured by Thales Training & Simulation Pty Ltd in 2001, and has been subject to a number of modifications since entering service.

On 29 November 2010, the AFS achieved its initial accreditation, qualified to Manual of Criteria for Qualification of Flight Simulators (MCQFS) Level II. However, a number of “restrictions” due to visual sub-system anomalies were noted by the accreditation authority Simulinc, which would not permit certain types training. The two notable restrictions were:

- Visual objects building (or appearing) too late on approach at runways 34 and 16 at Sydney airport, resulting in continuous visual approaches not being permitted.
- Ditching training not approved due to a lack of sea state modelling with the original visual system.

Visual anomalies manifesting as training restrictions in a Level D5 accredited flight simulator are obviously not ideal. Additionally, fidelity deficiencies in the sea state modelling are made even more acute given that the primary role of the aircraft is one of maritime patrol.

BACKGROUND

The restrictions with the visual sub-system were largely due to the technology “of-the-day” (circa. 1998), and would persist throughout the life of the AFS. With this technology now obsolete, and with the requirement to keep the AFS operational to 2021, the Commonwealth recognised the need to ensure supportability of the AFS by way of an Request for Tender (RFT) for the Through Life Support (TLS).

As the successful tender, CAE’s first port of call was to address the obsolescence of the visual sub-system via an upgrade. The upgrade sought to remediate the associated risks due to obsolescence, as well as retain and enhance the overall AFS visual performance and capability. As a result, this would provide for greater and more enhanced training outcomes by unlocking inherent potentialities within a modern visual sub-system when coupled with the extant capabilities of the Flight Simulator.

CHALLENGES

When replacing one sub-system with another, it is paramount that existing interfaces to other sub-systems need to be carefully considered. In order to minimise any (unwanted) impacts throughout the rest of the system, existing interfaces should be adhered to as much as possible.

One of the major challenges that the visual sub-system Upgrade project faced was the interface between the Host Computer and the to-be-replaced Image Generator (IG).

To appreciate both the problem and the approach taken to solve it, the following section is a quick primer on the role and importance of the visual sub-systems within flight simulation.

Visual Systems 101

An essential part of a flight simulator is the generation and display of a simulated point-of-view of the outside world, as observed by a Pilot, or Copilot, from the replicated cockpit. For a simulator to be qualified, its visual sub-system must meet certain, strict requirements relating to fidelity, capability and performance [3].

In broad terms, a visual sub-system can be considered as being comprised of three major components:

5 Level D is the highest level of qualification for a civil flight simulator allowing for “zero flight time” training – refer “www.casa.gov.au”.

Content: the synthetic environment and entities (or models) that inhabit and/or interact within this environment is typically represented in a database-like, proprietary format. This content is usually developed and published offline, and then stored in a repository for run-time access by the Image Generator.

Image Generator (IG): the visual content is read by the IG, along with the current status of the simulator, (such as the state of the aircraft, its position in the world, and what’s happening around it), in order to send a rendered image to the Display.

Display: the physical representation of the rendered image which can be observed from the cockpit of the simulated aircraft.

The figure below represents the old visual sub-system’s components and how it configures with, or interfaces to, the main simulator host.

Figure 1: Old Visual Sub-System.

THE OLD DOG

The visual sub-system Upgrade would significantly impact all three components as it sought to treat each sub-system, and in turn the overall visual sub-system, for obsolescence.

CAE have an array of Commercial Off-The-Shelf (COTS) Visual solutions for Flight Simulation within its portfolio, and these solutions can be further customised to better meet the end user’s specific training needs and requirements.

The challenge, then, was to fit and modify a CAE COTS visual solution to a non-CAE simulator in such a way as to not only meet the existing requirements, but to also exceed them.

However, in doing so, special consideration for the existing interface between the Host and IG needed to be made.

Host-to-IG Interface

The old visual sub-system comprised of an Evans & Sutherland (E&S) IG which communicated to the Host via a proprietary interface. The new visual sub-system is comprised of a CAE Medallion IG which utilises a different and incompatible communication protocol.

Figure 3: Host-to-IG Interface.

To overcome this incompatibility between the Host-to-IG interfaces, two alternative designs were considered: Add mini-host to translate interfaces

Adapt interface to new interface

Alternative 1: Interface Translation

The first alternative considered was to introduce a new computer that would act as an intermediary between the Host and Medallion IG. Its purpose would be to translate the E&S formatted information from the Host into the Medallion format to be read by the new IG, and vice versa.

Figure 4: Host-to-IG Interface Translator.

The principle advantage of this approach is that the software on the Host remains unmodified. This is significant in cases where there is either no access to the Host source code, or no Intellectual Property (IP) rights exist to modify it.

The disadvantages of this approach are the added overhead associated with an additional computer in the network, as well as being constrained by the existing feature set of the E&S IG exercised by the Host. Therefore, the more advanced features supported by the New IG cannot be triggered by a simple interface mapping approach.

Alternative 2: Adapt Host to New Interface

The second alternative maintains the direct Host-to-IG interface approach by adapting the existing Host software to be compatible with the new IG protocol.

Figure 2: A new solution fitted to a legacy host.
A key advantage of this alternative is that there is no additional node in the network. Not only does this reduce the network latency when compared to Alternative 1, it also means that the associated Life Cycle Costs (LCC) remains low due to forgoing the need of adding another computer.

Perhaps more importantly, however, are the advantages this alternative provides in functionality. Greater training outcomes can now be achieved by exercising the higher fidelity feature-set of the New IG.

The main disadvantage of this alternative is the associated higher technical risk, and that the modification of the Host-side software is not only required, but will result in an increase in the computational load on the Host Computer.

**Design Decision: Alternative 2**

The design decision taken in regards to the Host-to-IG Interface was that of Alternative 2: Adapt the Host Software to implement the interface of the New IG.

The two alternatives were assessed on the number of criteria. The rationale behind the selection of Alternative 2 was primarily centred on maximising performance and functionality, while minimising LCC for the duration of the life of the AFS.

**Performance**

In regards to network performance, Alternative 1 increases Host-to-IG network latency, while Alternative 2 has no impact.

In terms of computational load on the Host computer, Alternative 1 has no impact while Alternative 2 will incur an increase. However, analysis revealed that this increase could be accommodated by the current spare computing capacity on the Host computer.

**Functionality**

Alternative 1 will be limited to the feature-set of the Old IG since the Host computer software for this interface will not be modified. However, since access and modification rights to modify the Host computer software exists, Alternative 2 would be able to exercise a greater range of features offered by the New IG by adapting the Host computer software accordingly.

**Life Cycle Cost (LCC)**

Alternative 1 increases the LCC with an additional computer to maintain, whereas Alternative 2 does not.

Furthermore, Alternative 2 realises other LCC savings by way of leveraging the globally maintained baseline of visual sub-system software to take advantage of new features without incurring the cost of new development.

**NEW TRICKS**

As well as addressing the issues of obsolescence within the old visual sub-system, the successful completion of the Visual Upgrade project allows for further potentialities to be unlocked for greater training benefits.

One of the challenges that this upgrade successfully met was the issue of the Host-to-IG Interface, and has been the focus of this paper thus far.
Inherent characteristics of a modern visual sub-system upgrade include benefits of increased texture resolution, polygon count, special effects and overall performance. Collectively, these benefits improve the overall fidelity and effectiveness of the training that can now be conducted within the AFS, resulting in previously imposed training restrictions now being lifted.

Additionally, emergent properties of the new visual sub-system include more efficient re-use of content and effective interoperability due to the employment of the Common Database (CDB) open specification format for synthetic environments.

Figure 9: Cloud models from the old visual sub-system.

Figure 10: Cloud models from the new visual sub-system.

Restrictions Lifted
Quite significantly, the previously mentioned training restrictions that were imposed, related to the late appearance of 3D objects at Sydney Airport and the inability to perform Ditching training, were now lifted [5]: This was made possible due to the high fidelity sea state modelling that the new visual system is capable of simulating.

Figure 11: High fidelity sea state model now permits Ditching training.

Re-use of Visual Content
As part of the AFS Visual Upgrade, extensive re-use of synthetic environments and 3D models developed to very high levels of detail on the MRH-90 simulator program resulted in significant savings on development costs. Future plans include the re-use of high fidelity assets currently being developed on the Hawk simulator program.

A significant benefit also realised is the introduction of the CAE CDB world model. This replaces a previously limiting “generic world” representation that the old visual sub-system would render outside any customised areas. The CAE CDB world model, however, provides global and geo-specific representation comprising of satellite imagery at between 30 and 15 metre resolution and Terrain Detail Elevation Data (DTED) Level 1.

Out-of-the-box, the AFS is able to quickly patrol and train anywhere in the world which provides a real value-for-money proposition for operating in geographical areas where relatively “low” levels of detail are sufficient to meet the desired training outcomes.

Effective Interoperability
One of the key components to effective interoperability is synthetic environment commonality [1] to greatly minimise issues related to correlation errors, and differences in fidelity such as to enable a “fair fight” scenario to the greatest possible extent.
The CDB specification is an open synthetic environment data model format and is emerging as a simulation standard which enables the greater potential for effective interoperability. Not only is this possible with external simulators as separate entities but also enables the coupling of multiple training devices to conduct integrated crew training as a single entity.

As a proof-of-concept of this effective interoperability, CAE successfully conducted an Interoperability Concept Demonstration of the RAAF C-130J Full Flight and Mission Simulator (FFMS) with the Tactical Airlift Crew Trainer (TACT) as a single aircraft [2]. Such was the demonstrated value, the Commonwealth have contracted CAE into developing this as a permanent capability.

As the first opportunity for integrated crew training is primarily on live aircraft, the potential to conduct high fidelity synthetic training of this nature not only becomes possible, but is extremely time and cost effective to do so due to the open nature of the CDB specification. In the case of the AP-3C AFS (front-end), this may be implemented by coupling the AP-3C Operational Mission Simulator (OMS) as the back-end, in order to conduct integrated crew training on the AP-3C platform.

CONCLUSION

In successfully treating the obsolescence of the visual sub-system on the AP-3C AFS, greater potentialities have been realised. These potentialities are directly evident by the enhanced performance, fidelity and capability of the training device, and indirectly by enabling greater re-use of assets and improved effectiveness for interoperability. Key to realising these potentialities, both direct and indirect, has been the successful integration of a new visual sub-system compatible with the open CDB specification for common synthetic environments.

Looking forward, the CDB specification is currently going through a formal standardisation process of the Open Geospatial Consortium (OGC) - an independent, international, consensus-based Standards Development Organisation (SDO) [4]. Once established as a standard, further opportunities to unlock potentialities within extant, legacy simulators can only improve and presents a strong value-of-money proposition for teaching the old dogs some new tricks.

REFERENCES

Are We Simulated Beings In A Holographic Universe?

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Abstract. In the last 12 years, it has been proposed that we are likely to be living in a simulation. Also within the last 20 years, it has been proposed that the universe itself might be a hologram. In this paper, we firstly offer an introduction to both ideas. Then we discuss whether both ideas are complementary or whether they somehow contradict one another. In doing so, we assimilate simulation to Descartes’ demon and assimilate hologram to Plato’s cave.

INTRODUCTION

Two significant challenges to our understanding of ourselves have arisen in recent years. The first is the idea that we might be experiencing a simulation of the world and not the world itself. The second is that the world as we experience it is merely a holographic image of reality. These each raise serious challenges to our common understanding of how and what we know about the world. Curiously however they raise quite different challenges and do not interact with our antecedent commitments symmetrically. It is also very interesting to note that neither of these two challenges is utterly novel. In fact the holograph argument raises points very similar to those explored by Plato in his allegory of the cave. While the challenge raised by the possibility that what we experience is actually a simulation has many points of contact with Descartes’ famous discussion of the Evil Demon hypothesis in his Meditations.

THE SIMULATION ARGUMENT

The simulation argument starts with the reasonable assumption that in the future, computing power will be substantially superior to what we have today. In other words, the information processing capacity available to future civilisations might start to approach the holographic bound (Bekenstein, 2006). Let us call such civilisations “technologically mature”. With this amount of computing power, technologically mature civilisations will be able to create simulations of their ancestors that are so detailed that no-one could tell whether they are encountering another human in the simulation since their simulated ancestors will seem to have conscious minds. Note, that the simulation argument is not a proof that we are living in a simulation but rather takes the form of a challenge to a commonly held belief. We take the belief that we are agents encountering other agents in the real world and not merely experiencing a simulation with simulations of agents. This belief is commonplace and an important part of our views about the world.

In 2003 Bostrom suggested that at least one of the following propositions are true.

There is a very high probability that civilisations at our level of technological development will become extinct before becoming, what might be called, technologically mature.

There is a very low probability that technologically mature civilisations will bother to create a large number of detailed simulations of their ancestors.

There is a very high probability that we are living in a computer simulation.

In addressing the first proposition, we point out that there has been recently a great deal of debate about existential risk (Bostrom, 2013) with calls for greater research into these risks (Hawking, 2014). These are risks that would cause the entire human race to become extinct. They include, risks that are beyond our control such as strikes by large meteors, earthquakes and/or volcanic eruptions, and risks caused by the development of technology such as nuclear war, synthetic biology, nanotechnology weaponry, artificial superintelligence and possibly the use and evolution of relatively dumb, complex adaptive systems (see Holland 2014, and http://www.existential-risk.org/index.html). Until the world takes concerted efforts to tackle these risks, which would seem to be the only way to ensure that this proposition is not true, we can only hope that it is not true.

Accepting that there is a very low probability that technologically mature civilisations will bother to create a large number of detailed simulations of their ancestors suggests that all technologically mature civilisations will converge toward this limitation. This seems unlikely.
Now, if we were to assume that the first two propositions are false, as suggested above, then there is a high probability that many civilisations will become technologically mature with an interest in creating detailed simulations of their ancestors, i.e., creating simulations of us. In other words, we have little choice other than to accept the third proposition.

2.2 Descartes and the Simulation Argument

That third proposition challenges our ready acceptance of our experience at face value. If we accept the third proposition, we might consider ourselves to be being deceived by something similar to Descartes’ demon. Descartes conceived of a reason for doubt so powerful that if anything were to survive that doubt then, he felt he could be confident in the claim that he knew it. The famous ground for doubt he imagined was of an evil demon “no less powerful than evil” whose aims were to undermine the truth of his judgements. The demon could make him think he had a body when he did not; could make him think he was a man when he was not; could make him think he was seeing a swan when he was not; could make him feel ill when he was not ill; and so on. The mere hypothetical existence of the demon meant that he could not be utterly sure than as he sat by the fire and seemed to be warming his toes at the same fire that this was what was going on and that his experiences were not brought about instead by the malevolent demon. The challenge is that he might not be by the fire. It seems for all the world as if he were by the fire but that is just the Demon making it seem to him that he is. The challenge this possibility raises is intriguing: even such mundane claims about the world would be false under this hypothesis. It is not that he really was by the fire but that he was wrong about what that meant but rather that he was just wrong and fundamentally wrong about what was true about the world.

THE HOLOGRAPHIC UNIVERSE

To understand where the idea of the holographic universe came from, we need to understand something about black holes.

3.1 Some background on black holes

When a massive cloud of hydrogen gas collapses under its own gravity, the conditions at the centre cloud can cause that hydrogen to undergo fusion reactions. These fusion reactions release enormous amounts of energy. Assuming that in the simplest scenario that this collapsed cloud is close to spherical in shape, the resulting pressure forces exerted outwards by this release of energy can balance the inwards force due to gravity, resulting in an equilibrium condition between the two forces. Such a system is in this equilibrium condition is said to be a star.

When the star runs out of the fuel required for fusion reactions to sustain the stable equilibrium condition described, gravity overwhelms the system until other forces come into play. For a star that is around $1.4M_\odot$ (where $M_\odot$ represents one solar mass), electron degeneracy forces establish a new equilibrium state giving rise to a white dwarf star (see Islam, 1982). If the star is greater than $1.4M_\odot$ but less than $M_\odot$, neutron degeneracy forces establish another equilibrium state giving rise to a neutron star (a pulsar is a special kind of neutron star). It is believed that black holes form when stars heavier than $3M_\odot$ collapse as there is no other known force that can establish a new equilibrium state. It is believed that the system collapses to a single point known as a singularity. In doing so, space-time in the vicinity of the singularity is curved to such an extent, that nothing within a certain limit can escape its gravitational pull. Within a limit known as the “event horizon”, even photons of light cannot escape. This is why the system is called a black hole.

When these theoretical monstrosities were first studied, it was clear that the 1st law of thermodynamics (conservation of energy) was not rendered invalid by the behaviour of black holes. Validation of the 2nd law however was more difficult. To explain this, we write the entropy balance for an open system:

$$\Delta S_{\text{system}} = \sum_{i=1}^{n} \frac{Q_i}{T_i} + \sum_{i=1}^{n} S_{\text{in}} - \sum_{i=1}^{n} S_{\text{out}} + \sigma,$$

where $\Delta S_{\text{system}}$ is the change in entropy of the system, $Q_i$ is the energy transferred to the system by a temperature difference across the system’s boundary, $T_i$ is the temperature at the system boundary, $S_{\text{in}}$ is the entropy of the matter entering the system, $S_{\text{out}}$ is the entropy of the matter leaving the system and $\sigma$ is the entropy generated during the process.

During the 1970’s, Jacob Bekenstein speculated that the entropy of a black hole is proportional to the surface area of its event horizon. Here the surface area $A$ of the event horizon acts as the black hole’s system boundary. Further to that, he suggested that when matter passed through the event horizon of the black hole, the sum of the entropy lost by the matter and the entropy gained by the black hole must be greater than
zero. Noting firstly that \( \Delta S_{\text{system}} = \Delta S_{\text{bh}} \) where \( \Delta S_{\text{bh}} \) is the change in entropy of the black hole, secondly that no matter can leave the black hole \( (S_{\text{out}} = 0) \) and assuming that heat transfer to the black hole is negligible \( (Q_i = 0) \), the entropy balance in such a case reduces to:
\[
\sigma = \Delta S_{\text{bh}} - S_{\text{in}},
\]
For any real process involving irreversibilities, \( \sigma \) must be positive. This Bekenstein termed the generalised 2nd law.

Later, Hawking, et. al., (1974) described a quantum effect (Hawking radiation) that enabled the constant of proportionality conjectured by Bekenstein to be evaluated, namely:
\[
S_{\text{bh}} = \left( \frac{k_B}{L_p^2} \right) A
\]
where \( k_B \) is the Boltzmann constant and:
\[
L_p = \left( \frac{\hbar G}{c^3} \right)^{\frac{1}{2}}
\]
is the Planck-Wheeler length, where \( \hbar \) is the Planck-Dirac constant, \( G \) is the gravitational constant and \( c \) is the speed of light in a vacuum.

It is worth noting that today, there is plenty of evidence that black holes are not just theoretical possibilities, but that they can be observed. It would seem that they really exist (see Sobrinho & Augusto, 2014 and Broderick & Loeb, 2009).

### 3.2 The relationship between entropy and information

In 1948, Shannon proposed that the Shannon entropy \( H \) of a message is:
\[
H = -a \sum_{i=1}^{j} p_i \ln p_i,
\]
where \( a \) is a constant which can determine the units of \( H \) and \( p_i \) is the probability of a given symbol (Lemons, 2013). The Shannon entropy measures the information content of a message.

The Shannon entropy of a message is a generalised version of Hartley’s previous information measure, which can be thought of as quantifying “missing information” (see Lemons, 2013). This relationship is similar to the thermodynamic entropy \( S \) proposed by Boltzmann previously (1872), namely:
\[
S = -k_B N \sum_{j=1}^{j} p_j \ln p_j,
\]
where \( N \) denotes the number of identical particles in the system and \( p_j \) is the frequency with which particles occupy a particular energy level (see Lemons, 2012; Kondepudi, 2008 & Cercignani, 1998).

It is easy to see that both equations are of the same form, however, as their units are inconsistent, they give different values. Bekenstein (2006) shows that these can be consistent.

The Boltzmann entropy can be thought of as the logarithm of the number of ways that the microstates of a system can be rearranged such that the system macrostate remains the same. The number of microstates is essentially a detailed specification of the energies of all the particles that make up the system. Boltzmann entropy also measures missing information (see Lemons, 2013 and Leff, 2012). The missing information is that information that would be required to represent all of these individual microstates. The relationship between both entropies suggests that the black hole entropy is a measure of the information hidden behind the event horizon of a black hole (Bekenstein, 1980).
3.3 The holographic principle

Gravity limits the amount of entropy that can fit into a region of space. If matter is continually packed into a region of space, gravity causes it to eventually collapse into a black hole. As a consequence, the maximum entropy that can fit into a region of space is limited by the size of a black hole that can fit into that region. As the entropy and therefore the information hidden behind the event horizon of the black hole is proportional to the area of its event horizon, the entropy and information is not proportional to that region of space's volume.

Figure 2: Microwave background radiation (COBE) view of the universe, 13.77 billion years ago, plotting temperature fluctuations as different colours. http://commons.wikimedia.org/wiki/File:Ilc_9yr_moll4096.png

In his paper on the holographic principle, Bousso (2002) spells out the fact that the maximum possible entropy and information is dependent on the surface area and not on the volume enclosed by that area. As a consequence, it has been suggested that the universe itself may be enclosed by a surface. Because of the relationship between entropy and information, this lower dimensional surface could in principle, be fully compatible with the higher dimensional space enclosed.

Here we must distinguish between two models of the universe presented by de Sitter. The “de Sitter” universe is empty, symmetrical and expands at an accelerating rate while an “anti-de Sitter” universe is empty, symmetrical but contracts (Carroll, 2010). Bekenstein (2007) suggests that by combining anti-de Sitter spacetime with superstring theory, all the information is embedded in the boundary of the universe. As a consequence, the hologram idea could enable difficult problems in our world to be solved in a lower dimension making the process much easier (also see Maldacena, 2005). This idea has interesting implications for simulation.

3.4 What sort of challenge does the Holographic Universe raise?

The challenge raised by the Holographic Universe is the idea that the world might be radically different from the way we have ordinarily thought it was. However even here we have to urge caution. There are two ways in which we can have been mistaken about the world. These can be illustrated by considering the notion of a solid. On an everyday conception objects, like tables, cups, etc. are solid, Attendant to that conception might be the idea that if something is solid, it is solid ‘all the way through’. Then we have the realization that in fact solid things are mostly vacuum according to physics. We face a choice between two ways of responding. First we can say that we were wrong: tables are not solid objects. Or we can say that tables are solid but now we understand what it means to be solid and see that we had made certain mistakes in thinking about solids. Similarly when we consider claims we make about the world, we contend what is important is that the explanations we give are true. So, as it might be, we might say that it was metal fatigue that led to the failure of a certain structure. The issue we need to be clear about is whether the causal claims we make can be true, even if what makes them true is quite different from what we might naively have thought. This really is the issue that Plato was concerned with in his famous allegory of the Cave.

In this thought experiment, Plato imagines a group of people imprisoned and raised in a cave. He imagines that they are chained so that they can only see shadows cast on a wall by an unseen fire behind them. They come to recognise objects and their characteristics; they develop expectations “Once this type of object appears it brings about this other sort of object!” and so on. They develop theories about causal relationships.

The idea Plato explores is that the prisoners are dealing only with shadows and do not have access to the underlying causal story. Similarly in the holographic universe the idea is that our ordinary claims are at the level of shadows, the underlying causes are not available to us. The really important question is whether that changes the truth of claims such as the metal fatigue caused the failure of the structure. The prisoners think that the occurrence of such and such a shadow precedes (and causes) the occurrence of some other sort of object. They can be correct about the
precedence and there can in fact be a causal story that explains why the occurrence of the first sort of shadow precedes the occurrence of the second sort of shadow. The idea that the holographic universe challenges our ordinary conceptions is not a settled matter, it may rather be explaining why and how what we take to be true is in fact true.

**IS THERE ANYTHING COMMON TO BOTH ARGUMENTS?**
The two arguments we have considered, the simulation argument and the holographic universe argument both in their different ways challenge the ordinary picture we have of the world. However they do this with rather different consequences. The holographic universe raises the possibility that what we discern and the patterns we find in what we discern are to be explained at a deeper level, that we are merely discerning the shadows on the wall to use the analogy with Plato’s cave allegory. Shadows are part of reality, however, and the complete story of reality will explain how it is that the shadows have the character that they do and it may even discern that the causes of the shadows do fit the patterns we discern.

This is quite different from the simulation argument. Here the challenge is not that we are mistaking shadows for the real causal level but rather that what we think is reality is no part of it at all.

**CONCLUSIONS.**
The differences between the two arguments are important. They raise quite different challenges to our understanding of the world. The simulation argument may undermine that understanding whereas the holographic universe argument may raise the threat of its incompleteness.

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Simulation – A Doubly Disruptive Phenomenon
(Releasing the Benefits of Common Cross-Simulation Technologies)

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Abstract. This paper suggests that Simulation is on the verge of a second wave of disruption. The first wave resulted in a disruption to training paradigms, from the long-standing “apprenticeship model” to “virtual”. As a result, simulation is widely used today to deliver effective and efficient virtual training, such as through high fidelity flight and mission simulators. Modern day simulators use state of the art technologies to deliver tangible outcomes that enhance personnel safety at significantly reduced costs. The focus is now shifting to further enhance training outcomes and reduce costs through re-use of common cross-simulation technologies. However, this re-use is being limited by established “vertical” or “silied” management paradigms and contractual constructs. Interestingly, it’s not the technology, but the management paradigms (or the “delivery context”) that now needs to be “disrupted” to release the significant benefits of re-use of common cross-simulation technologies. This paper examines innovation in this “delivery context”, and builds on Systems principles to define a support systems framework for simulation. This framework is then used to scope the disruptive innovation needed to release latent benefits of common cross-simulation technologies. Consideration is also given to legacy simulators, and recommendations made for future simulator acquisitions. It concludes that innovation is not just about the technology but also its “delivery context”; releasing the significant benefits of common cross-simulation technologies will require disruptive innovation in extent simulation acquisition and sustainment paradigms away from the extant platform-centric approach. It sets out a vision for a simulator configuration comprising an aggregation of specific simulation sub-systems and common cross-simulation assets integrated into a Common Simulation Framework (CSF) to deliver effective and efficient single, joint and combined training.

INTRODUCTION

From its inception, the significant safety and cost benefits from Simulation continue to force a disruptive transformation in training paradigms from “apprenticeship based” to “virtual” across application domains. Simulation based flight training has been the means for aircrew qualification for well over 50 years. The use of simulation for training continues to expand across domains while the scope of its application now spans the capability development life-cycle itself, and encompasses Live, Virtual and Constructive (LVC) exercises.

![Figure 34: The Evolving Context.](image)

With increasing use of simulation, user needs matured and evolved, as did simulation technology – at an ever increasing pace (Moore’s law). Figure 34 [Reference 0] depicts this evolving context for Simulators and Simulations.

A current example is the increasing requirement within the Australian Defence Force (ADF) for effective interoperability, and the associated frustrations that result when multiple simulators are “connected” in a joint exercise. SimTecT 2014 paper 118 [Reference 0] explained the challenges of interoperability and re-use and proposed a four-dimensional technical framework to gauge interoperability effectiveness. It included architectural recommendations for improved interoperability and re-use of common cross-simulation assets. SimTecT 2014 paper 119 [Reference 0] went on to outline a technology road map for legacy simulators to improve interoperability and re-use and recommendations for future simulation acquisition. While the focus of both these papers was on technological change, they recognized an associated need for a “change in our approach to the management” [Reference 0, section 9] of simulations. This is the focus of this paper.

BACKGROUND AND CURRENT FLIGHT SIMULATION CONTEXT

The approach to acquisition and sustainment of training simulators in defence has matured from being an “after thought” to a key element of the parent capability.

Today we have numerous fielded simulators for ADF platforms, including helicopters, fixed-wing aircraft, land vehicles, and surface and submarine craft. Each is acquired and sustained as a separate Configuration Item (CI), typically with a strong linkage to the parent platform.

Figure 35 depicts this “platform centric” approach for a sample set of ADF flight simulators. It includes a high
level system breakdown of the simulator into four key Sub-Systems:

Synthetic Environment (SE) – i.e. the virtual world within which the simulation executes;

Platform Simulation - i.e. the simulation model of the particular platform (vehicle) including aero/land/sea dynamics, vehicle-frame, equipment and sensors;

Instructional Environment - i.e. the functionality for Instructional control and delivery of training; and

Enabling or support Software and Hardware Sub-Systems.

Figure 35: A "Platform Centric" Approach.

An obvious observation is the potential for re-use of common elements across multiple simulators. For example, a significant saving (and improvement in training delivery) would result if specific Sub-Systems (such as the Synthetic Environment) could be effectively re-used across compatible simulators.

BENEFITS OF COMMONALITY AND RE-USE

The benefits of re-use are significant and include:

- Significant cost savings by minimising duplication of effort and materials where re-use of common elements is possible;
- Consistency of training fidelity and outcomes resulting from re-use of common elements across the scope of simulations;
- Reduced timelines for training and mission rehearsal and readiness;
- Significant improvement in interoperability effectiveness across compatible simulators;
- Improved client-device robustness / determinism;

Significantly reduced infrastructure costs resulting from minimization of duplication of data storage requirements for SE databases;

Economies of scale and scope related to consolidation / harmonization in development infrastructure;

Economies of scale and scope related to consolidation / harmonization of support infrastructure;

Simplification and consolidation of management effort and materials related to common elements;

Potential for logical aggregation / distribution of tactical management centers;

Releasing these benefits is key to effective and efficient use of common cross-simulation assets across domains and foundational to the Joint Project (JP) 3035 (previously 3028) vision to deliver a persistent, integrated, and distributed core simulation capability through a system or services and using common cross-simulation products to support single, joint and collective training outcomes.

SO WHAT’S STOPPING US - BARRIERS TO RE-USE OF COMMON ASSETS

The “technological” challenges of interoperability and re-use have to a large extent been understood. Whereas legacy simulator architectures limited effective re-use, recent technological innovation towards modular, runtime based implementations and in the introduction of defined interface specifications [References 0,0] between sub-systems and between simulators, support re-use and interoperability.

One example towards improving effectiveness of interoperability and re-use is the initiative to establish a new simulation industry standard for SE databases. The Common Database (CDB) is an open format specification that is currently going through a formal standardization process of the Open Geospatial Consortium (OGC) - an independent, international, consensus-based Standards Development Organisation (SDO) [Reference 0].

Interestingly, despite these technological innovations, our ability to effectively re-use common cross-simulation assets is significantly constrained and cumbersome. Examples of barriers to effective re-use, based on the authors personal experience across multiple fielded ADF simulations / simulators (such as those depicted in Figure 35) include:

- Extant “platform centric” contractual / legal frameworks that limit the rights to use a sub-system or component on the parent simulator only;
- Data access control measures that limit the sharing of common sub-systems or components across multiple simulators;
- Extant “platform centric” Configuration Management (CM) paradigms that force a “copy-for-re-use” approach, resulting in multiple and branching configurations (instead of re-use of a common asset);
- Unclear responsibility for maintenance and distribution of common assets, in terms or who maintains, distributes, authorizes, approves or pays;
- Extant Engineering design change processes built on a single-use / single CI paradigm that “force” a “copy-for-re-use” approach resulting in multiple and branching configurations (instead of design control of a single common asset);
- Unclear responsibility for update / modification for potentially shared / common components in terms or who authorizes, approves, pays or accepts;
- Extant infrastructure not supporting effective and efficient means for distribution of common assets such as SE databases;
While the technology itself is ready, “barriers” such as those listed above, are limiting the significant benefits from re-use of common cross-simulation technologies. This in turn is restricting effective and efficient training outcomes in terms of consistent fidelity and mission rehearsal agility.

The question then is what and how do we need to innovate to allow for effective and efficient use of common cross-simulation technological assets such as SE databases.

To consider this, it is worth examining Innovation itself and its application in a separate and equally disruptive technology.

DISRUPTIVE INNOVATION

A disruptive innovation [Reference 0] is one that helps create a new market and value network, and eventually disrupts an existing market and value network (over a few years or decades), displacing an earlier technology. It improves a product or service, typically by designing for a different set of consumers in a new market and eventually by lowering costs in the existing market.

A disruptive technology is one that displaces an established technology and shakes up the industry or a ground-breaking product that creates a completely new industry [Reference 0].

Consider an example of a contemporary disruptive technology – that of the mobile or cell-phone. Today most people are “connected” via a Smartphone, however the uptake of mobile technology did not increase at the same rate globally.

![Mobile-Cellular Telephone Subscriptions per 100 Inhabitants](image)

**Figure 36**: Mobile Phone Growth Rates for Australia and the US.

*Figure 36* [Reference 0] compares the rate of mobile subscriptions per 100 inhabitants for Australia and the United States (US) between 2000 and 2013. The data shows that despite the common (mobile) technology, the subscription uptake was higher in Australia then in the US.

Call charges, both in Australia and the US, were more expensive for calls between a mobile and a land-line than between land-lines. However, while the technology and its use-costs was essentially the same in the US and in Australia, there were two key differences:

In the US, the extra cost of a call between a mobile and a land-line was always charged to the mobile user, including charges for calls received, whereas in Australia it was always the caller (never the receiver) that paid applicable call-charges; and

In the US, mobile phone numbers could not be differentiated from land-line numbers, whereas in Australia a mobile number has a clearly recognizable pattern.

This meant that early adopters of mobile technology in the US ended up bearing the cost of not just the calls they made, but also calls made to them from land-lines! It was this risk of additional costs to mobile users in the US that was a significant barrier to subscriptions, and the resulting lower rate or uptake of mobile phone technology in the US when compared to Australia.

So while the technology was equally disruptive, the difference in the “delivery context” (i.e. pricing methodology coupled with the number format) resulted in a significant difference in the rate of uptake of the disruptive technology in the US and Australia.

The author defines the “delivery context” as the framework within which a particular (innovative) technology is delivered for use. This is depicted as the central shaded area in Figure 37 surrounding or encapsulating the Simulator in the centre. Users access the technology within the limitations of this “delivery context”. Typically, it’s the technology that evolves first and may then drive a change in its “delivery context”.

![Innovation Needed in both Technology and Delivery Contexts](image)

**Figure 37**: Innovation Needed in both Technology and Delivery Contexts.

The key conclusion here is that disruptive innovative technologies will typically drive/require disruptive innovative changes to their “delivery context” in order to effectively release their full potential of benefits.

The author contends that releasing the significant benefits from innovations in simulation technology (such as effective interoperability and re-use of common cross-simulation assets) will require disruptive and innovative changes to current simulator acquisition and sustainment paradigms (i.e. the “delivery context”).
DEFINING THE DELIVERY CONTEXT

Based on the author’s experience and the application of Systems thinking, effective ongoing utility of a System post acquisition, through its utilization phase, typically, requires five key ingredients:

- Personnel in terms of key roles, authorities and competencies;
- Management systems and tools;
- Facilities and supporting infrastructure;
- Governance processes; and
- Technical data, including access and IP rights, licenses and any necessary 3rd party arrangements.

These five key dimensions define the “delivery context” for any capability or technology, and their scope may be established by the application of Systems Engineering principles.

A System may be described functionally and physically, and typically by a set of characteristic properties and attributes [Reference 0]. In broad terms, a System has a boundary, is typically composed of Sub-Systems and Components, and operates in a particular environment.

Importantly, whenever we consider a System, we must in fact consider three Systems. Figure 38 depicts this “Systems Context”, identifying the three Systems by number:

- the subject (or Mission) System,
- Other (Interfacing) Systems, and
- Management Systems.

These three core Constituent Support System Capabilities (CSSC) are defined as follows:

- **Use/Operate** – capabilities for the effective use / operation of the accepted System configuration through its utilization life.
- **Maintain** – capabilities that ensure the ongoing utility (availability) of the accepted System configuration through its utilization life (Note –Maintenance does not include changing System Scope/Configuration).
- **Modify** – capabilities that enable a change (enhancement) to the accepted System to establish a new (enhanced or modified) Scope/Configuration.

Additionally two enabling CSSC’s apply across the scope of the three core CSSC’s:

- **Training Support** – to train users/operators, and as applicable, maintainers and modifiers to effectively use, maintain and modify the System; and
- **Supply Support** – to ensure necessary support required from third parties / external agencies across the three core CSSC’s for use, repair and modification.

It may seem obvious, but the scope of the Support Management System (and its CSSC’s) must align with the associated acquisition contractual and legal frameworks. So for example, not considering re-use of a common cross-simulation asset during its acquisition (due primarily to a “platform centric” approach) will result in significant (legal) barriers or limitations to effective re-use across other compatible Systems during utilization.

While a more detailed discussion on a Support Systems framework is beyond the scope of this paper, a summary contextual depiction of the author’s Support System model is depicted in Figure 39. The area inside the red box defines the scope of the Support Management System in terms of the five CSSC’s, delivered in a Quality Management framework and constrained by applicable data access controls, security and IP limitations. This essentially is the “delivery context” (refer Figure 37) for our common cross-simulation assets (i.e. a System, a Sub-System or Component – refer “common” elements in Figure 35) through the utilization (sustainment) phase.

The Management Systems evolve over the Systems’ life-cycle, from Acquisition, transitioning to Support (through the Systems utilization phase) and concluding with Disposal Management.

The Support or Utilisation Phase is typically the main phase of use – i.e. why the System exists! As a minimum the Management Systems for Support must cater for **Use or Operation** of the acquired System. Additionally, there may be a need to **Maintain** the System, and in some instances, to **Modify** the System.

We may now scope our five key dimensions (listed at the start of this section) by considering them across each of the five CSSC’s in a 5X5 CSSC “framework matrix” as follows:
Figure 40: A CSSC Framework Matrix.

The cells in Figure 40 collectively define the “delivery context” for the System, Sub-System or Component through the utilization phase (refer Figure 37).

For example (and brevity), the cells along the diagonal from A1 to E5 in Figure 40 are explained below, while a summary level expansion of all cells is included at Annex A at the end of this paper.

**Cell A1** – the Organization required for effective Operation/Use, in terms of key roles & responsibilities, such as Operations Manager, Scheduler, Instructor, Operator etc.

**Cell B2** – the Management System required for effective Maintenance, such as for preventative and corrective maintenance and to implement temporary fixes (permanent changes are delivered through Modifications); typically termed the Maintenance Management System (MMS).

**Cell C3** – the Facilities & Infrastructure required for effective Modification, such as a desktop ICT environment for software, a development lab, and the enabling distribution infrastructure for Modified assets.

**Cell D4** – the Governance Processes related to Training Support to ensure right competencies across applicable CSSC’s such as the approval of training packages for Operator or Maintainer training or on the conferring of technical authority to Engineering support staff.

**Cell E5** – the Data & Access Rights for Supply Support such as IP Registers or Schedules comprising IP Licenses as well as data access rights such as TAA’s.

**SCOPING THE DISRUPTION – WHERE AND HOW DO WE INNOVATE?**

Potential areas for innovation in our “delivery context” (refer Figure 37), based on the authors experience, may be identified as follows:

- Identify and establish common cross-simulation asset as Common Configuration Items (C-CI) that can then be referenced as a product from within the parent simulation/simulator configuration;
- Establish the scope of the Support Management System envisaged for the C-CI in terms of the three core CSSC’s – i.e. does it need just Operational Support, or are Maintenance and Modification Support also required;
- Develop a CSSC Framework Matrix (similar to Figure 40) adding in the enabling CSSC’s of Training Support and Supply Support appropriate to the scope of the three core CSSC’s;
- Work through each cell in the CSSC Framework Matrix (as per example in section 0 following Figure 40) to scope the optimum Support Management System (i.e. the “delivery context”);
- Conduct a gap analysis to compare the optimum “delivery context” (as per step 0) to the extant “delivery context” to identify potential areas for innovation.
- Work through to bridge each gap to release the benefits of commonality and re-use as noted in section 0.

Applying the above approach to Figure 35, would result in a revised look at a simulator configuration composed of specific common CI’s, such as for example components of the SE or the Instructional Environment, as depicted in Figure 41.

**Figure 41: A Change to CI Management.**

**LEGACY SIMULATORS AND FUTURE ACQUISITIONS**

The approach proposed above will support the definition of an optimum support framework for simulators that include common cross-simulation technologies (such as common SE databases). To maximize the benefits of re-use, we must also consider legacy simulators (and how these may be modified to benefit), and ensure an optimum approach for future simulator acquisitions.

Legacy Systems, where feasible, should be subjected to a progressive architectural migration through modification, towards a CDB compliant / Run-Time architecture. These aspects are addressed in previous SimTecT papers [References 0, 0] and in a current SimTecT paper [Reference 0].

More importantly, future simulation acquisition must consider interoperability and re-use of common cross-simulation technologies right from the very start. The following are key recommendation for consideration:
- Include the Platform Simulation in the parent (platform) capability acquisition and specify compliance with specific interoperability standards, such as DIS [Reference 0] and/or HLA [Reference 0];
Specify a run-time execution architecture (as opposed to a legacy and/or proprietary “compile time publish”) for the simulator that is compliant with extant Common CI’s (such as the SE CI as depicted in Figure 41) so as to allow for effective (re)use of these existing common CI’s in and with the acquired simulator;

Ensure rights for potential common CI’s delivered in the acquisition scope are compliant with the envisaged Support Management System scope for the C-CI (as per section 0) to allow for effective re-use on other compatible simulators.

The longer term vision is for just the “platform simulation” to be acquired with the parent capability, delivered to comply with published architectural and interoperability standards. This platform simulation (using the system breakdown depicted in Figure 35 as an example) would then be integrated into Common Simulation Framework (CSF) to create a specific standalone simulator, or to interoperate as part of a larger exercise by the addition of other common CI’s such as a SE CI and an Instructional Environment appropriate to the training need as well as common supporting hardware and software sub-systems. The resulting simulation could then be used for effective and efficient single, joint and collective training, delivering significant benefits of common cross-simulation assets noted in section 0.

CONCLUSION

Simulation has been disruptive from the start. It forced a change in training paradigms from “apprenticeship based” to virtual. This first wave of disruption continues today in more recent domains, such as in emergency management and health-care.

Meanwhile in more mature applications, such as flight and defence, evolving user needs and technological innovations have opened up a whole new scope for efficiencies and benefits through potential re-use of common cross-simulation assets.

However, releasing the efficiencies and benefits of current innovations in simulation technologies will require a disruptive change to the “delivery context” for simulation – i.e. in our existing platform centric acquisition and sustainment paradigms. Our approach to acquisition and sustainment will need to change to recognize a simulator as an aggregation of common cross-simulation technologies integrated in an open standards compliant common simulation framework.

Changing our acquisition and sustainment frameworks to account for these changes will result in significant benefits that will include cost savings through re-use as well as improved training outcomes across the training spectrum of single, joint and combined training

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IEEE 1516 - Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)

ANNEX A – CSSC FRAMEWORK EXPANSION

This section includes a complete high-level expansion of the CSSC framework defined in Figure 40 of section 0.

Cell A1 – the Organization required for effective Operation/Use, in terms of key roles & responsibilities, such as Operations Manager, Scheduler, Instructor, Operator etc.

Cell A2 – the Organization required for effective Maintenance, in terms of key roles & responsibilities, such as Maintenance Manager, Maintenance Coordinator, Maintenance Technician etc.

Cell A3 – the Organization required for effective Modify, in terms of key roles & responsibilities, such as Engineering Manager, Design Engineers, Competent Technical Staff etc.

Cell A4 – the Organization required for effective Training Support, across the applicable core CSSC (Operate, Maintain, Modify) such as Instructor Operator Trainer, Maintainer Trainer and Engineering Trainer.

Cell A5 – the Organization required for effective Supply Support, across the applicable core CSSC (Operate, Maintain, Modify) such as for Procurement, Legal and Security staff.

Cell B1 – the Management System required for effective Operation, such as for scheduling of the simulator or to review and report on issues identified during operation (training).
Cell B2 – the Management System required for effective Maintenance, such as for preventative and corrective maintenance and to implement temporary fixes (permanent changes are delivered through Modifications); typically termed the Maintenance Management System (MMS).

Cell B3 – the Management System required for effective Modification, such as for engineering changes to the simulator configuration (typically one of a Modification, Substitution or a Deviation) resulting from changes to the simulated platform, from evolving training needs or to mitigate technology obsolescence risks; typically termed the Engineering Management System (EMS).

Cell B4 – the Management System required for effective Training Support, such as for managing the competency of all staff required to support the simulator through applicable CSSCs (operate, maintain or modify); Typically this would include a Skills Matrix of staff across applicable competencies and the means for its update, typically termed the Training Management System (TMS).

Cell B5 – the Management System required for effective Supply Support, such as for managing approved sub-contractors, and parts in support of maintenance activities via the establishment of a Maintenance Support Network (MSN) and for engineering support via the establishment of a Design Support Network (DSN); the management system would also need to include export control, data access and IP rights associated with the simulator.

Cell C1 – the Facilities & Infrastructure required for effective Operations, such as the simulator facility itself, associated briefing and de-briefing facilities, amenities, and recreational facilities as appropriate, including any applicable restrictions or security implications.

Cell C2 – the Facilities & Infrastructure required for effective Maintenance, such as the clean and dirty workshops for the conduct of corrective and preventative maintenance tasks and for temporary fixes, including housing of all necessary tools and test equipment.

Cell C3 – the Facilities & Infrastructure required for effective Modification, such as a desktop ICT environment for software, a development lab, and the enabling distribution infrastructure for Modified assets.

Cell C4 – the Facilities & Infrastructure required for effective Training Support, related to the training for operators, maintainers and engineers as applicable to the core CSSC’s.

Cell C5 – the Facilities & Infrastructure required for effective Supply Support, and would typically include storage facilities for office supplies required for operational support and for spare parts and related equipment and technical data required for maintenance support and any development / laboratory facilities required for engineering support.

Cell D1 – the Governance Processes related to Operations of the simulator, such as its release for training each day and on modes of training conducted.

Cell D2 – the Governance Processes related to Maintenance of the simulator, such as preventative and corrective maintenance and for temporary fixes, and for the technical authorization of maintenance staff.

Cell D3 – the Governance Processes related to Modifying the simulator, such as that for initiating a change to the approved configuration, for the design process related to an engineering change, and for the acceptance of the approved change back into the authorized configuration, or for a temporary or permanent deviation of the approved configuration for training. This would also include process for technical authorization of engineering staff.

Cell D4 – the Governance Processes related to Training Support to ensure right competencies across applicable CSSC’s such as the approval of training packages for Operator or Maintainer training or on the conferring of technical authority to Engineering support staff.

Cell D5 – the Governance Processes related to Supply Support to ensure the us or right suppliers and interfaces across applicable CSSC’s such as the authorization of particular vendors as suitable suppliers of parts and on the receipt and inspection of parts received. It may also include the conduct of external audits of sub-contractors to ensure they comply with contracted regulatory requirements and quality systems.

Cell E1 – the Data & Access Rights for Operations such as the availability of suitable User / Operator documentation.

Cell E2 – the Data & Access Rights for Maintenance such as the availability of suitable Maintenance Manuals, Illustrated Parts Breakdown and user manuals for tools and test equipment.

Cell E3 – the Data & Access Rights for Modification such as the availability of suitable design documentation, software and associated access rights to enable modification of the simulator for an enhancement or to correct a deficiency.

Cell E4 – the Data & Access Rights for Training Support such as the training material required to train the support staff across the core CSSCs, and may include Operator Training material, Maintainer training material and training in particular technologies that comprise the simulator to allow for effective modifications.

Cell E5 – the Data & Access Rights for Supply Support such as IP Registers or Schedules comprising IP Licenses as well as data access rights such as TAA’s.
SimHealth

Free Papers - Technology and Innovation

The Virtual Dementia Experience – Empathic Education Through Virtual Reality

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Background.

The Virtual Dementia Experience (VDE) is the world’s first application of serious computer game technology in dementia-care education. Developed by Alzheimer’s Australia Vic in partnership with Opaque Multimedia, the team has created an innovative, immersive and interactive virtual reality experience that takes people into the world of a person living with dementia - simulating thoughts, fears and challenges faced.

Materials and Methods.

The VDE forms part of a two hour workshop and uses multi-sensory stimulation to immerse participants in the effects of aging and dementia, so that they can gain an appreciation of the issues confronting people with dementia. The experience enables participants to understand the environmental elements that are friendly or hostile to a person with dementia by experiencing a home environment in the same way a person with dementia would. The participants are encouraged to reflect on their own approach to dementia-care and to think about ways in which they can enhance the support environment.

Evaluation of the Innovation.

The innovation of the Virtual Dementia Experience was widely recognised. It was the winner of the 2014 iAward for education innovation and it will go on to win the prestigious APICTA award and most recently, the top World Citizenship honours at the 2015 Microsoft Imagine Cup.

The VDE has also received a written recommendation by the Senate Standing Committee on Consumer Affairs for its educational significance and has been consistently rated highly by participants, with many describing it as ‘an invaluable experience’.

An independent evaluation of the VDE has been completed by Swinburne University with very encouraging outcomes. This evaluation has both quantitative and qualitative evidence that, carers who uses VDE as a part of their training has a significantly improved empathy for people with dementia.

Lessons Learnt and Recommendations for Use.

The Virtual Dementia Experience is the product of the unusual collaboration between the aged and dementia care field and the games and virtual reality field and marks many “firsts” in their respective fields. By thinking outside the square, Alzheimer’s Australia Vic has delivered their vision of a new approach to dementia education to transform dementia practice and improve the quality of dementia care.
Enhanced Clinical-Realism In Medical Simulation Training

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Background. Medical simulation aims to provide realistic, immersive, situational training that mirrors the practice environment of the real world. The ultimate goal of the procedure is to engage the participant in the training scenario to the point that it feels genuine and in order to accomplish this, the level of realism must be high. Information is best retained when the information cues are embedded within the simulation scenario. Offering information to a student in a situation that is bare of appropriate indicators, makes recollection of correct information more difficult.

Medical simulation based training complemented with realistic patient simulators and scenario cues, permits the student to translate both information and cues, therefore increasing the probability of effective recall when the situation is presented in a real life situation. High fidelity manikins are therefore an effective pedagogical approach to medical education.

While simulator-based medical educational experiences are generally highly regarded, students and lecturers frequently mention the lack of clinical-realism and feedback from the patient simulator as a significant limitation. Such limitations include:

Most many patient simulators are based on representations of young, physically fit, Eurasian adults. This is not typical of most medical situations presented at hospital.

The patient simulator can only provide limited visual feedback as its skin colour cannot change. This can be problematic with simulator-based training programs as skin colour changes can often be an indication of successful intervention.

Most many patient simulators neglect the infinite patient variation generated by age, gender, and race. These variations can potentially play a significant role in intervention scenarios and engagement with the procedure.

Immersive learning environments require expensive and time consuming moulage procedures, to be undertaken in order to changing the appearance of a simulator. This can be problematic and cannot change over time or in response to treatment.

The manikin's face is static and cannot interact with the student.

The application of Spatial Augmented Reality (SAR) was therefore explored, as a means of providing visual feedback enhancement, through the projection of three dimensional visual textures onto the face of a manikin, that simulate patient disease, disorder and trauma.

Materials and Methods. Research and prototype testing has indicated that a number of technological enhancements may be possible, to increase clinical-realism and feedback through the application of a SAR medical simulation mask technology. This approach also has the potential to enhance existing low, medium and high fidelity manikins, in order to promote student engagement and immersion.

Evaluation of the Innovation. Through conceptual development, prototyping and testing, it has become apparent that the innovation has the potential to:

Significantly alter the manikin’s appearance, to portray an infinite variety of patent characters with different racial features, ages and genders and therefore increase realism and cultural appropriateness.

Display a variety of facial pathologies that can alter in response over time to different interventions.

Use pre-existing manikins with minimal modification.

Lessons Learnt and Recommendations for Use. It is apparent that the technology has the potential to allow patient simulators to demonstrate appropriate responses to therapeutic interventions and provide immediate feedback about the quality of clinical decisions. Further developments of this technology will include; tracking the face between lying and seated positions, enhancing the system’s ability to function in ambient lighting conditions, simplify the SAR calibration sequence and to make the system mobile between treatment stations.
References.


Video Simulations in Exercise Science Education

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Background. As a requirement for the attainment of accreditation as an Exercise Physiologist or Sports Scientist, students within the discipline of Exercise Science must be exposed to the many exercise testing and training protocols in order to have sufficient experience and knowledge to eventually practice in the industry. To date students participate in practical instruction on campus and within the industry to gain this experience. However it is not possible to cover all scenarios regarding testing and training in different populations of athletes/patients/clients within the undergraduate and postgraduate courses in Exercise Science. In the clinical setting, Exercise Physiologists need to be able to respond to changes in the patient's condition in a timely manner, and this can be difficult to assess in every student in a clinic setting. There has been a shift towards simulation of practical knowledge or simulated learning environments (SLE) assisting in increasing the breadth of student learning. New technology plays an important part in the efficient delivery of SLE’s. One possible solution is to simulate the testing protocols using high-definition video and digital data overlay technology. We found no current commercial simulators available that were designed to produce physiological data during exercise.

Materials and Methods. Three projects trialled video data overlay technology to teach and assess competency of skills for students in the discipline of Exercise Science at undergraduate and postgraduate levels. In the undergraduate project, high definition video (GoPro, GoPro Inc., San Mateo, CA) was taken of an individual exercising on a cycle ergometer (Monark, Vansbro, Sweden) performing a basic exercise test. Post production of the video included overlay of data via digital ‘gauges’ (Dashware, GoPro Inc., San Mateo, CA). These gauges displayed collected data at 1Hz in real time syncing with the video. The gauges included revolutions per minute, heart rate and resistance in newtons. The video was embedded in the ACU online learning platform LEO (Moodle, Pty Ltd, West Perth, Australia) with questions relating to the data to assess competency.

The postgraduate Master of High Performance Sport project was similar to the above methods except gauges and data presented were reflective of the course content taught. Elite cyclists were videoed performing several maximal oxygen uptake protocols using gas analysis equipment (Cosmed, Rome, Italy). Students, after viewing the videos, could download data spreadsheets to practice and be assessed on analytic skills.

For the Masters of Clinical Exercise Physiology, high definition video of an exercise stress test was overlaid with simulated ECG, heart rate, blood pressure, and oxygen saturation data using a tablet-based simulator (iSimulate, Canberra, Australia). Actors played the role of patients who displayed visual symptoms and gave verbal queues as appropriate to the scenario. Twenty-three scenarios were created, five of which were used for teaching and the remainder for assessment.

Evaluation of the Innovation. Student’s perception of the use of video simulations in the Undergraduate and Masters of Clinical Exercise Physiology was evaluated via online questionnaire. Also a comparison of previous years’ face-to-face competency versus video test results was compared.

Lessons Learnt and Recommendations for Use. The advantage of using video data overlay technology is that students can view activities with data overlayed in real time, multiple times, improving understanding. A library of videos can then be accumulated on varies topics within the discipline enhancing student experience at low cost within a limitedly resourced higher education setting. It also enables students to experience clinical scenarios that they may not experience otherwise, and allows assessment of their decision making in a real-time environment.
A Novel Approach To ECMO Training For Nurses In A High Fidelity Simulated Environment

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Aim of the Education Program
Extracorporeal membrane oxygenation (ECMO) is a modality of treatment offering cardiac and/or respiratory support in critically ill patients. Sydney Children’s Hospital has an active education program for ECMO nurses, relying predominantly on didactic sessions with wet lab drills to ensure that skills are maintained at a high standard. Although wet lab drills are frequently used to simulate catastrophic events, the presence of props and personnel required to manipulate the circuit detracts from the fidelity of the simulation, one of the key purposes of team based exercises and learning. The inauguration of a new high fidelity simulation centre has provided the opportunity to modify our ECMO training program within the more realistic setting. Therefore, our aim was to design a simulation program with an appropriately high level of realism to enhance clinical authenticity and enable the application of wet-lab drills in a realistic patient setting.

Methods Adopted
The simulation space was replicated to match the CICU environment using SimJunior™. The ECMO circuit was connected to a reservoir bag placed underneath the manikin. A novel method for remotely inflating the intraluminal balloons positioned inside the circuit tubing allowed for the independent modification of arterial and venous pressures from the control room via concealed tubing fed through a specifically designed sub-floor conduit in the simulation centre. As well as independently manipulating the venous and arterial pressures of the circuit, this method also allowed for the simulation of massive venous air entrainment. The ECMO console continuously displayed realistic flow rates, revolutions per minute, venous inlet and arterial outlet pressures and pre-programmed alarms which the participants used for troubleshooting. A very high level of authenticity was achieved with the simulation co-ordinator working in tandem with the perfusionist to vary physiological parameters. Two scenarios were developed based on veno-venous and veno-arterial ECMO modalities which encased fourteen emergencies to allow for participant immersion with hands-on experience. A pause and discuss style of debriefing was utilised to allow for the implementation of multiple frames.

Evaluation Data from the Program
A questionnaire using a five point Likert scale (1-strongly disagree to 5-strongly agree) was created to evaluate relevance of material and skill/knowledge gained from the exercise with space for comments and examples as well as open and closed ended questions. 100% of participants (n = 12) strongly agreed that they had gained skills and knowledge from the session, the content was relevant and that the patients of the Children’s Intensive Care (CICU) would benefit from this simulation based training.

Conclusions and Recommendations for Future Use and Development
Limited techniques for remote control of the ECMO circuit have been described. Remote inflation from the control room of intraluminal balloons positioned inside the circuit tubing via a subfloor conduit allows manipulation of circuit physiology and utilisation of actual ECMO circuit monitoring parameters. We believe our system which has yet to be described in the literature offers a very high degree of realism in duplicating real life situations.

References
SimHealth
Workshop

**“Fast Track” Scenario To Simulation – “From The Chair”**

**Presenter Details.**

Janiece Roche (Jan) has published and pioneered work within the clinical reasoning domain of simulation based education. Through involvement across health professional groups, the need to develop clinically relevant scenarios suitable for use in simulation and teaching which reflect the local environment and are authentic to all stakeholders is increasingly evident. This workshop is designed to address this need in a manageable time frame.

Jessica Stokes-Parish, Simulation Coordinator, Chameleon, University of Newcastle; Hunter: Extensive experience in simulation. Keen interest developing moulage related to simulated patients, with a vision to see increased participant buy-in through simple solutions, leading to more realistic simulations, better educational outcomes and patient care.

**Overview.**

There is a growing interest in Simulation Based Education (SBE) to deliver authentic situations using clinical scenarios for health professionals both undergraduate and post graduate. Authenticity is reliant on reviewing and rehearsal of scenarios to ensure they are both valid and contextual for the participant’s clinical situation.

Scenario and simulation validation with testing typically takes hours of multiple professional’s time to be effective across inter-professional environments.

This workshop will present a “fast –track” method of developing, validating, testing and rehearsing clinical scenarios. This is a fast paced, interactional session which will produce a scenario that is effective for use in SBE for health professionals

**Expected Outcomes.**

Following this session, participants will be able to:
1. Develop, validate, and rehearse an authentic scenario for simulation based education
2. Translate these principles for use within the context of multiple clinical situations and health professional groups

**Detailed Description.**

The major stages of this course are:

1. Orientation and learning objectives
2. Develop and validate a clinical situation
3. Apply time parameters to management within the scenario
4. Define the roles required to set the scene
5. Rehearse the scenario – “from the chair”
6. Documentation

**Part 1. 5 minutes** -Setting objectives and creating a safe and conducive learning environment.
**Part 2. 15 minutes** -Using a clinical reasoning tool the group will validate a clinical scenario for full development.
**Part 3. 15 minutes** - All participants will be asked to attempt a time stamping exercise. The group will then be divided into 3 equal groups to present an agreed scenario outline. The best outline will be chosen by consensus.
**Part 4. 15 minutes** - The character in each scenario will be explored.
**Part 5. 15 minutes** -The scenario will be rehearsed “from the chair”.
**Part 6. 10 minutes** -The scenario is documented on a template.
**Part 7. 5 minutes** -Electronic session evaluation.
Evaluation.

The web-based response system MQlicker will be used to provide feedback from participant learning outcomes, the facilitators and equipment used. Using web based mobile devices the audience will be asked to participate in providing feedback.

Timeline.

As above – 90 minute

References.


SimHealth

Posters
Simulated Patients/Paediatrics

Establishing And Maintaining A Multi-Campus Simulated Patient (SP) Program

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Aim of the Education Program. To recruit, train and use simulated patients in the delivery of undergraduate Health Science programs at the La Trobe Rural Health School.

Methods Adopted. Preparation phase – SP methodology and simulated patient programs both in Australia and internationally were researched. Faculty were interviewed regarding potential use of SPs and requirements.

Recruitment phase – Albury-Wodonga was the pilot campus. An information evening for interested applicants was held in June 2013. This comprised an overview of the SP role and responsibilities, the expectations and amount of work available, demonstration of SP and hybrid scenarios, then a Q&A session. Suitable applicants were identified and offered positions as casual employees in the SP program. Roll-out to other campuses was completed by July 2014.

Training phase – Initial small group training comprising understanding the role, calibration of performance, how to improvise and how to redirect a scenario was delivered. Further training regarding giving feedback and calibration of feedback was also provided.

Implementation phase – the pilot session was practical exams for second year nursing students. SPs have performed in workshops, clinical and examination settings in nursing and allied health units, training videos and interprofessional scenarios.

Review phase – Student and SP feedback was overwhelmingly favourable. Reasons for withdrawal were noted and steps taken to prevent further withdrawals.

Maintenance phase – New SPs have been recruited to fill demographic gaps or replace withdrawals from program. A quarterly newsletter is distributed to all SPs.

Evaluation Data from the Program. Students complete a survey before and after participation in a simulation session. Feedback from students acknowledges their preference to learning with ‘real people’ and the benefit of receiving feedback on their performance from the perspective of the patient.

Conclusions and Recommendations for Future Use and Development. La Trobe Rural Health School is not unique in establishing a simulated patient program however our program has been particularly successful with SPs taking on very challenging roles right from the start. The time spent at the beginning of the project reviewing successful factors in other programs and consulting with faculty about their SP requirements was a valuable investment and prevented a lot of costly errors.

Recommendations

Identify the capability of SPs and use them accordingly; use enthusiastic but limited SPs for skills-based scenarios and keep your star performers for more challenging roles. Take care not to overwhelm or unnecessarily challenge SPs by limiting individuals to two roles per day, and four hours of role portrayal. A comprehensive scenario template is essential to ensure that all the information that the SP needs to portray the role accurately is provided. Maintain engagement with training and newsletters, and feedback from students. Like everyone, they like to know that their efforts are appreciated and are making a difference.

References.

University of Toronto. (2013). The standardized patient program. Retrieved May 2013, from University of Toronto Faculty of Medicine: http://www.spp.utoronto.ca/
A Multi-Disciplinary Approach To Simulation Training In Healthcare: James Cook University’s Collaborative Experience

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Aim of the Education Program.
The use of simulation as an educational tool is becoming increasingly popular in healthcare training as increasing student numbers and concerns with patient safety challenge opportunities for traditional bedside teaching\(^1\). However, healthcare training centers face many challenges when implementing a simulation training program. Available guidance for successful program implementation is limited, and adaptation for each institution’s unique setting is often required.

This presentation describes James Cook University’s (JCU) College of Medicine and Dentistry and the College of Healthcare Sciences (Townsville campus) approach for developing a multi-disciplinary, simulation-based training program with shared resources and centralised asset management.

Methods Adopted.

Initial setting

The project was funded by a Health Workforce Australia grant aimed at educational capacity building of JCU’s Medicine, Nursing, Midwifery, Physiotherapy, Speech Pathology and Occupational Therapy colleges. Funds were used between 2012 and 2014 to renew and upgrade existing infrastructure and equipment, acquire additional simulation assets, embed additional simulation activities into the undergraduate curricula, and increase the total number of simulation sessions delivered to accommodate the rising numbers of enrolled students in each discipline.

Main activities performed

All Simulation Assets, equipment and consumables were registered and barcoded upon arrival to JCU;

An organisation plan was implemented for distribution and goods distributed to relevant teaching sites;

Key staff positions were appointed to assist faculty in the development, implementation and evaluation of simulation training activities;

Training opportunities were provided to staff and simulation education providers across both colleges;

Simulation education materials were developed and embedded into the curricula (ongoing);

Total ‘simulation education hours’ delivered within the health colleges throughout the reporting period were calculated (number of hours delivered multiplied by the number of students);

‘Simulation education hours’ delivered to undergraduate students from each discipline, hours delivered to postgraduate students and hours of simulation education with inter-professional applicability were also calculated;

Students attending simulation sessions were surveyed on their learning experience.
**Evaluation Data from the Program.**

A total of **103,709** simulation education hours were delivered to **4,909** undergraduate students across all disciplines involved during the active reporting period of July 2013 to December 2014. Of these, 915 hours were delivered with inter-professional applicability.

**One-hundred and sixty-six (60%)** of the 274 students surveyed after attending simulation education sessions either ‘agreed’ or ‘strongly agreed’ they now had proficient knowledge and skills in the clinical skill targeted by the simulation activity.

**Conclusions and Recommendations for Future Use and Development**

The Simulation Capacity Building Project successfully facilitated the expansion of simulation education for undergraduate healthcare students in the Townsville campus. The early establishment of a culture of sharing and a multi-disciplinary approach to Simulation Capacity Building were key factors to the success of this venture.

Some disciplines had limited simulation exposure prior to commencement of the project. Therefore, incorporation of simulation principles into the curricula has needed to occur in a slow, steady manner to allow staff and faculty members to assimilate new ideas and practices. In addition, despite the strong multi-disciplinary approach, the overall number of simulation sessions with inter-professional applicability was quite low when compared to the total number of ‘simulation education hours’ delivered. Strategies for sustainability of simulation education, including ongoing maintenance costs, staff training and staffing costs must be sought for continued development and success of Simulation Capacity Building projects.

**References**

Measuring The Impact And Responsiveness Of The Expanding SLIPAH (Simulated Learning In Paediatrics For Allied Health) Program Across Queensland

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Aim of the Education Program

Between 2011 and 2103 the SLIPAH framework was developed as a model to provide transportable and standardised paediatric clinical training using simulation based methods for allied health practitioners, from students to clinician. The project aimed to embed inter-professional education to improve access for regional, rural & remote students/practitioners to paediatric simulation based education, while providing standardised clinical paediatrics exposure. The project initially involved collaboration with 3 universities and 3 regional Queensland Health facilities.

Following the success of the project, ongoing funding (HWA/DoHA) was secured for 2014, with the expectation of expanding delivery across the state of Queensland for occupational therapists, physiotherapists and speech pathologists. The aim is to provide a foundation to equip Queensland allied health professionals with the skills required for safe, effective and equitable paediatric healthcare. Ongoing impact evaluation aims to facilitate refinement of the Program in terms of accountability, performance, responsiveness and dissemination of outcomes.

Methods Adopted

In order to deliver simulation based training across Queensland, SLIPAH utilises the high accessibility of e-learning and augments it with mannequin based paediatric simulation. Paediatric mannequins are a compact, light, transportable modality that offers a level of standardisation and sustainability, not available with simulated paediatric patients. The SLIPAH team is highly mobile and transports simulation expertise, resources and assets across the state of Queensland. In situ simulation is delivered via pocket centres within universities and hospitals providing cost-effective training. Inherent to the program is strong collaboration with clinical educators, university faculty & subject matter experts (SMEs), fast-tracking the translation of research into clinical practice.

Impact evaluation, in terms of responsiveness, is determined by many factors including:

- Extent of collaboration with participating universities/centres to identify specific training needs
- Adaption of delivery to target requirements, especially regional & remote workforce
- Numbers of students/workforce accessing SLIPAH
- Level of exposure received by different cohorts
- Change in mannequin capacity/assets and staffing

Evaluation Data from the Program

The SLIPAH staff establishment increased from 1.5 FTE in 2013 to 2.5 FTE in 2014, with the inclusion of profession specific facilitators and a Program Manager. The adhoc use of SMEs to assist in scenario development and delivery, increased from 5 to 7 as the Program grew. SLIPAH was embedded into 6 allied health Programs across 3 Queensland universities in 2013, the following year this became 14 Programs across 6 state-wide universities. Collaboration with Queensland Health regional facilities expanded to provide training to the workforce. Assets were also increased related to demand, with particular focus on the highly realistic but low-tech infant mannequins.
SLIPAH Delivery:

E- Learning Registrations (2 packages approx. 2 hours each to complete)

2013: 749 students, 605 workforce

2014: 801 students, 630 workforce

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* = Regional and remote

Table 1: SLIPAH Delivery 2014 - Direct Contact Scenarios

Conclusions and Recommendations for Future Use and Development

The data shows this model is efficient and meets the training needs of Queensland allied health across the continuum. The positive feedback received on evaluation2 is mirrored in the uptake demonstrated over the 2 year period. For example, the initial workforce demand was in the acute setting, with a high throughput. The focus then changed in response to paediatric capability requirements and SLIPAH provided targeted education to each centre. The expansion into all Queensland universities will continue with an aim to introduce SLIPAH to the 7th university and the remaining few Programs. Ongoing analysis and synthesis of the data will ensure effective response to the changing requirements of students & workforce.

References


2. Kelly K, Moller M, Wright SE. Simulated learning in paediatrics for allied health (SLIPAH) as an effective approach to clinical education: the emerging student perspective. Sim Health 2014
Learning Needs Analysis: To Assist With The Development Of A Simulation Program For Anaesthesia Trainees During Their Paediatric Rotation, Focusing On The Management Emergencies In Paediatric Anaesthesia

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Aim of the Education Program.
Emergencies are uncommon in paediatric anaesthesia yet prompt action is often critical to ensure a safe outcome. Clinical practice is unlikely to expose anaesthetic trainees to all paediatric emergency situations during a 3 month rotation in a tertiary paediatric facility (the minimum period of paediatric experience mandated by the Australian and New Zealand College for Anaesthetists). With a significant number of paediatric surgical cases still being delivered outside of tertiary level paediatric centres it is important that the trainees develop the appropriate skills to deal with these high-risk / low frequency scenarios. Simulation allows trainees to experience the cognitive steps and familiarise themselves with the equipment and techniques required to effectively manage these emergencies.

We intend to implement a simulation-based course aimed at developing trainee’s knowledge and skills in the management of key critical events in paediatric anaesthetic practice. Prior to this we plan to undertake a learning needs analysis (LNA) of the anaesthetic trainees to explore the specific learning objectives required of such a course within our quaternary paediatric facility.

Methods Adopted.

Components of this Learning Needs Analysis include:

- A survey of the clinical experience and perceived learning needs of trainees who have recently completed a term at our facility. We are going to have a panel of Specialist Paediatric Anaesthetists to help in the design of the survey, to help us gather the most helpful data.

- A review of the learning objectives and guidelines provided by the ANZCA curriculum for trainees during their paediatric anaesthetic rotations / module.

Evaluation of the Program.

We will provide a summary of our learning needs analysis and subsequent recommendations for the simulation based training program in the Management of Emergencies in Paediatric Anaesthesia aimed at a population of specialist anaesthesia trainees undergoing the paediatric component of their training.

References

1. Anaesthesia Training Program Curriculum, December 2014 ANZCA, v1.5 20141202
Comparing Cognitive Aids In Paediatric Cardiac Arrest Using Simulation – A Pilot Feasibility Study

Rebecca Singer¹; Dr. Arjun Rao¹,²

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Aims.

1. Is it feasible to use the simulation environment to study the design and relative utility of cognitive aids in paediatric cardiac arrest?
2. Is the functional utility of the cognitive aid for paediatric cardiac arrest produced by the Australian Resuscitation Council (ARC) better than that produced by Advanced Paediatric Life Support (APLS) Australia?

Background.

Given the low occurrence of out of hospital cardiac arrests in the paediatric population(1) deviation from best-practice guidelines is common and not unexpected(2, 3). Easily accessible diagnostic and treatment information, such as visual cognitive aids, improves adherence to evidence based practice(4), yet there are practical difficulties in directly studying cognitive aid use(5). The simulation environment can mirror real life situations accurately allowing risk-free practice of poorly retained skills(6) and potentially an environment in which to study the usability and practical design of cognitive aids.

Methods.

This was a prospective, un-blinded, simulation-based study. A VF arrest scenario was developed. Simulations were carried out in-situ in the Emergency Department of a tertiary children’s hospital in Sydney, Australia using a low capability mannequin in a high fidelity environment. Participants were provided with an algorithm published by either the ARC or APLS Australia. The cognitive aids were alternated between simulations. An observer collected data using a specially designed data collection sheet. Outcomes measured were appropriate identification of steps in management, delays in aspects of care and correct dosing. Following debriefing all participants were asked to complete a short survey on usability and usefulness of the provided cognitive aid.

Result.

Nine scenarios were run and 41 participants were recruited. The majority of participants were medical students (83.93%, n=34) but also included medical and nursing staff. All statistical tests were performed using SPSS 20.0 (SPSS Inc., Chicago IL, USA). There was a significantly shorter time from the second shock to adrenaline administration in the ARC groups. There were no other significant differences in management or participant rating. 24.4% (n=10) provided qualitative feedback. We did show the feasibility of the simulation environment for studying the functional utility and design of cognitive aids. Sample size calculations were also conducted using StatMate (GraphPad Software Inc., La Jolla CA, USA) to indicate the number needed for significance if these proportions were to hold true. A minimum sample size of 30 would be needed for significance across most parameters.

Discussion.

This was a low powered study and consequently we only found a statistical difference in one variable, however we did demonstrate the feasibility of the simulation environment for assessing cognitive aids in high-risk yet low yield situations such as paediatric cardiac arrest.

There was a statistically significant longer delay in first adrenaline dose in groups using the APLS algorithm as opposed to the ARC algorithm (p<0.05). This was converse to intuition as the ARC aid provides drug-dosing information outside of the algorithm whilst the APLS algorithm includes it. However, one group using the ARC algorithm failed to administer amiodarone, whereas no groups in the APLS group omitted this step. Although this
difference was not statistically significant, it was clinical interesting provoking us to calculate the number needed to prove significance if these proportions held true.

Direct effects of cognitive aid use in critical events would be near impossible to assess due to ethical and logistical difficulties. Although direct morbidity and mortality may not be possible to measure there are distinct actions in resuscitation that can be measured and are crucial to good outcomes, such as delivery of CPR, defibrillation and drugs. This study was carried out in a high fidelity environment, in-situ, using a low capability mannequin. Higher levels of fidelity lend to higher degrees of authenticity, which allows better application of learnt skills to real life situations(7), as well as an opportunity to identify risks and improvements without endangering patients. Using simulation also grants control over the clinical scenario. We were able to maintain consistency over environmental variables and improving the reliability of the assessment of the cognitive aid.

This study had a high number of student participants (86.38%), which could have acted as a confounding factor due to low levels of experience and lack of prior knowledge. However student participants afforded us a naïve population who would rely on the algorithm provided and allowed us to gain better insight into their utility and effectiveness. The students also provided us with qualitative feedback echoing the value they derived from simulation-based learning, 46% of the comments received pertained to the enjoyment and benefit of simulation as a learning tool which corroborating the value of simulation-based learning in medical education(8).

Conclusions.

We have demonstrated the feasibility of the simulation environment to compare -cognitive aids in paediatric cardiac arrest. Several clinically interesting differences were noted; consequently, a higher power study should be performed using similar study design to assess if these are true proportions.

References.


People Leading Learning: Use of Volunteer Consumers as Simulated Patients in Occupational Therapy Simulated Learning - A Pilot Study

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Aim of the Education Program.

The importance of health services partnering with patients, families, carers and consumers is recognised at a national and international level. Using volunteers as simulated patients provides a unique opportunity to engage with consumers whilst also increasing the fidelity of simulated learning activities.

Through partnership with the Volunteer Simulated Patient Program (VSPP), a DoH funded Northern Health (NH) project, this pilot study aims to evaluate the use of volunteer consumers as simulated patients in an OT student simulated learning activity.

Methods Adopted.

Three volunteer consumers were recruited and trained as simulated patients (SPs) through the VSPP at NH. An existing NH simulated resource focusing on teaching non-technical skills to OT students was run with ten OT students using consumers as SPs. Qualitative data was collected from OT students, facilitators and SPs post-activity. Data was collected again three weeks post activity from students to analyze how transferable the skills learnt were to real practice. This data was compared with previous data collected from students that completed the activity with an OT staff member acting as the SP. Further iterations are planned in early 2015.

Evaluation Data from the Program.

Findings will inform clinical educators whether use of consumers as SPs improves learning outcomes and retention of skills through increasing fidelity of learning activities. Findings will also be shared about the process of recruiting, training and debriefing volunteer consumers and the other perceived benefits of partnering with consumers in this way.

Conclusions and Recommendations for Future Use and Development.

The use of volunteers as simulated patients provides a unique opportunity to engage with consumers whilst also increasing the fidelity of simulated learning activities.

References.


Exploration Of Motivators For And Barriers To Uptake Of A Simulation-based Paediatric Basic Life Support Course

Marissa Alexander; Dr Ben Lawton; Louise Dodson; Jason Acworth

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Aim of the Education Program.

Recognition and management of the deteriorating paediatric patient (RMDPP) is a simulation-based paediatric basic life support course. The Simulation Training on Resuscitation for Kids (SToRK) team offers this course and its resources on a train-the-trainer basis to facilities caring for children throughout Queensland Health. Course development, faulty training, resources and support are provided by Children’s Health Queensland; elearning and simulation equipment are provided by Children’s Health Queensland and Clinical Skills Development Service (CSDS) at no cost to participating Hospital Health Services (HHS).

Methods Adopted.

To date the SToRK team have delivered train-the-trainer courses in 17 hospitals over 10 HHSs, training a total of 167 ‘RMDPP Faculty’ across Queensland. We have offered site support for delivery of RMDPP courses by trained local faculty. Ongoing delivery of RMDPP by local faculty has varied across the state and we explore the perceived motivators and barriers to uptake of this program.

Evaluation Data from the Program.

Local co-ordinators for all sites where a train-the-trainer course had occurred were contacted and asked to rate the significance of several motivators and barriers to delivery we anticipated to be relevant. Co-ordinators were also asked to describe any other barriers to implementation they had experienced and outline any motivators to uptake they had found useful within their HHS, as well as what other support they envisage could be usefully provided by our team.

Conclusions and Recommendations for Future Use and Development.

We describe the barriers and motivators to uptake of the RMDPP course in HHSs across Queensland and make recommendations for facilitating the delivery of a simulation-based paediatric basic life support course across a heterogeneous group of healthcare facilities.
**CIS SET: Exploring The Role Of Confederates (Simulated Participants) In Competency- Based Surgical Education And Training**

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**Research Question.** To evaluate whether confederates (simulated participants) are an effective tool in competency based training of general surgery SET (Surgical Education and Training) trainees.

**Methodology (proposed).** The project is designed to explore the knowledge in a learning context of the competences required for general surgery training and uses four confederate-based clinical scenarios to recreate clinical situations over 4 sessions. The scenarios are designed to be relevant to SET trainees’ experiences. All confederates are actors.

Six SET trainees will participated in each session. Two will participate as the ‘test’ trainee, one at a time with the other 5 observing. The scenario will be played out twice in each session. The briefing and debriefing will led by two faculty members and two focus groups, one for trainees and one for the faculty and actors, each, led by one of the investigators will address the research question.

Scenario 1: Confederate: Daughter of patient dying in ICU from complications of surgery. Trainee to interview daughter with focus on open disclosure, and demonstrate knowledge of advanced care directives.

Scenario 2: Confederate: Surgical Supervisor. Trainee is asked to provide support to a fellow SET trainee on drugs and under-performing, and demonstrate knowledge of services available to support doctors with substance abuse problems and RACS (Royal Australasian College of Surgeons) policies of dismissal from training.

Scenario 3: Confederate: NUM on surgical ward concerned about an intern who is not coping at work. Trainee to give advice and demonstrate knowledge of mentoring and a way forward.

Scenario 4: Confederate: Intern being bullied by consultant: Trainee to give advice and demonstrate knowledge of the RACS Bullying policy and Code of Conduct

**Timetable for sessions:** (times using 24 hour clock)

- 1815 - 1830 Arrive, registration and coffee/tea
- 1830 -1845 Introduction and explanation with Professor Bruce Waxman (BW) and Professor Debra Nestel (DN)
- 1845 -1855 Briefing
- 1855 - 1910 Scenario: 1st run
- 1910 - 1915 Change over
- 1915 - 1930 Scenario: 2nd run
- 1930 - 1950 Debrief and feedback
- 1950 - 1955 Changeover
- 1955 - 2015 Focus Groups: Group 1 trainees (BW), Group 2 faculty and confederate (DN)
- 2015 - 2030 Refreshments and finish
Analysis (proposed). The research method is qualitative using a thematic analysis of transcripts taken on audiotape at the debriefing and during focus groups. Human Research Ethics approval has been granted by Monash University and RACS.

Results (preliminary) Value of the scenarios for hard communication challenges, affording learning of advanced communication skills, providing a framework for learning and a formal teaching experience not common in SET training. The high realism and relevance of confederate based scenarios.

Questions for the Audience.

Was the use of confederates the appropriate model for simulation?

What about the ‘fish bowl’ & repeating the scenario design, compared with other options?

Was the design of this scenario realistic, so that a trainee would identify this as plausible and was it too complex?

Was this an effective method of assessing the core competencies, identified as the objectives of this exercise?

Is thematic analysis the appropriate qualitative tool for analysis or are there other more appropriate qualitative methods?

References.


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Free Papers
Simulation in Games - New Potentials

Using The LCS Experience To Develop Effective Game-Based Training

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bill.rebarick@cubic.com

Abstract. As one of most technologically advanced organizations in the world, the US Navy has a pressing need to fill highly technical jobs quickly, effectively and at the lowest possible cost. Its most recent challenge has been to develop training for its newest warship—the Littoral Combat Ship (LCS). The LCS platform presents several unique requirements for the crew, stemming from its flexible, multi-mission design and minimally-manned concept. To meet these challenges, Cubic Corporation proposed an innovative strategy for training which involves creating a virtual ship and certifying/qualifying LCS Sailors in a game-based training environment.

This paper describes Cubic’s efforts to date in developing immersive courseware for LCS and identifies key lessons learned. Evidence-based research is also provided to support the argument that immersive game-based technology can be optimized to shorten time to proficiency, enhance transfer and retention, provide more accurate preparation, increased motivation to learn, and ultimately better performance on the job. The paper concludes with ideas for leveraging the LCS experience to other domains and tasks.

INTRODUCTION

The US Navy’s Littoral Combat Ship (LCS) presents an especially challenging training requirement for several reasons. First, LCS is a new US Navy warship and unique in that its mission is to be deployed relatively close to shore. In addition, two distinct variants of the ship are being built. As such, training developers must understand the numerous differences between the two versions and develop training that is equally effective for each. Second, due to minimal Manning requirements, the opportunity to receive on-the-job training (OJT)—which is a primary mechanism for Surface Navy training—is extremely limited when Sailors report to the ship. Instead, the requirement is that Sailors are fully trained, qualified and prepared to assume their watch prior to beginning their tour. A third challenge for training is the unique multi-mission design of LCS. Specifically, it is modular, accommodating multiple missions, such as Anti-Surface Warfare, Intelligence, Special Operations, and so forth. Each of these missions imposes unique training demands on the crew.

Finally, it is important to note that the LCS is conceptualized as a new element in naval warfare. As such, there are not many subject matter experts who have experience on the ship, and little to no strategic knowledge or historical scenarios upon which to draw in designing the training. Hence, training designers are forced to anticipate future performance challenges in designing training for the ship. Furthermore, they must develop a system that allows easy, inexpensive integration of new material to meet evolving training requirements as they develop.

These challenges forced the US Navy to consider innovative solutions to meet the Train to Qualify (individual level) and Train to Certify (team level) requirements for LCS Sailors. Specifically, it was decided that Sailors would complete their training in virtual space prior to reporting on board. To date, the LCS program represents the largest single attempt at developing and fielding immersive, game-based courseware. Moreover, the courseware is the major component in the blended LCS Training Solution; integrated with tactical simulators and live training (where appropriate) to attain Train to Qualify (T2Q) and Train to Certify (T2C) outcomes. As the prime contractor, Cubic has embraced a game-based approach that leverages advances from the commercial gaming sector, while drawing on expertise from the learning sciences.

BENEFITS OF GAME-BASED TRAINING

The potential benefits of immersive, game-based training contributed greatly to the Navy’s decision to adopt it for the new LCS. These benefits include:

- Provides a fully immersive training environment that engages learners
- Provides instrumented environment tied to repeatable, quantitative performance metrics and standards
- Provides low overhead for practice and repetition, delivering enhanced proficiency
- Increases learning and retention
- Removes schedule dependencies on sea frame during embarked mission package availability
- Minimizes damage to equipment from improper operation, non-standard configurations and increased wear and tear
- Can simulate casualties, exceeding operating limitations and other dangerous configurations to illustrate point without endangerment personnel or equipment
Return on Investment (ROI):

In addition to the benefits noted above, it is also informative to consider the return on investment (ROI) of game-based training. The benefit of a purchase over time is typically estimated using ROI, which measures the increase in value of the purchase to the cost of the purchase, or Net Present Value (NPV) for investments that vary in cost or return over multiple time periods. Though commonly applied to financial investments, these measures are rarely applied rigorously to training investments either in industry (Wright and Stewart) where cost sensitivity is high, or in the military which has invested in at least 23 intelligent virtual training environments in recent years, by one count (Schatz, et al., 2012).

The most authoritative recent study (Cohn and Fletcher, 2010) found that US Department of Defense (DoD) investment in technology based training to replace equivalent conventional training should produce an ROI of 3.36 or $3.36 for every $1 invested. The same study computed NPV for one, specific intelligent training system for Navy information technology specialists, found a net present value over 12 years of $1.3B, due largely to accelerated acquisition of expertise, concomitant reductions in the workforce, and reduced On-the-Job-Training (OJT) requirements for those more expert workers.

In a less formal analysis (Schatz, et al., 2012) asserted that intelligent, virtual training environments can reduce training costs by as much as 98%, due in some part to manpower reductions as great as 95%. The authors point to several case studies. When the Tactical Action Officer Intelligent Tutoring System (TAO-ITS) was integrated with an existing system, the Surface Warfare Officer’s School reduced the number of instructors per 42-student class from 21 (a 1:2 teacher:student ratio) to 2 (1:21) (Stottler & Panichas, 2006). Similarly, The IATS shipboard maintenance training environment reduced the cost per seat from $1,172 to $28 per year (Madni, Sorensen, & Madni, 2005).

Effects on Learning

Research into game-based and immersive learning also shows that they can be superior to other forms of instruction in terms of amount learned and retained. A recent meta-analysis of 32 independent studies found that interactive simulations or games reliably produce higher gains on cognitive tasks than do traditional teaching methods (Vogel, et al., 2006). The finding bolstered older studies, including a meta-analysis that found 22 of 27 rigorous comparisons of games and traditional teaching methods favored games (Randel, Morris, Wetzel, & Whitehill, 1992).

Individual studies of game-based or simulation training also show positive results. Sebrechts (Sebrechts, et al., 2003) found that training in a simulation improved knowledge of a building and the ability to navigate in it, relative to other forms of training, in part because the simulation made walls transparent to clarify (literally) the locations of rooms relative to one another. In an evaluation of a damage control trainer the research team (Hussain & Drake, 2010) found that simulation-based training reduced critical errors in a team field exercise by 80%. In another evaluation of an intelligent training simulation for a complex team task (dynamic targeting) it was found that optimal scenario selection reliably doubled learning relative to a conventional instructional strategy (Levchuk, et al., 2012), and that feedback based on automatically computed solutions reliably increased learning and roughly halved theoretical time to achieve expertise (Shebilske, et al., 2009).

Speed of Training

A final benefit to game-based training is that it fosters incorporation of Intelligent Tutoring Systems (ITSs). ITSs are comprised of advanced software that automatically selects new problems, feedback and/or remedial strategies for the student based on his/her performance in training. Research concerning the accelerating effects of practicing complex cognitive skills (e.g., troubleshooting, programming, geometry) in intelligent training environments shows measurable effects. For example, VanLehn (2009) found that such a tutoring system decreased time to acquire mathematical problem solving skills by 30%. This is the same time savings students achieved using a tutor that taught computer programming skills (Corbett and Anderson, 1991).

Comparisons of tutoring systems to OJT are also informative. For example, students who used an Air Force avionics tutor for 20-25 hours achieved the skill of practitioners with 4 years of experience (Lesgold, et al., 1991). A system for training Navy information technology specialists produced in 16 weeks of training students who outperformed Fleet technicians with 7 years of experience (including OJT) on average (Fletcher, 2011).

A sampling of longitudinal studies of specific tutoring systems also shows positive outcomes. An intelligent tutor for high school algebra improved test scores by 100% (relative to classroom training) over a prolonged experimental study (Koedinger, Anderson, Hadley, & Mark, 1997). A system for teaching physics at the United States Naval Academy produced similar gains and improved conceptual understanding over several years of evaluation (VanLehn, et al., 2005). Studies across tutoring systems, on average, find that student scores improve one standard deviation (e.g., a letter grade) compared to traditional teaching (Corbett, Koedinger, and Anderson, 1997).

LEVERAGING THE LCS EXPERIENCE

Clearly the opportunity to leverage the lessons learned from Cubic’s LCS experience have wide spread applicability to many other domains and training tasks. Indeed, the core concept that underlies LCS courseware—that is, that immersive environments can
be superior training environments—can be replicated across tasks and domains. However, it is necessary to understand why these environments excel in training, so that similar successes can be obtained.

WHY GAME-BASED LEARNING WORKS

It has been well established from several lines of learning science research that immersive training environments (i.e., those that have high physical, functional and cognitive fidelity) can achieve better training outcomes (in terms of lower costs, reduced training time and better performance), while avoiding the disadvantages of more traditional (classroom-based) training (Cannon-Bowers & Bowers, 2010). Specifically, immersive learning environments enable the following:

**Situated instruction**—trainees are learning in a realistic context, which enhances the transfer and retention of newly learned material to the job (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990). Also improves decision making and problem solving by allowing trainees to build up strong mental models of what works and what does not (Chi & Glaser, 1985).

**Increased trainee engagement and motivation to learn**—are also achieved in immersive environments by enhancing the meaningfulness and applicability of the learning content (Baek & Whitton, 2013).

**Adaptive guidance**—via dynamic performance tracking/intelligent tutoring—allows the training system to tailor feedback based on the trainee’s specific needs (Jackson & McNamara, 2013), which has been shown to be more effective (Lester et al., 2013) and efficient than traditional training (Chiong, 2010).

**Gaming features**—exploit the popularity of video games among “digital natives”, making games an attractive medium in which to embed instruction. Research in this area suggests that game-based learning is indeed effective (DeRouin-Jessen, 2008).

**Mobility, scalability and flexibility**—phrases such as just in time training, on demand training and training anywhere, anytime—which have practically become buzz words—are now actually achievable. Immersive learning environments developed with game engine technology can easily be ported to tablets and smartphones, making training available when and where it is needed.

**Unobtrusive skills assessment**—while an intelligent tutor can be used to provide instructional guidance, it can also be used to evaluate performance in scenarios where the trainee must complete tasks within the virtual environment without assistance. This works well as an assessment since the virtual environment perfectly replicates the operating environment. The capabilities of the virtual environment also allow for assessment in scenarios that are otherwise too dangerous or rare to assess in real-world circumstances. It also allows for evaluating skills that are otherwise truly impossible to gauge with a multiple-choice question.

**Knowledge evaluation through performance**—certain knowledge-based learning objectives can be evaluated through carefully-designed procedural tasks. For example, whether a trainee knows where a particular piece of equipment is located can be inferred if he/she can quickly locate it while completing a task. Other knowledge-based assessments, which normally require a paper-and-pencil style assessment, can be recreated within the virtual environment in an unobtrusive way, for example, by having a non-player character ask the trainee a question. This mechanic is often used in commercial off-the-shelf games to allow players to interact with other characters, and can be used to disguise a multiple-choice test as a part of an engaging narrative.

**Electronic performance support**—once training resources are available in the operational environment, the line between training and can blur so that instead of memorizing infrequently used (but important) tasks, the individual can access the needed material on a mobile device just before and during the actual performance (Kaganer, Giordano, Brion, & Tortoriello, 2013).

LESSONS LEARNED FROM LCS

Cubic is implementing the vision for game-based learning described above in partnership with the Naval Air Warfare Center Training Systems Division (NAWCTSD) to deliver a shore based training continuum for the LCS. The emerging business case in support of the Cubic approach to a blended LCS training solution shows a cost vector that rivals the largest application of advanced training technologies ever attempted. Moreover, it will include an intelligent tutoring capability that ensures individualized attention to the needs of the Sailor.

In the course of developing LCS courseware to date, we have learned a number of important lessons that should be considered in future game-based training developments. These include:

**It Takes an Interdisciplinary Team**

An important lesson learned from the LCS game-based learning development experience is recognition of how important it is to have a well-functioning, multi-disciplinary team. Perhaps more than any other
instructional or system design effort, developing an educational game requires collaboration across many diverse disciplines. Our team is comprised of a variety of competencies, including:

- Subject Matter Experts
- Instructional Systems Designers
- 2D and 3D Artists
- Game Designers
- Game Programmers
- Human Performance Experts
- Learning Scientists
- Systems Engineers
- Simulation Engineers
- Quality Assurance Analysts, and
- Program Managers/Administrators

Creating and maintaining a high performance team comprised of such diverse skill sets, experiences, and backgrounds, was challenging and requires on-going attention. To begin with, we had to recognize and work through cultural differences among these disciplines early in the program. This was essential—and continues to be—since it affects everything from preferred work schedules to desired level of lighting in open work spaces. While these differences may appear trivial, they actually reflect different expectations for the work environment and the product. They can also have an unwanted influence on communication and information exchange, which are both essential to high performing teams. Hence, we are constantly looking for ways to bridge any differences (real or imagined) within the workforce and improve communication and workflow. This includes everything from published glossaries to an extensive Wiki to well established procedures for document sharing and configuration management. To some extent, this is true of any large project. The difference here is more a matter of degree.

We have also had to work through issues associate with how we organize ourselves to get the work done. Traditionally, game development companies have adopted titles such as “Producer” and “Director” to define key positions on the team. These titles are common in other creative fields (e.g., film production), but not so much in typical government contracting. Over time, we have become comfortable with these titles—as has our customer—but it took some time for this transition to occur.

**Expectations Must be Managed**

The phrase “game-based” has a different meaning and connotation to different people. Indeed, it seems to be a “loaded” phrase that brings with it a fair amount of baggage—some positive and some not so much. On the one hand, many are excited at the prospect of game-based training because it congers up notions of highly engaging—almost addicting—video games that capture the attention of the players for countless hours. Parents and grandparents of teenagers for at least the last decade can relate to this feeling. Hence, the idea that LCS sailors would be that motivated to engage in training is exciting. Equally positive, those who are gamers themselves find the idea of an LCS virtual training game to be intriguing, and immediately envision something that is very cool and fun. On the not-so-positive side, some people find the word “game” almost offensive since it can be seen as trivializing the seriousness of the content. Besides, they think, training should not be “fun”. Interestingly, these opinions do not run classically as Government versus Contractor; rather, if anything they appear to be related to generational differences and comfort with technology.

The peril of these differing opinions for the Cubic team is that everyone has had an opinion about product, its potential and eventual success well before we even had a design finalized. Moreover, the opinions seem to be based on individuals’ experiences—both good and bad—with entertainment video games since no serious games of this magnitude exist upon which to form a comparison. On the other hand, what we are developing is often also compared with traditional computer-based training (CBT), which conjures up some not so positive images in the minds of many. Hence, we have spent considerable time producing demos and creating slide decks designed to describe what we are doing, distinguishing it from traditional CBT on the one hand, and frivolous fantasy games on the other. We have also spent time interacting directly with stakeholders at all levels, trying to ensure that they have a realistic vision of what we are producing. This process is on-going and has probably taken more time than we anticipated.

**Quality Assurance (QA), Validation, Verification, and Assessment (VV&A), and Game-Based Training**

Game-based training requires additional evaluation components that are not common in traditional training. One such requirement is to evaluate *usability*. It has been demonstrated that the usability of an educational game is an important predictor of eventual learning (Schwabe & Goth, 2005). It is important that the user understands the interface and how to use it. Further, the learner must understand how to navigate through the software, understand messages from the system, and recognize critical cues. Olsen, Procci, and Bowers (2010) describe an iterative process for evaluating the usability of serious games. These researchers argue that usability analysis should include a series of small studies in which both observation and subjective assessment is used to identify usability shortcomings. After each of the sessions, designers and programmers work together to create solutions to observed problems. This pattern continues until all pre-established usability metrics have been accomplished. The LCS team will implement this iterative approach to usability so that we ensure success.
A similar, equally important, evaluation need is *playability*. Playability refers to the degree to which learners can understand how to accomplish goals within the game (Desurvire, Caplan & Toth, 2004). This includes how to move the avatar, how to achieve good scores, how to accomplish assignments within the learning module, and so forth. Playability is frequently accomplished using trained play-testers. Our approach to play testing is to create internships for students who will function part time in our development labs. Many of them are avid gamers and while not very experienced in traditional quality assurance functions, are well suited to play testing.

**THE WAY AHEAD**

Cubic’s success in developing immersive, game-based training for LCS provides a roadmap for how these technologies can be leveraged in the future. Furthermore, the LCS experience will demonstrate how highly realistic, immersive, game-based environments can be developed at roughly the same cost as traditional computer-based training. This is due to Cubic’s investment into a suite of tools that streamline and speed up the design-development-validation cycle. Through an agile development approach, LCS courseware will achieve its goals on time and within budget, producing the most sophisticated training program in the US Surface Navy’s history. Moreover, the approach employed for LCS can be replicated in other domains and task areas so that the benefits of game-based training can be more broadly realized.

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The Value of Increased Fidelity of Communications Simulation in Serious Games

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Abstract. Despite rapid and continuing improvements in the fidelity of the visual systems used in serious games, the simulation of communications systems has lagged significantly. Solutions that communicate only in clear, unaffected transmissions are frequently used despite the potential for inadequate or limited training results. The immersion of participants in training scenarios is of vital importance if value from the transfer of skills and knowledge is to be achieved. For this to occur, the same level of realism is required in communications simulation as is provided in simulation visuals, physics and terrain.

INTRODUCTION
There can be no question as to the ubiquity and value of serious gaming in military training. The benefits due to logistical simplification, reduced danger, adaptability and importantly - cost, are well known. Synthetic training systems have evolved to a point where the acquisition of knowledge, skills and experience is at such a high level that they can be used to supplement real world training in a variety of different fields. These fields include R.O.E., hand signal recognition and reconnaissance, which are all able to leverage the advanced, complex and realistic visuals available in modern games.

Programs such as Games for Training and the Dismounted Soldier Training System in the US, as well as substantial domestic investment in serious games such as Virtual Battlespace (VBS), all contribute to the advances that have been made in simulation visuals over the past decade. The result is an increase in the value provided by synthetic training through transfer. Transfer is “the application of knowledge, skills and attitudes acquired during training to the environment in which they are normally used” [3] and is achieved largely through fidelity and immersion.

While fidelity and immersion in the visual aspects of serious games is very high, the same cannot be said for the simulation of communications. This paper will discuss the disparity that exists between the two, what successes have been achieved to bridge the gap and what future improvements might entail.

Fidelity and Immersion
The fidelity of the serious game, i.e. the way it “looks, sounds, and feels like the operational environment” [1] has been improving consistently for the last two decades, predominantly in the visual realm. From the early days of Doom with its 320x200 pixel resolution, 256 colours, 15 frames per second and 2D static textures, games have evolved to the point where one is hard pressed to differentiate between virtual representations and real life.

VBS for example, employs real-time object aggregation and object fading to provide a more believable visual experience. It uses paged-in roads technology and network optimisation to allow for more participants in larger, more complex scenarios. It also leverages Nvidia’s PhysX engine to provide physics-based interactions including destructible buildings.

It is improvements such as these in visuals, game physics, textures and terrain that greatly increase the immersion of participants. Immersion refers to “the degree to which an individual feels absorbed by or engrossed in a particular experience” [5] and it is argued that it is this immersion that maximises transfer and thereby the value of the training.

Currently, the same realism is not carried through to the simulation of communications. Since real-time voice communications first became available in commercial games, this aspect of serious games has remained largely unchanged and has stagnated. This represents an environment that is entirely divorced from the reality of degraded and patchy battlefield communications.

If participants in a training exercise have to use knowledge, skill and experience to understand or extrapolate degraded battlefield communications, then they are likely to be drawn deeper into their training scenario, resulting in a greater transfer of skills and knowledge and increasing the value of the exercise.

WHAT CAN BE DONE?
Over the past three years Calytrix has undertaken research and development into ways in which more realistic communications can be integrated into virtual training environments. This work started with simple algorithm-only approaches and has grown to include methods that integrate deeply with the rich virtual environments present in training tools such as VBS.

Power Over Distance
In any simulation network, basic information about the state of participants is readily available. As a first step towards generating a more realistic communications environment, the location of a transmitter and receiver and the transmitter power was used to provide an approximation of signal degradation. Simple propagation models such as Hata and Friis are used to perform the same basic calculations- the further away a
sender is from a receiver, the weaker the received signal is.

**Figure 42:** Free Space Signal Propagation.

These calculations provide an immediately perceivable impact when deployed within serious games. Clear communications can no longer be assumed and users must contend and plan for loss of signal strength, readability and even complete communications failure. Although simplistic, these models provide a useful and forgiving introduction to radio reception issues and are particularly aimed at participants who are inexperienced with radio use.

**Line of Sight**

The next step was to extract live system data from the rich games-based training environment. Information was gained by querying VBS to generate a terrain profile between the sender and receiver. This information was then used to perform Over-the-Horizon Loss (OHLOSS) calculations. These calculations take into account parameters such as the number, size and shape of intervening terrain features, radio frequency and power and effective Earth radius.

**Figure 2:** OHLOSS Signal Propagation.

Taking this work further, additional elements of the virtual world were folded into degradation calculations. The presence of buildings and areas of foliage within the simulated world, the type of the antenna and the runtime weather conditions were all extracted and added to the calculations.

**Figure 3:** High Fidelity Signal Propagation.

The resulting model provides greater integration between the communications environment and the virtual world. By incorporating the aforementioned parameters, a wide range of communications effects can be generated. For example, based on the signal-to-noise ratio and power at the receiver, the signal may suffer from dropouts, which cause a ‘jitter’ in the transmission, attenuation, which makes the transmission quieter or the introduction of noise such as ‘static’.

Under these circumstances, emphasis would be placed on the participants to employ their knowledge of radio operation, signal propagation and navigation. They would need to select the optimal location and radio settings to establish or improve communications, or alter their course-of-action decisions based on the scenario presented.

In this, trainees are forced to deal with difficult situations similar to those they would likely encounter in the field, which provides for greater knowledge and skills transfer.

**High-Fidelity Models**

The work discussed thus far has focused on the application of open, public domain models to generate a training affect. With a pathway open between the virtual environment and the radio simulation it becomes possible to explore the use of higher fidelity models.

Calytrix’s latest research and development activities have sought to go this step further. Working in cooperation with IDS UK (Ingegneria dei Sistemi), development has focused on combining virtual world information with high-fidelity signal propagation modeling software.

**HF Skywave Model**

The high frequency (HF) skywave model provides another step up in fidelity in communications simulation, for tactical HF radio, enabling training environments to mimic actual real-time environmental conditions.

HF skywave propagation is made possible by the presence of the ionosphere – an electrically charged region of the atmosphere, 60 km – 600 km above Earth’s surface. At certain frequencies (dependent on
time of day, month and year), radio waves are refracted (or bent), by the ionosphere, returning to Earth hundreds or thousands of kilometers away.

Shorter-range HF radio, using near vertical incidence skywave (NVIS), is an increasingly important option for the modern battlefield. In NVIS the transmitted energy reaches the receiver from high (near overhead) incidence angles; NVIS operations are essentially unaffected by mountainous or hilly terrain, urban structures, and other terrestrial factors such as foliage, and can provide gap-free tactical HF radio up to hundreds of kilometers in range [2], giving coverage over typical brigade operational areas.

Modern tactical HF radios (e.g. PRC-150) mitigate problems inherent with skywave propagation (coverage varying on an hourly basis due to the vagaries of the ionosphere; impossibility of relying on a single assigned frequency [4], through the use of automatic link establishment (ALE). Using ALE, available channel frequencies are constantly scanned and assessed for real-time link quality – the best available channel being automatically selected for use.

The new HF skywave model enables simulation of tactical HF-ALE radio operations, for both long range (reach back) and NVIS communications. At the heart of the model there is an appropriately detailed, physics-based, representation of ionospheric propagation, based on International Telecommunication Union (ITU) Recommendation ITU-R P.533-12.

The HF skywave model takes account of:

Actual latitude and longitude of transmit and receive stations,

Actual month, year and time of day,

Antenna types at transmit and receive stations (whip, RF-1936, CODAN Code 463 etc.),

Type of ground at transmit and receive stations (e.g. wet ground, dry ground, desert, sea),

Height of the antennas,

Transmit power and environment at the receiving station (e.g. city, residential, rural).

The inclusion of these factors, together with the time-varying nature of the modeled ionospheric propagation, allows the skywave model to bring to the synthetic training environment the realism of real-life tactical HF operations.

**BENEFITS OF INCREASED FIDELITY**

With research and development activities starting to provide more realistic, true-to-life radio simulation environments, one must turn attention to the potential application and benefits of such advancements.

**Situational Awareness**

The fidelity of communications modeling is not the only aspect of serious gaming that affects immersion and adds to the value of synthetic training. Most serious games invest heavily in realistic game sound effects from vehicle noise to weather, gunfire and explosive detonations. These stimuli not only draw the participant deeper into the training scenario, but also provide valuable experience in many of the difficulties faced trying to communicate in the theatre of operations.

Consider a simulated training scenario where a combat patrol in contact, radios their command to request quick response force support. Without provision for situational awareness, the player receiving the request will be unaware of any difficulty the transmitter might have hearing communications.

By adding this information to radio transmissions, both participants gain a deeper appreciation of the challenges of communicating in difficult, imperfect situations, the norm for real-world operations.

**Electronic Warfare and Electronic Attack**

Electronic warfare (EW) is an area that presents particular difficulties in training. Electronic warfare is the use of electromagnetic or directed energy to control the electromagnetic spectrum. The purpose is to either inhibit or jam an enemy’s ability to use the EM spectrum to communicate or to prevent the interruption of friendly communications by the enemy.

The equipment required for this type of warfare is necessarily high-powered and broad spectrum. Its use in populated areas would compromise civilian communications (radio, television, Wi-Fi) and is therefore unfeasible.

The use of clear communications in training for electronic warfare clearly provides no knowledge or skills transfer in this area. With greater fidelity, it is possible to apply effects ranging from severe signal degradation, injection of artificial tones all the way to the complete termination of signal reception. Identification and rectification of the problem would therefore fall to the participants who would need to apply their skills and knowledge to restore communications. This is an example of where increased fidelity in communications simulation not only improves skills and knowledge transfer; it actually makes new areas of training possible.

**Course of Action Alteration**

One of the most compelling arguments in favour of increased communications fidelity is the impact it has on decision-making. With enhanced audio simulation able to deliver richer communications environments, the scope for training higher-order decision making skills also increases.

A commander who receives all information via clear communications is in an enviable but unrealistic position to make correct and appropriate decisions. Compare this to a commander who receives heavily degraded communications. The probability of flawed decision-making under pressure is greatly increased so preparing for this scenario is an important training objective at all command levels.
Whether applied in the context of command post training, casualty evacuation, fires, close air support or otherwise routine convoy operations, a direct line of communication between trainees can never be assumed. This adds to the immersion a player experiences, which as highlighted at the beginning of this paper, is a key aspect in supporting improved skills development and knowledge transfer.

**NEXT STEPS**

The development of games for the entertainment industry is one of the main driving factors in the advancement of serious games. Unfortunately, the area of communications simulation is not high on the list of their priorities. Considerable inroads are being made by a small number of innovative companies but much more can be done to realise the full potential of communications simulation.

**Modeling Digital Systems**

Calytrix’s research and development efforts thus far have focused on degradation and effects for voice communications. For increasingly digital defence organizations, methods of communication have extended well beyond voice.

The sharing of tactical data such as event reports, imagery and intelligence is central to the goals of a connected Army, Navy and Air Force. As our dependence on this information increases, our exposure to the negative impacts of its degradation or loss also increases.

Modeling the effects of imperfect communications environments on data networks, and the impact on situational awareness that this can cause, is a key element in enabling the next level of training realism.

**Complex Communications Environments**

As the modeling of various communications methods improves, the way training exercise participants are required to interact with the various forms of simulated communications still remains somewhat cumbersome.

A participant’s immersion in a training exercise is likely to be interrupted if the tools they are using require a number of steps to complete a simple action. For example, when a trainee exits a vehicle in VBS they are required to manually switch their radio profile settings from the vehicle mounted, high power AN/PRC-117G to their individual AN/PRC-152 personal role radio. If serious games are to truly emulate real life, the choice of radio, radio mode or even plain vocal proximity communications (talking) should be simple or better still, automated.

The emphasis needs to move from simulating a particular communications device to simulating a complete communications platform. A communications agent would be aware of and react to an avatar’s changing situation in a serious game. For example, it might react to the egress of a vehicle by automatically disabling the vehicle radio and enabling the personal role radio. If two players in the game were located within close range of each other, radio communications would be replaced by vocal proximity communications, which would alter the volume of otherwise clear-communications based on the distance between the players.

The immersion in training can be greatly increased when the trainee can forget they are using a tool and concentrate solely on the activity. This can only occur when the tools become so intuitive and fundamental that they become transparent.

**After Action Review**

After Action Review (AAR) is a central part of all training activities, allowing instructors and trainees to re-enforce instruction points and reflect on the execution of a training mission.

When employing the enhancements discussed in this paper, the communications for each trainee in the virtual battlefield are likely to differ and this presents a challenge for AAR.

The existing integration with systems such as VBS replays all communications in a clear, degradation free channel that is not representative of what the trainee would have experienced. This traditional approach needs to be enhanced to allow AAR to include an understanding of the communications context at the receiver. Such an enhancement however, would need to be carried out in a way that did not distract from the primary focus of the review.

**CONCLUSION**

Given the vast and numerous benefits in logistics, safety, adaptability and cost simulation brings to military training, all efforts should be made to ensure the maximum transfer of knowledge and skills is achieved. This fact is evident by the extent to which gaming graphics, physics and terrain production are continuously improving. Driven by the entertainment game industry, the importance of these parameters in increasing immersion is well understood. The buy-in experienced by players is created largely by fidelity and immersion and strongly correlates with the transfer of knowledge and skills.

The gap between the visual simulation of the virtual world and that of communications within it is both wide and avoidable. It is an area of training that is particularly suited to simulation, with a solid base of existing radio simulation tools. The application of these tools in a manner that couples them more tightly with the virtual environment helps deliver a richer, more immersive and realistic world, but more importantly, opens up new or enhanced training opportunities that simply did not exist prior.

Increasing the realism of simulation is a central goal of the serious games industry. One largely untouched frontier is that of communications simulation and this is a frontier well worth exploring.
The authors would like to thank John Kazik (IDS UK) for his contribution to the HF Skywave model.

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The potential for games engines to simulate dynamics about an asteroid

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Abstract. Analytical solutions for dynamics of spacecraft near non-spherical asteroids are unavailable, so numerical approaches are used to propagate trajectories in simulations. Games engines can be used by designers, engineers and lay people to see the effects of different forces on spacecraft moving near an asteroid in real-time, making for a rapid and intuitive realisation of mission plans and their consequences. Spacecraft orbiting asteroids have been gamified as part of this research in order to produce an intuitive view from points of interest. The physics in this game were designed to adhere to the twin goals of realistic experience and rigorous physics. It was found that games engine deployed was a capable development tool which allowed for a vast array of physical interactions between entities in the space environment. This approach can be used as a sandbox for ideas to be developed, where unknown dynamics and theories can be tested and quickly discarded or marked for further investigation.

INTRODUCTION

Visualisation of orbits about asteroids can be an important tool for engineers, mission designers and others to understand the mix of forces that contribute to complex spacecraft trajectories. The programs that exist for orbit propagation are reliable in well-defined orbital environments, such as in Earth orbit, but are less useful about lesser explored bodies. The research presented here explores the ability for physics-based games engines to provide an accurate and immersive experience for users investigating orbits of spacecraft about asteroids. This study leads on from work previously performed with building simulation tools for this specific environment (Crowe, 2014).

The research presented in this paper follows work performed in the area of application of games technologies for serious purposes (Stapleton, 2004). Specifically, the use of the Unity® games suite builds upon work performed by the Defence Science and Technology Organisation (DSTO) (Sgario, 2014). The application of this game to orbital mechanics required the use of newly created code which directly tested the efficacy of the built-in force integrator in the Unity suite. The focus of the work presented in this paper is simulation of orbits around asteroids with asymmetric gravity fields, as this perturbation source is difficult to simulate using existing orbital propagation tools.

Spacecraft and astronomical bodies exert a gravitational force on one another. This force changes the trajectory of both bodies over time, especially the least massive. Analytic solutions exist for the simplest of these interactions (the two-body problem and restricted three-body problem), but the addition of bodies involved and asymmetric gravities require numerical integration of the accelerations to provide mathematic representations.

Current orbital analysis tools include NASA’s GMAT (General Mission Analysis Tool) and AGI’s STK (Systems Tool Kit), which are both widely used by planners for Earth missions and transition to and about other planets. Spacecraft maneuvers must be implemented before running the simulation and so there is no ability to change the mission whilst the simulation is under way.

The games environment was created with the help of Blender™, a 3D-animation creation suite. This engine is open-source and allows integration with community developed add-on programs which contain Python code as part of the Blender library of open-source content. Several of these add-ons have been used in this study to assist in translating different data types into shape models.

In this work, asteroid shape models were exported to the Unity® suite, where further environmental conditions could be applied. The transfer of the model across these platforms led to some challenges, but directly rendering in Unity® was found to be far less supported. As the physics in Blender™ has not been verified independently, and the physics in Unity has, the selected solution combined the best aspects of each program.

The Unity® platform allows for the implementation of immersion technology, such as Oculus Rift®. The research presented here has employed simulations using this technology and thus provides an immersive experience from the point of view of the spacecraft.

The asteroid 433 Eros has been used as a target about which to develop the gamified simulations presented in this research. This asteroid has been visited by NASA’s NEAR/Shoemaker spacecraft and investigated extensively. Some of the vast amount of information gathered has been analysed and then publically released. 433 Eros is relatively massive for an asteroid and has a distended shape, making the dynamics relevant and interesting to this investigation.
ENVIRONMENT CREATION

The environment was created to simulate the visual experience that would occur during the trajectory of a spacecraft about an asteroid. The accuracy of the physics was important qualitatively, but accuracy over long time periods was seen to be insignificant. This attitude reflects the uncertain nature of the dynamics environment about asteroids addressed in this work.

Size and Shape

Many asteroids have had their sizes and shapes estimated. This is through a variety of methods, including estimations from the apparent magnitude for size and seeing the change in the asteroid light curve for shape (Masiero et al., 2009). Some of these asteroids have their size and shape well determined after being visited by spacecraft (Miller et al., 2002) or after flying close to the Earth (Hudson & Ostro, 1995). These measurements are made using stereoscopic images, Lidar data or through ground based radars. The quality of the data sets is dependent on resolution of each technique, how close the observer is to the asteroid during observation and what proportion of the asteroid is displayed to the observer. When imaging is used, shadowing can also play a part in obscuring the complete shape.

Many asteroid shape models have been released to the public by space research organisations, generally in .OBJ or .WRL formats. These files provide a series of vertices as vectors originating from the assumed centre of mass, with information on which of the vertices form triangular surface faces. The orientation of the shape models generally take on the convention of positioning the x, y and z axes about the three principal axes of inertia. The positive z-axis coincides with the north spin pole of the asteroid, the positive x-axis coincides with the prime meridian of the asteroid while the positive y-axis completes the right-hand coordinate system.

The shape model of the asteroid is imported via one of these file formats to Blender™. Both the .WRL and .OBJ formats are recognised by the engine and rendered immediately. Vertex lists can be imported via .TXT or .CSV files with the use of add-ons, then appearing as point clouds. With the use of a further Blender™ add-on, these can be rendered correctly. The source files are generally scaled by the creators and so must be rescaled to the correct size in blender units.

Unity can import .BLEND files but will split the mesh into multiple parts to make the file manageable. Figure 1 shows, in the case of 433 Eros, the imported product. The figure also clearly shows the triangular mesh.

Blender™ and Unity© use dimensionless units for all dimensions and forces, which can be used at any scale of choice. It is therefore the responsibility of the user to ensure that the units always follow the convention imposed. In this particular gaming simulation, all data has been converted to SI units (by multiplying by a scalar). When exporting the file to Unity®, the orientation and scale of the asteroid can change and so should be checked for correctness before proceeding.

Lighting and Texture

Lighting on asteroids is harsh, as there is no atmosphere to defuse it, resulting in obvious shadows over the surface. This produces the visual effects that arise from the natural texture seen on astronomical bodies. The ability of a visiting spacecraft to make visual measurements and see features on an asteroid is directly related to how the light shines on the surface, making this aspect of modelling important for a mission planning simulation. An example of lighting on the asteroid Eros and spacecraft has been displayed in Figure 2.

Figure 43: A close-up of the triangular plates making up the surface of the model of asteroid 433 Eros.

Figure 44: Showing lighting applied to the form of 433 Eros, highlighting natural texture. Note that crater features resolve well using this method. A spacecraft is also shown at top left, with shadow applied.
The simulated asteroids are lit as if from the Sun, with individual rays modelled as running parallel to one another. The default lighting function of Unity© produces this method of lighting automatically. The simulation programmer must dictate the direction from which the light is coming and align this with the modelled Sun. The renderings have been left grey, which matches the generally low albedo but full colour spectrum reflected by asteroids. There was no perceivable need to add highlighting colours or accurate tones for this simple model, although implementing this could be performed with sufficient data and as required. Through the wrapping of the shape in the Blender engine, a cloud texture function was implemented to make the surface “bumpy” (see Figure 2). This was performed for realism, as boulders and smaller craters are missed in the shape models but create shadows across the asteroid.

Background

The background is set using stock pictures of stars and the Sun. These are placed on a box of background images, which is rendered by Unity© to create an almost seamless image. The main concern is having the Sun as the approximate source of the light. This was performed by assigning the light source orthogonally to the plane of the Sun. The background would remain motionless over the course of each simulation. This approximation holds well for a short period, (for example, 433 Eros moves about its orbit approximately half a degree every 24 hours). This simulation currently supports the user determining the orientation of the background, and therefore the light source, to represent the lighting conditions about the orbit. To modify this, the user must have knowledge of the asteroid right ascension and declination at the desired point and input these before each simulation begins. Although not considered in this research, a potential need for an accurate star map as background could be useful when planning for attitude control.

Mass

Both the mass of an asteroid and its mass distribution have a significant effect on the dynamics of an orbiting spacecraft. This was the principle effect investigated in this study and is one of the primary attributes investigated in small body space missions (Scheeres, 2004). The total mass of the asteroid can be determined through observing the perturbing effect on passing spacecraft and other asteroids at distance. Mass distributions remain largely unknown, except for inferences from dynamical effects on visiting spacecraft. It is generally expected that asteroids have homogenous mass distributions and this is the method used to predict spacecraft movement before visitation. There are several mathematical representations that have been used to model asteroid gravity fields. All have drawbacks (Werner, 1996). In this work, the representation chosen is a modified use of “mascons” (mass concentrations). These mascons are an approximation of an asteroid as a number of spherical concentrations of mass. This representation was chosen for this study, as it allows for calculation of a continuous gravity field from the asteroid surface and does not require extensive computation. The mascon method requires an equally spaced grid of points that represent spheres filling the asteroid volume as closely as possible. The equal spacing reflects the assumed constant density. The approximation becomes better as the number of spheres increases, but this leads to longer calculation times. The mascon method was modified in this study for added simplicity by reducing the number of spheres and giving them a distribution of radii with a uniform density. The spheres were created individually and the placement of these was at the discretion of the designer. Using mascon concentrations, a solution that fills a larger proportion of the total space is better than one that leaves more free space. In this work, the final approximation filled about 35% of the space, where the mathematical limit of space that can be filled using this method (assuming an infinitely large number of mascons) is 52% (Werner, 1996). Figure 3 shows a cutaway of an asteroid with the skeletons of the mascons exposed, each of different size. Each sphere was created as a “child” object to the “parent” asteroid object. This created a relationship where any dynamics, scaling or removal of the asteroid would cause the same changes to the mass concentrations. Using this method can cause scale confusion, as the children are scaled as a proportion of the parent, and so applying “mass” to the spheres must be done carefully. The efficacy of this method relative to other methods will be investigated in later research.

![Figure 45: Cut-away of the asteroid, showing embedded mass-bearing spheres.](image)

Asteroid Spin

The rotation of many asteroids has been determined through measurement of the periodic divergence in light reflected (“light curve”) or Doppler radar measurements.
Unity© can allow for uniform rotation to apply to an asteroid over every frame and is set to the model in degrees per second. The light reflected by the asteroid model will adjust to its new spatial orientation as time progresses. The rotation applies evenly to all of the parent body’s children (i.e. mascons).

**Spacecraft**

In this research, the spacecraft used were modelled as rigid, spherical bodies. They were not given mass, although were accelerated due to the gravity of the asteroid. It was assumed that no torque was applied to the spacecraft through their interactions with the asteroid.

Unity can support multiple spacecraft to simulate cooperative missions. The addition of more spacecraft can put pressure on the computer processor to render the simulation.

**ORBITAL DYNAMICS**

This section describes how forces are applied to the spacecraft in this simulation. These include gravitational and physical interactions. The forces that were not modelled have been briefly addressed in sections 3.3 and 3.4 and the ability of the games engine to apply its physics in this context has been investigated.

**Gravitational Force**

As mentioned earlier, the asteroid model used in this study was essentially, a series of points containing the mass of the asteroid. Assuming that the spacecraft was also a point, Newton’s law of gravitational attraction can be used:

\[ \vec{F} = m_s \vec{a} = -G m_s \sum_{i=1}^{n} \frac{m_i \vec{r}_i}{r_i^2} \]

where \( G \) is the empirically-derived gravitational constant, \( m_i \) is the attracting mass and \( m_s \) is the spacecraft mass. The distance between both is designated by \( r_i \). The sum is negative, as it is an attracting force. The \( \vec{r}_i \) term designates the unit vector in the direction that the force is applied.

Unity allows for an acceleration to be applied to rigid body objects regardless of the object’s mass. This is good for simulating orbital dynamics, where the spacecraft mass and gravitational force combine to effectively produce a uniform acceleration regardless of the spacecraft mass.

Code was produced to apply the acceleration proportionately to, and in the direction of, each mascon point. The acceleration is applied via a numerical integrator based on the Verlet method, which has been described as stable and accurate (Sgarioto, 2014).

**Integrator Validation**

The integrator was tested to provide confidence that it operated well with the gravitational force code. To do so, the Unity force integrator was tested against special orbital mechanics cases. Quantitative measurements were made of the integrator performance in several running configurations. This allowed for a qualitative understanding of the different running configurations investigated. The previously validated Matlab code was run for comparison.

The simulation for validation was set-up so that it could be compared against exact analytical models. This required stripping back the gravity model to include only a single point at the origin of the coordinate frame with the entirety of the reference asteroid mass concentrated at that point. The spacecraft would then be off-set from this point mass along one axis and later provided with an initial velocity in the direction of an orthogonal axis with a magnitude calculated so as to create a circular orbit. Even without perfect circularity, the orbit should repeat through the starting point at the starting velocity for every orbit. Some of the inaccuracy of the integrator can then be observed as an offset during orbit repetition.

The integrator was tested over a variety of cases in Unity. These cases are listed in Table 1 and test different radii, accelerated simulation speeds and calculation step rates (defined in Table 1 under “scenario”). These results provide a window for future simulation changes, where changes to scaling and operating speeds can result in errors in propagation.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Error in y (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50km 100xspeed</td>
<td>0.73</td>
</tr>
<tr>
<td>50km 10xspeed</td>
<td>0.73</td>
</tr>
<tr>
<td>20km 100xspeed</td>
<td>-0.04</td>
</tr>
<tr>
<td>20km 10xspeed</td>
<td>-0.04</td>
</tr>
<tr>
<td>50km @20 steps/second</td>
<td>-4.42</td>
</tr>
<tr>
<td>Matlab 50km</td>
<td>-0.02</td>
</tr>
<tr>
<td>Matlab 20km</td>
<td>0.01</td>
</tr>
<tr>
<td>20km non-circular</td>
<td>-0.20</td>
</tr>
</tbody>
</table>

Table 3: Error for Unity and Matlab simulations in several scenarios.
Figure 46: A test of integration in Unity. This particular shot shows a circular orbit of 20km radius, assuming a point gravity source, which repeats almost perfectly.

The scenarios tested are analytically easy to implement and follow classic two-body orbital mechanics. They are compared with an existing program coded in Matlab to simulate the same dynamics. The Matlab integrator uses the high-accuracy, Adams-Bashforth-Moulton method, whilst we believe that the Unity engine probably runs Verlet’s method. Our analysis suggests that fast-forwarding simulations does not affect the accuracy of the orbit. The same cannot be said for decreasing the number of integrator steps per unit time.

Comparing to the Matlab model from the previous study, we see that the Unity model is not as accurate. When seeing the game simulation of the test, in Figure 4, we find that the error is imperceptible to a user of the simulation.

Contact Interactions

The contact interactions between spacecraft and asteroid were investigated here qualitatively. Contact interactions using the Unity® engine have been investigated quantitatively in other research (Sgarioto, 2014). One issue with modelling realistic contact interactions in this particular situation is that the surface make-up of asteroids is still largely unknown. This has led to difficulties with landing in the past, (note the recent landing of the Philae lander of the Rosetta mission on comet 67P/Churyumov-Gerasimenko).

There is restitution between the two bodies, when the spacecraft hits the asteroid, it will recover some kinetic energy through bouncing. Each bounce will lead to a loss in energy of the spacecraft. The default settings were left untouched for this interaction. There is no momentum transfer for this bounce, similar to a ball bouncing off of a wall. Figure 5 illustrates this effect. The spacecraft can also land on the surface after bouncing a number of times, with the spacecraft object “going to sleep” when the movement decreases below an unquantified threshold. After landing, the spacecraft moves without the presence of bouncing by sliding over the surface, towards areas of lower potential. This continues until the spacecraft comes into equilibrium with friction forces.

Solar Tides

Solar tides were neglected in this study, though they are a major perturbing force on spacecraft orbiting the Earth and other minor bodies. There is difficulty in implementing this effect, as it is a nonlinear perturbation acting over the linear grid. The consequences of neglecting this force were broadly investigated by using the Matlab model developed in previous research (Crowe, 2014).

For comparison, the asteroid was assumed to have a circular orbit about the Sun, at the radius of Earth’s orbit for convenience. It is noted that this is a simple example, with the more eccentric asteroid orbits likely to see very different effects over time. A different orbital configuration of the spacecraft about the asteroid would produce different effects to the circular orbit exampled here.

In the configuration shown in Figure 6, the positive x-axis is always aligned with the Sun. The gravity of both the Sun and the asteroid have been modelled as
point masses, to highlight the effects of the tidal forces only. This force will need to be considered for a more complete dynamics simulation.

**Figure 48:** A Matlab plot showing the effects of Solar tides on the spacecraft as it moves about the asteroid. This particular orbit is initially circular with 50km radius, with the simulation showing the cumulative effect over many orbits.

**IMPLEMENTATION**

The final step to making this simulation useful is to produce controls and outputs that are intuitive to users. The brief required text output of some changing variables over time as well as views from spacecraft point-of-view cameras and an overview camera. The simulation is supportive of Oculus Rift© headsets to provide an immersive environment for users.

To provide realism, one necessary part of the simulation was to leave some constants definable by users, such as lighting angles and spacecraft initial conditions. This was realised in the executable product through a user interface. Other constants required definition in the development phase.

Cameras can be positioned during development and there are options to lock them onto objects (the asteroid, for example). The overview camera can be repositioned during play, centred on the asteroid or one of the spacecraft involved. It can also zoom as desired. As a default, the tracks of moving objects are produced by the games engine. It is useful for users to see where the spacecraft has been and acts as a reference to how the trajectory has evolved. An example of the orbital track is displayed in Figure 7, where the orbit has been propagated about the model of asteroid 433 Eros. The track must have a finite length which can be defined by the user. Having a significantly long track does produce a liability for the program, as it is another aspect to be rendered.

![Figure 48: A Matlab plot showing the effects of Solar tides on the spacecraft as it moves about the asteroid. This particular orbit is initially circular with 50km radius, with the simulation showing the cumulative effect over many orbits.](image)

**Figure 49:** View of the asteroid 433 Eros with a spacecraft orbiting and displaying trajectory tail. Note the change in trajectory due to asteroid spin and gravitational asymmetry.

Executable files have been created that can be used outside of the Unity© platform and indeed, independently of the platform. This has been developed in response to the requirement for a simple and intuitive interface for the user.

One issue experienced was the calculation of the physics. This was limited by the desire for substantial rendering. This issue can lead to lapses of the ability of the engine to display realistic physics. For example the spacecraft has been seen to fly through the asteroid at difficult moments of intense calculation.

As rendering is the key concern, reducing the requirement to render in high definition is the easiest solution. The games engine renders a field of view as a volume for each camera that has been set up and will stop rendering the parts of the asteroid and other spacecraft that exit that space. This volume can be adjusted based upon the user’s requirements.

The spacecraft was provided with thrusters, allowing it to move in four directions relative to its camera direction. The thrust provided by these engines can be changed as desired. One thing to note is that the actual position of thrusters is generally different for each mission flown. That said, the direction of the thrusters can be easily changed in the design of this simulation and so it can be used as a test bed for thruster configuration in the design phase.

It was found that the computer had more trouble rendering the trajectories as the number of spacecraft was increased. This did not affect the physics, but did make adjusting camera angles and interacting with controls during the simulation difficult. Reducing the fidelity of the displayed trail was found to help with this and could be an avenue of study in the future to enhance the simulation experience.
Immersive Technology

Oculus Rift® has been enabled in this simulation to provide an immersive experience for the user. This is facilitated through Unity®, where a stereoscopic camera can be applied to an object and track through the environment as a normal camera would. This can feed out to an Oculus Rift® headset to emulate some of the 3D visual experience that one might experience if in the position of the camera.

DISCUSSION

This simulation was designed primarily to provide engineers with an intuitive tool for use in rapidly testing hypotheses and producing graphics to clearly represent their findings in the field of flight dynamics about asteroids. The options available, the models created and the forces considered provide a good basis for this work.

There is an issue with the time that it takes the spacecraft to move with respect to the asteroid. As asteroids are bodies with small gravities, to achieve a closed orbit, velocities are low and so periods are large. The example 50km circular orbit about 433 Eros has a period of about 29 hours. Even with the engine pushed to its limit of 100 times movement speed, the propagation is still slow to watch and barely perceptible when compared with the large size of the asteroid. As smaller asteroids produce a lesser gravitational force, changes are even more difficult to see when trajectories are simulated about these.

Our team perceives that there could be some benefit in scaling parameters to run the simulation faster. This will require further research and is beyond the scope of the current project.

The background used in the current simulation displays stock pictures of Sun and starscape. Future iterations of the simulation could be improved by displaying a near-accurate map of the stars as background. This could be a useful future addition when testing spacecraft navigation and attitude control. Inconsistency in the seaming of the box-like background function is one issue that needs to be overcome if this is to be effective.

The only source of gravity considered was that of the asteroid. This can be suitable over a short time period and in close proximity to a large asteroid. The Solar tides are a large source of perturbation however and must be accounted for if confidence in the simulation is to be had over several revolutions in the case displayed in this study or fewer in the case of other asteroids.

Another force that went unconsidered is Solar photonic pressure. This is a force always acting away from the Sun and is proportional to the ratio of the area of the spacecraft exposed to the Sun. This force varies with space weather, which remains difficult to predict.

CONCLUSION

A model of the asymmetric gravity about an asteroid was produced. This was joined with a spacecraft trajectory simulation to build a tool that can be used by engineers and mission planners to rapidly execute mission designs and modify them in real time. This is something that is not currently possible with propagation tools available today.

This research highlights some of the possibilities that game engines can apply to the simulation of complex dynamics environments, especially in the case of spacecraft moving in proximity to asteroids.

Future work could focus on providing further rigour to the physics by factoring in the other forces that are unaccounted for in this work. By speeding up the simulation and reducing the computing requirements, the simulation could be developed further.

REFERENCES


Large Scale And “Lean” Interprofessional Learning: Preparing 450 Undergraduates For Ward Calls

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Aim of the education program. Interprofessional learning (IPL) is an identified priority for our Faculty. Simulation-based IPL is typically resource-intensive but highly valued by students. Undergraduates are often underprepared for transition to practice yet new graduate nurses must identify inpatients requiring medical review, and junior doctors must diagnose and manage while seeking appropriate advice. We created the WardSIM course, bringing together medical, nursing and pharmacy students to simulate the “ward call” (unplanned review of an inpatient), aiming for interaction and learning together in a realistic clinical context. WardSim course objectives include development of IPL competencies – respect for skills and values, clarity of roles and responsibilities, communication and teamwork – plus a systematic approach to patient presentations. We aimed to achieve IPL objectives in a “lean” and sustainable course.

Methods adopted. An interprofessional faculty developed the course for all fifth year medical students plus final year nursing and pharmacy students, divided into 7 cycles over the year: usually 45 students on Day 1 and 60 on Day 2. After an introduction in 2 streams, 6 smaller interprofessional groups managed or observed simulated ward calls and were debriefed before regrouping into streams to undertake relevant activities. Over 2 days students were exposed to 8 simulations and 8 activities. Faculty delivering the course include several who change every 6 months: most regular faculty also required development of simulation skills. Logistic challenges are major and solutions include technician support, student preparation pre-course, colour coded name badges, a video exemplar for orientation, detailed faculty “scripts” for familiarisation and activities, participant confederates, rigorous timekeeping, and cloud access to current versions of materials. A key aspect is faculty training, achieved with pre-reading, videos of cases and activities, a ½ day workshop and a debriefing handbook.

Day 1 delivery requires minimum 9 personnel including technicians and timekeeper, increased to 10 on Day 2. Students completed a 16 item Readiness for Interprofessional Learning Scale (RIPLS) pre and post course. An end-of-course questionnaire was administered on cycles 2-7 using a 5 point Likert scale, and free text comments were sought on each item.

Evaluation data from the program. In 2014, 421 undergraduate students attended WardSIM. Completed RIPLS forms totalled 288 pre- and 322 post-course. Significant differences pre and post course were seen across all items suggesting improvement in readiness for IP training. End of course questionnaire results are shown: 5 = strongly agree, 1 = strongly disagree with the given statement.
<table>
<thead>
<tr>
<th>Statement</th>
<th>Likert score median (range)</th>
<th>Number of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>I learnt to be more systematic in patient assessment.</td>
<td>4 (1-5)</td>
<td>316</td>
</tr>
<tr>
<td>I learnt strategies to help me communicate more effectively.</td>
<td>5 (1-5)</td>
<td>319</td>
</tr>
<tr>
<td>I feel clearer about my role in a patient care team.</td>
<td>4 (1-5)</td>
<td>318</td>
</tr>
<tr>
<td>I feel clearer about the roles and capabilities of others from different disciplines in the patient care team.</td>
<td>5 (1-5)</td>
<td>317</td>
</tr>
<tr>
<td>I learnt more on this course by sharing it with other professional groups.</td>
<td>5 (2-5)</td>
<td>314</td>
</tr>
<tr>
<td>The size of the groups was appropriate for effective team learning today</td>
<td>4 (2-5)</td>
<td>320</td>
</tr>
</tbody>
</table>

Free-text responses were positive and centred around insight into roles and responsibilities, structured communication, leadership and effective teamwork. Students placed significant value on the experiential learning aspect of WardSIM.

**Conclusions and recommendations for future use and development.** Student self-report data suggests IPL objectives were achieved in the setting of a relatively “lean” simulation-based course. In 2015 the course has attracted numerous university and clinical staff wishing to teach which bodes well for sustainability. Future plans include increased integration with undergraduate curricula.
Developing a Co-Created Curriculum for an Inter-Professional In-Situ Critical Care Simulation Education Program

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Aim of the Education Program.

The Austin Intensive Care Unit (ICU) is a complex, multi-system support service for Liver and bowel transplantation, Cardiac Surgery, Spinal cord injuries, Neurosurgery, Thoracic Surgery, General Medicine and liver failure. Currently open to 20 beds with a capacity of 29 beds the ICU is in a graduated growth period. We are fortunate to have a strong research and teaching culture that already utilises simulation in some form. With a growing staff base, rotating junior-intermediate medical workforce and an increasingly more complex inpatient hospital population there was a need to develop plans to address educational and clinical standards. Simulation based training programs offer a suitable education platform to advance many of the education needs to help close the gaps in knowledge/experience. 1, 2, 3

Over the past 2 years we have developed a more structured, relevant and sustainable inter-professional in-situ simulation program. There is overwhelming recognition in the literature to endorse inter-professional training programs. 1, 3, 4 The aim of this program was to seek staff contribution in designing an in-situ inter-professional critical care simulation program. Through this, a curriculum could be developed that is relevant to the department and its needs whilst engaging knowledgeable staff to contribute to the roll out of the curriculum.

Methods Adopted.
Over two weeks Doctors and Nurses were surveyed for learning needs through a simple anonymous questionnaire seeking three topics for simulation education.

Evaluation Data from the Program.

Responses rate; 100% capturing 48 of 215 (22%) nurses and 8 of 14 (57%) doctors. The average years of ICU experience was 8.7. The questionnaire results are presented in Graph 1. Top two topics were: Extra Corporeal Membrane Oxygenation (ECMO) and Difficult intubation drills.

Conclusions and Recommendations for Future Use and Development.
A positive result from our survey findings was the alignment of ideas with the Simulation Group. The main leading responses were activities that have been a recent focus in our ICU. Topics such as ECMO is an emerging complex therapy in many ICU’s locally and beyond. This data enabled us to create a six month curriculum coinciding with the medical training program in ICU. A low response rate may conceal unmet educational need and would be addressed in the next iteration of this approach.

The development of our inter-professional simulation curriculum through co-creation of learners and faculty has been a simple and worthwhile exercise. We would encourage other simulation educators to consider this approach. It has contributed to a recurring Friday afternoon (1400-1500hrs) session under the banner of: “Team Skills” that is well attended and received.

References.
An Inter-Professional Learning Workshop For Mammography And Sonography Students Focussing On Breast Cancer Care And Management Via Simulation

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Aims.

1. To apply theoretical knowledge to a clinical scenario
2. To explore the impact of inter-professional learning and simulation on attitudes of sonography and mammography students in terms of learning with, from and about one another

Background.

In 2010, breast cancer was the most common cancer in Australian women accounting for 28.0 per cent of all new cancers in women. (14,181 new cases).

The journey of the breast cancer patient to diagnosis and management, involves consultation and interaction with a range of health professionals. This group includes but is not limited to radiographers, sonographers, GPs, breast surgeons, breast care nurses, physiotherapists, medical oncologists, radiation oncologists and radiation therapists who all perform significant tasks in relation to the patient.

A Cochrane review of inter-professional education, reported a range of positive outcomes which included improved working culture, increased patient satisfaction, decreased error; improved management of the care delivered and improved knowledge and skills of professionals providing care. The rationale and literature surrounding inter-professional education claims that students who learn with, from and about one another in well-designed inter-professional programs will practice together collaboratively upon graduation, given the skills to do so.

Project design and methodology.

The authors identified an opportunity to deliver an inter-professional learning (IPL) session focusing on the patient care pathway in a mammography workshop. A mammography course is offered as part of the postgraduate breast imaging program at the University of South Australia. The course is delivered by Breast Screen South Australia as the Australian Institute of Radiography accredited educational provider, for the Certificate of Clinical Proficiency in Mammography.

30 postgraduate students attended a week long mammography workshop which comprised didactic lectures from clinicians. The sessions provided an overview of breast anatomy, physiology and pathology; mammography techniques, knowledge of skills, the role of other imaging modalities (including breast ultrasound and MRI) in the detection of breast cancer, knowledge of the methods of biopsy, management options and research into breast disease and the importance of communication skills in the management of breast cancer.

An IPL session was incorporated on completion of the workshop to consolidate learning. Props and authentic resources were used to increase the fidelity of the simulation. Props included a scripted simulation scenario with cue cards, simulated ‘patient’ notes, breast image examples, positional manikins, task trainers and breast ultrasound phantoms. The session was facilitated by trained faculty.

Participants completed pre and post-workshop questionnaires comprising an inter-professional education and collaboration scale and a quiz to gauge knowledge of pathway specific content related to professional roles. The
post-workshop survey also had a series of open-ended questions. Responses to each statement in the scale and quiz score, pre-/post-workshop were compared, whilst responses to open-ended questions in post-workshop survey were thematically analysed.

Evaluation of the innovation.

This study confirmed learning with other health students through an IPL simulation improved attitude toward the importance of shared learning, teamwork and communication in healthcare service. Students consolidated knowledge of the roles and tasks of professionals involved in pathways to diagnosis and management of breast cancer patients. Simulation is a powerful tool to provide opportunities for learning in a safe environment, and technology can be used in diverse ways to provide authentic learning.

Future recommendations.

Whilst participants in this study were students from only 2 disciplines, this innovation could be applied to broader groups of health professionals who work in a multi-disciplinary team to care for breast cancer patients. The scenario is flexible and authentic props could be supplemented to provide added context. The production of a video would allow implementation of this innovation into the online environment.

References.

Aim of the Education Program.

Malignant hyperthermia is a rare, life-threatening condition which most healthcare professionals will never see but need to be prepared for. Using a case scenario based on an actual case of MH from New Zealand in 2011, an interprofessional simulation session was developed to take staff beyond a presentation and a look over the MH emergency box contents.

Outcomes:

Role clarity
Improved anticipatory response
Overall team cohesion and interaction
Staff identification of quality improvement initiatives

Methods adopted.

An initial 45 minute presentation was delivered that reviewed the 2011 case interspersed with videos of 3 anaesthetic techs and the OR coordinator describing the incident and their responses to it. This included what had been done well, what was learnt and how improvements were subsequently implemented. This was followed up three days later with three x 1 hour long simulations involving 20 interprofessional staff in each session.

I used the California Simulation Alliance (CSA) template for scenarios to prepare these sessions (CSA REV template). Learning objectives were developed which were linked to the Nursing Council (NZ) competencies for practice and critical learner actions were identified. A clinical nurse educator from the department acted as a confederate, the lead anaesthetic tech took the role of the anaesthetist for all three simulations and each of the 20 group members was given a lanyard to signify their role in the simulation.

Senior management staff were briefed on the simulation case details, the learning objectives, the plan for each simulation hour, the manikin state changes, key triggers for each state and the observer sheet that would be used.

Each hour simulation included a pre-brief, simulation for 10 minutes, debrief for 30 minutes, repeat of the simulation for 10 minutes, with a final debrief for 10 minutes.

Evaluation data from the program.

Observational data was recorded by five staff members (management, nursing, anaesthetics) on Observer Record Sheets. Multiple quality improvement initiatives were identified, with some being addressed within a week of the simulation. DASH learner evaluations were completed by 18 participants.

Conclusions and recommendations for future use and development.

Interprofessional simulations are highly effective because they mirror the types of interactions and clinical expectations of a real situation. The debriefing sessions, in particular, were enlightening for all staff involved as the ideas and input from varying staff member roles enabled the rest of the staff to consider aspects from a myriad of perspectives. This process allowed crystallisation of thoughts, ideas and hunches so that specific quality improvement initiatives were clarified.
References.


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Simulation Improves Student Skills And Confidence In Conservative Sharps Debridement: A Pilot Randomised Controlled Trial

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Aims.

To determine if a combination of simulation and traditional training in podiatry clinical placements improves student skills and confidence in conservative sharps debridement of callous compared to traditional training alone.

Background.

Conservative sharps debridement is an essential skill for podiatrists. The risks of poor technique include lacerations, infections and possible amputation. This study explores if adding simulation to traditional clinical placements improves conservative sharps debridement skills among podiatry students.

Method.

Thirty students (7 male, 6 English as second language, 18 final year, mean age 23.9 yrs) were randomly allocated to either a control or an intervention group. The Intervention group (n=15) were offered a 2 hour simulation workshop as part of their clinical placement and the Control group (n=15) received a 2 hour tutorial on a different topic. Both groups continued to learn conservative sharps debridement of callous skills when appropriate opportunities arose during their clinical placement. Students had their debridement skills assessed on their first and eighth day of placement using medical footcare models. An assessor blind to group allocation rated the students’ skills in 7 areas: scalpel loading, body ergonomics, scalpel position, scalpel movement, skin tension, hand location and blade removal. Students also rated their confidence using an 8-item questionnaire (possible range of scores 8-40).

Logistic regression was performed to assess the impact of group allocation and baseline competency on the likelihood that participants were rated as competent post-intervention. Analysis of covariance (ANCOVA) was used to analyse between-group differences in student confidence immediately after the intervention with baseline scores as covariate.

Result.

The logistic regression model containing both predictors explained between 27% and 38% of the variance in competency at the follow-up assessment and correctly classified 75% of cases. Group allocation was the only variable contributing to the model and predicted post-intervention competency with an odds ratio of 16.6, indicating the intervention group were 16 times more likely to be assessed as competent (95% CI 1.65 to 167.42, p = 0.017) compared to the control group. At follow-up the intervention group had increased confidence (MD 3.2 units, 95%CI 0.5 to 5.9) compared to the control group.
Discussion.
Incorporating simulated conservative sharps debridement skills training with a medical footcare model appears to be a useful addition to clinical placement for podiatry students in terms of their debridement skills and confidence levels. As the assessments were simulated on foot models further studies would need to determine if the benefits translate into clinical practice.

Conclusion.
A pilot RCT including 30 students indicates that incorporating simulation into traditional podiatry clinical placements appears to improve student skills and confidence with conservative sharps debridement of plantar callous.
The effect of assessor presence versus absence during clinical competency assessments

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Aims.
To investigate the extent to which the presence or absence of an assessor in simulation-based live clinical competency assessments effects students’ distraction, anxiety and performance.

Background.
Clinical assessments using simulation-based scenarios are often used to gauge students’ ability to translate theory into practice. However, such experiences can be highly stressful for students [1,2] and may not provide a true reflection of clinical competency [3]. One method proposed to reduce student stress during clinical examinations is by removing in-situ clinical assessors. Quick and Ross found that in addition to the stress associated with simply being assessed, the presence of an assessor altered student behaviours and attentiveness through student-teacher discourse and a tendency for students to seek ongoing confirmation about their progress via ‘sideways glances’ to the assessor [4]. Conversely, the removal of an assessor from the environment decreased students’ sense of intimidation and self-conscious behaviours, and facilitated greater student ‘ownership’ of the scenario, allowing them to better focus on the clinical scenario itself. The authors concluded the presence of an assessor has the ability to disrupt the continuity of a scenario, potentially leading to poorer student performances, and ultimately detracts from the purpose of the assessment [4]. The generalisability of this study is limited by its qualitative nature so we sought to replicate the findings using a quantitative methodology in order to determine the extent to which assessor presence impacts upon students’ performance. This project received funding from the Australian Government.

Methods.
Participants were 31 volunteer second-year paramedicine students from Edith Cowan University. Students were separated into groups of three as per the ‘Physicians Model of Assessment’ [5] undertaking a total of six distinct clinical scenarios (completed in random order); two as the ‘delegator’ responsible for clinical decision-making and delegating tasks, and four as the ‘respondent’ performing tasks requested by the delegator. Whilst acting as the ‘delegator’ students completed (in random order) one scenario with an assessor being present in the room and another with the assessor anonymously viewing scenarios from behind a two-way mirror. One trained live-actor patient was present in each scenario providing information to students about clinical symptoms and responses to medications and treatments. If students asked assessors in the ‘present’ condition for clinically relevant information about the scenario, assessors were permitted to respond but instructed to keep responses brief and provide minimal potential feedback to performance.

Video-recordings were used to quantify time-to-completion as well as interaction time and non-verbal glances towards assessors in the ‘present’ condition. Anxiety was inferred via continuous heart-rate (HR) data collected from delegators at five-second intervals during each scenario. Two expert assessors independently reviewed students’ video footage and rated their performances using a structured clinical assessment checklist.

Results.
No statistical difference was detected between students’ mean performance scores in the assessor ‘absent’ versus ‘present’ condition (71.6% vs. 69.4% respectively, p=.496). However, the average time-to-completion in the ‘absent’ scenario was over a minute quicker than the ‘present’ condition (6.6 vs. 8.4 minutes respectively, p<.001). In the ‘present’ condition students spent an average of 61.4 seconds conversing with the assessor, accounting for 13% of their time-to-completion. This time was spent discussing clinically relevant information (43.4s), extraneous matters (17.9s) and non-verbal glances toward assessors (5.2s) an average of 2.8 times per assessment. Over the duration of each clinical assessment HR deviation from baseline remained consistently higher for students when the assessor was ‘present’ compared to ‘absent’ (see Figure 1). In the ‘absent’ condition, students’ average HR decreased by 9.1 bpm from baseline compared to only 4.3 bpm during the ‘present’ condition; a statistically significant difference (p=.040).
Discussion.

In the assessor 'present' condition, our HR data provided a clear indication of heightened anxiety in students, disruptive time spent interacting with the assessor and significantly longer time-to-completions. In comparison, students in the assessor 'absent' condition performed just as well and significantly quicker. It appears that with an assessor present our students were contending with dual aspects of the scenario—clinical-decision making and the ongoing reminder that their performance was being judged. Removal of the assessor allowed students to narrow their focus to the patient.

Conclusions.

If possible assessors should not be physically present when students undertake clinical assessments and alternative methods of observation, such as two-way mirrors or video-recordings should be considered. Doing so would be popular with students, likely decreasing their anxiety, and facilitating a more timely performance of clinical skills without adversely affecting overall performance.

References.

The value and challenges of embedding role-play simulation across entry-level physiotherapy clinical education: a qualitative evaluation involving students, staff and actors from 16 Australian Universities.

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Aims. This qualitative evaluation aimed to assess the impact of clinical role-play simulation training on the efficiency and effectiveness of physiotherapy clinical training. In addition, its impact on the self-perceived confidence and clinical competence of entry-level physiotherapy students will be analysed.

Background. Health Workforce Australia (HWA) (an Australian Government organisation), provided $5.75 million to fund a consortium of 16 Australian physiotherapy programs to undertake a project to embed simulation into physiotherapy clinical training across Australia in 2014 and 2015. The project substitutes 20% of traditional clinical placement time with clinical role-play simulation. This predominantly involves actors portraying simulated patients who interact with physiotherapy students in realistic clinical environments. In an increasingly complex clinical environment, with limited capacity to provide comprehensive and effective training for the increasing numbers of health care professionals, it has been suggested that simulated learning environments (SLEs) may offer an alternative training setting. SLEs have the potential to increase clinical training capacity but equally importantly also provide a unique learning experience, where all students can be given exposure to complex clinical situations in a controlled learning environment that allows them to learn from their mistakes without creating risks for patients.

Methods. 16 Australian schools of physiotherapy participated in the project at varying times from January 2014 to April 2015. The project involved xxx students participating in at least 200 different simulation units each of 5 days duration. Each University determined the number of students undertaking placements and selected one of 3 different simulation placement models in up to 3 core practice areas (cardiorespiratory, neurological, musculoskeletal) as best suited their programme. Whilst each University had some flexibility, many aspects of the simulation intervention were standardised. This included specific simulation scenarios, student-supervisor ratios and simulation facilitation techniques. Alongside quantitative evaluations, the educational outcomes of simulation were evaluated using qualitative methodology. Volunteers were recruited from across all participating universities following their completion of simulation units (students, simulation supervisors and actors) or following supervision of simulation-trained students (fieldwork supervisors). These volunteers participated in a series of focus groups. Each focus group was facilitated using key questions, with transcripts then analysed for themes.

Result. More than 100 focus groups were conducted with emerging themes suggesting an overwhelmingly positive response by both students and staff to simulation training as part of clinical education. Students particularly valued simulation as a bridge between academic and clinical learning. Staff reported that they valued the opportunity that simulation offers to modify the clinical environment according to the needs of an individual student. Staff also commented that students who have completed simulation training are more prepared for some aspects of the ‘real’ clinical environment. Full results from the focus groups will be included in the presentation.

Conclusions. This large profession-wide national project appears to show that clinically-realistic role-play simulation is an effective alternative clinical teaching method. Although clinical simulation should never replace traditional placements, it may well have a future role in enhancing student preparedness for practice.

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Aim: The overall aim of this doctoral study was to explore the use of simulation-based education (SBE) in cardio-respiratory physiotherapy in the UK. One of the outcomes of this study was the development of a new conceptual ‘integrated simulation learning framework’.

Background: Evidence of the development of clinical skills through practise on ‘real’ patients and part-task trainers has reported as far back as the inception of the profession in 1895. A literature review failed to identify a framework to facilitate the design, development and evaluation of SBE in physiotherapy. A commonly cited nursing simulation education framework is that developed by Jeffries. Alternatively, instructional design models have been used to guide the development of healthcare SBE initiatives. Neither of the aforementioned simulation or instructional design frameworks acknowledged learning activities beyond the simulation intervention or debrief.

Methods: A sequential, two phased explanatory mixed methods was study selected to provide a comprehensive examination of the use of simulation-based education in cardio-respiratory physiotherapy, in the UK. Phase 1 consisted of two national postal self-administered questionnaire-based surveys undertaken, during 2009-10. Findings of the survey were used to develop the SBE resources used in phase 2. Phase 2 used focused video-reflexive ethnography (VRE) to explore behaviours, error recognition abilities and personal experiences of 21 final year (pre-registration) physiotherapy students from one Higher Education Institution. The new conceptual ‘integrated simulation learning framework’, was developed from the methodological design used in phase 2, VRE interview analysis and pedagogical literature pertaining to learning theories applied to SBE.

Results: The proposed framework consists of 3 distinct but interlinking, essential components to be considered when designing, developing and evaluating SBE including: ‘preparation’, ‘intervention’ and ‘evaluation/research’ (figure 1).

Preparation: This component includes three constituent elements: ‘learners’, ‘facilitator’ and ‘theories and educational practices’. Within healthcare SBE, adult learners are responsible for their own actions and development. Clearly defined SBE skills and roles help facilitators to optimize learning through the provision of support, encouragement, guidance and feedback. ‘Theories and educational practices’ includes adult learning (e.g. behaviourism, connectionism, constructivism, and experiential), cognitive (e.g. cognitive load and situated learning) and socio-material theories (e.g. cultural-historical activity theory and complexity). In addition, educational principles such as blended learning, flipped classroom, instructional design, scaffolding and deliberate practice, are considered to optimize learning in the simulated environment and beyond.

Intervention: The ‘intervention’ component features three separate elements: the ‘simulation design characteristics’, ‘pre-brief and debrief’ and ‘linked learning activities’. Simulation design characteristics refers to selecting the most appropriate simulation medium, method and modality required to ensure the learners achieve the intended learning outcomes. Consideration of how the appropriate level of fidelity, realism and authenticity can be achieved within the constraints of the course/programme/curricular is essential. The use of physical/verbal cues can be used to facilitate achievement the desired learning outcomes. Pre-brief and debrief intervention planning refers to the focus, style, format, duration and use of assistive technology. Linked learning activities such as post-event reflection/reflexivity activities is encouraged. It is important to stimulated the learner to think beyond the debrief, in order to implement learning derived from the feedback. Simulation, debrief and post-event reflective activities may be used as evidence of performance, achievement or involvement in CPD and documented in paper or electronic formats (such as an e-portfolio).
Evaluation/research: It is essential that an evaluation of the SBE intervention is undertaken to evaluate effectiveness/assess achievement of learning outcomes. Evaluation should be undertaken to explore the impact of learning gained in the simulated environment through to practice, providing evidence of bridging the theory practice gap. Following evaluation, information may then be analyzed, and actioned accordingly within curriculum / programme / course review. Feedback from learners, trainees and facilitators should be sought alongside requirements from relevant professional regulatory bodies, where applicable.

Discussion
This framework presents 3 major interlinking components for consideration when designing SBE, whether this be for a short course or embedded within healthcare curricular. Components within this new framework are derived from learning theories and practices that lead to effective learning. Previous simulation and instructional design frameworks lacked the presence of a feedback loop and acknowledgement of reflective learning activities beyond the simulation debrief. Therefore, one of the key additions of the proposed framework was to illustrate that evaluation and research cyclically drive changes. Thus arrows have been presented to indicate feedback loops from outcomes (evaluation/research) to the other constructs (preparation and intervention).

Conclusions
A new ‘integrated simulation learning framework’ is proposed to support the design, development and evaluation of SBE in healthcare. Further testing of this framework is required in physiotherapy and other healthcare disciplines.

![Integrated Simulation Learning Framework](https://example.com/)
References.

Does An Individual’s Learning Preference Have An Impact On Satisfaction With Simulation-Based Education (SBE)?

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Aims.
1. Investigate the extent to which the preferred learning style of a participant in an SBE activity relates to their satisfaction with the educational activity.
2. Investigate whether the learning style of participants varies between those electing to attend an SBE activity and those whose attendance is compulsory as part of their course of studies.

Background.
It is argued that simulation is a useful educational tool to improve the practical knowledge and skills of undergraduate health care students by offering a realistic clinical experience in a safe and secure environment (Gaba 2004). When appropriately integrated, simulation activities attain educational goals with a number of advantages, such as:
- avoiding risks to patients and learners
- reducing undesired disruptions to the learning experience
- creating on demand tasks and scenarios
- repeatedly practicing skills
- individually tailored training
- increasing retention and accuracy
- enhancing the transfer of training from the classroom to a real situation
- creating standards against which to evaluate student performance and diagnose educational needs. (Maran and Glavin 2003).

With an increasing number of students entering the tertiary sector there has been a high demand on clinical placements. As a result, the number of students requiring undergraduate clinical placements in Australia now exceeds supply (Rudd, Freeman, Swift, & Smith, 2010). The increasing pattern is for simulation to be utilised for educating and possibly for future clinical placement. There is a clear need to reproduce clinical experiences through innovative approaches. Simulation-based learning is widely suggested as part of the solution. Its advantages include experiential learning in a secure environment (Cioffi, 2001), avoidance of any risk to patients (Ziv, 2000) and recreation of important but rare clinical situations that most students would miss in random clinical encounters (Kohn, Corrigan, & Donaldson, 2000). This has also been the rationale for the inclusion and use of simulation from many of the patient safety advocates around the world.

However, the learning preference of participants in health professions has had very little research conducted and none when investigating the use of SBE in the education process. This study investigated the relationship between learning preference and involvement and immersion in SBE to assist with future educational planning. This project received funding from the Australian Government.

Methods.
Participants

The study consisted of two groups attending SBE. The elective group (n=82) consisted of postgraduate health care professionals that had elected to attend a simulation-based course. The compulsory group (n=82) consisted of participants for whom attending simulation based education was compulsory as part of their professional entry program.
**Materials**

Participants completed the North Carolina State University (NCSU) Learning Preference Questionnaire containing 44 items that score respondents along four dimensions of learning preference style (*Active vs. Reflective, Sensing vs. Intuitive, Visual vs. Verbal* and *Sequential vs. Global*). After completing their simulation-based training, participants then completed the Simulation Satisfaction Survey, validated by Newcastle University, consisting of 18 items that provide an indication of the level of satisfaction for the SBE learning activity from the perspective of the participant.

**Procedure**

The procedures for this study are detailed below.

**COHORT 1**

(n=82)

- Simulation-based activity as part of formal course work.
- Recruitment of volunteer participants through explanation of study and information sheet provided.
- Consent to be involved in study and allocation of participant number to de-identify data.
- Completion of North Carolina State University Learning Preference Instrument using de-identifying participant number.
- Involvement in Simulation-Based Activities.
- Completion of Newcastle University Simulation Satisfaction Survey.

**COHORT 2**

(n=82)

- Postgraduate health professional attends simulation-based as a self-selected participant.
- Recruitment of volunteer participants through explanation of study and information sheet provided.
- Consent to be involved in study and allocation of participant number to de-identify data.
- Completion of North Carolina State University Learning Preference Instrument using de-identifying participant number.
- Involvement in Simulation-Based Activities.
- Completion of Newcastle University Simulation Satisfaction Survey.

**Data Analysis**

**Write of final report**
Statistical Analysis

Participants’ responses to the 18 items of the satisfaction survey were aggregated into a single score of overall satisfaction ranging from 18–90. An independent-samples t-test was then used to compare average satisfaction scores between voluntarily attending and compulsory groups. The MANOVA technique was then used to compare groups’ average responses to each item of the satisfaction survey to compensate for Type 1 error. Participants were also assigned to dichotomous groups based upon their learning preferences for all four dimensions of the NCSU. Independent samples t-tests were then used to compare average global satisfaction scores between each dimension’s groupings.

Results.
1. There were no statistically significant differences for aggregate scores for the satisfaction survey between the elective and compulsory group (78.5 vs. 78.3, p=.859).
2. On a scale from -11 to +11, participants from both groups demonstrated a balanced distribution of preferences for the Sequential/Global (mean=1.46 SD=4.42) and Active/Reflective (mean=0.67 SD=4.30) dimensions but preferences were skewed towards visual preference for the Visual/Verbal dimension (mean=3.99 SD=4.89) and sensing preference for the Sensing/Intuitive dimension (mean=4.29 SD=4.51).
3. Overall, involuntary participants were significantly more likely to prefer active learning styles than voluntary participants (72.0% vs. 52.4%, $\chi^2$(1)=6.639 p<.05) but no between-group differences were found for the remaining learning preference dimensions.
4. Participants with a preference for Active learning returned small but statistically significant higher levels of satisfaction with SBE than those with a preference for Reflective learning (79.4 vs. 76.4, t(156)=2.521, p<.05).
5. Elective participants with a preference for active learning returned significantly higher satisfaction with SBE than those who had a preference for reflective learning (81.0 vs. 75.8; t(74)=3.080 p<.01).

Conclusions.
This study indicates that participants who attend SBE activities with a preference for active learning will demonstrate higher satisfaction with their experience than those who have a preference for reflective learning. It also indicated that voluntary attendees had a more balanced preference for active and reflective learning. Given that this group was comprised of graduates compared to the involuntary group being undergraduates, it is likely their increased level of experience facilitated an ability to link their immersion in the simulation and debrief to their clinical experiences. The reflective learners may find greater value in the debrief process post immersion which allows them to link their recent activity to their clinical work.

Study results suggest that active learning is the only learning preference that has an impact on satisfaction with SBE. It also suggests that simple debrief methods may be most appropriate for those attending SBE as part of their compulsory course of study and that participants who elect to attend may require more in-depth debriefing. Debriefs should focus less on the events that occurred during the SBE activity and more on human factors contributing toward the occurrence of that event.

Analysis of the data also displayed a need to move toward a more robust measure of simulation, other than personal satisfaction with the SBE activity, in order to truly quantify impact on learning.

References.
Pop-Up Simulation: A Program To Recognise The Deteriorating Patient At The Point Of Care

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Background and Aims of the Educational Program.

Mater Health Services (MHS) is a complex tertiary level teaching health service operating 3 hospitals at South Brisbane campus incorporating private and publicly funded beds. The inclusion of the Pop-Up Recognition of the Deteriorating Patient (RODP) Simulation Program aims to bring simulation training from Mater Education Practice Improvement Centre (MEPIC) to the clinicians in their own environment. The transportable nature of the program facilitates greater access for clinicians from all disciplines across the health service (not just those who have attended Advanced Life Support (ALS) or Paediatric Life Support (PLS)) for the improvement and retention in skills, knowledge and interprofessional care of our patients.

The aims of the program include:

- Improve clinician’s ability to recognise and manage the deteriorating patient.
- Provide opportunities for clinicians in engage easily accessible point of care (in-situ) simulations during their work day, with minimal impact to patient care delivery.
- Reinforce and further scaffold Basic Life Support (BLS) and ALS training within a clinician’s own clinical area to ensure skill and knowledge retention between annual recertification.
- Review and enhance escalation and emergency response team processes utilising bi-direction feedback with the Clinical Safety and Quality Unit (CSQU) and the Resuscitation Committee.

Methods Adopted.

Preparatory Pop-Up Cardiopulmonary Resuscitation challenge and Pop-Up Clinical Skills sessions were conducted over a three month pilot period. Subsequently, negotiation with local clinical educators and managers occurred; with weekly sessions scheduled. Forty simulations were held from January to August across 16 clinical areas. Four simulations were designed to include technical and non-technical skills, with the content addressing clinical issues highlighted by CSQU data. One simulation activity was run in each area every three months to reflect educational theory pertaining to skill retention. Each simulation lasted 10 minutes followed by a 10-15 minute debrief which occurred in the clinical area. There was ongoing consultation between Mater Education, CSQU and the resuscitation committee to ensure simulations met organisational need.

Evaluation Data from the Program.

Multiple evaluation methods were used to analyse the program. Clinical response data was captured using Sim Designer© and was analysed to determine response improvements over time. The Teamwork Emergency Assessment Measure (TEAM) tool developed by Cooper et al., (2010) was used by faculty and participants to evaluate team members’ leadership and communication skills in the simulations. A post simulation participant survey was also conducted to evaluate learner reaction and to identify other clinical and non-technical skills that participants would like to have further deliberate practice.

Initial program data demonstrates an increase in teamwork skills and improvement of the quality of clinical skills with further descriptive and statistical data to be analysed in July. Relevant CSQU audit data will also be analysed to determine systemic improvements in recognition of deteriorating patients within the context of this initiative.
Conclusions and Recommendations for Future Use and Development.

The Pop-Up RODP simulation program has enabled those participants who ineligible to attend ALS/PLS training an opportunity to develop skills and knowledge around the management of the deteriorating patient. Participants reported rehearsal of the escalation process for a deteriorating patient and working with a real code blue team valuable. The point of care nature of this program has allowed participants and managers to address process and crisis resource management issues inherent in their own clinical environment. Future recommendations for this type of program would include the completion of mandatory competencies during/post the simulations with further focus on the utilisation of the ADDS (Adults deterioration detection system) and CEWT (Child early warning tool) charts to ensure clinical areas are escalating patient deterioration in a timely and coordinated manner.

References.

Effectiveness Of Medical Simulation As A Clinical Training Model For Interns At The Royal Adelaide Hospital

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Aim. To evaluate the efficacy of a scenario-based simulation programme for interns at the Royal Adelaide Hospital.

Background. Simulation training has become an important tool for training in health and medicine, from the use of task trainers to teach specific skills, to simulated emergency ‘drills’ to assess management of specific clinical situations.

Since 2006 the Department of Anaesthesia at the Royal Adelaide Hospital, in concert with the hospital’s Postgraduate Medical Education Office, have delivered a programme of structured scenario-based simulation teaching sessions to hospital interns. Each intern is required to participate in two formative small group sessions over the course of the year, during which they are exposed to common clinical emergencies in order to practise safe and appropriate management according to local protocols and best practice.

Participant feedback has consistently shown that these sessions are well received, useful and run in an organised and enjoyable way at an appropriate level for experience.

Method. All participants were asked to complete a questionnaire, which was a combination of polar questions and propositions requiring responses along a Likert scale. A free text section was provided at the end for any additional comments. An internet-based program was used to facilitate questionnaire response.

Results. 24 anonymous responses were received from a total cohort of 93 interns (26%). 100% of respondents felt that the simulation training programme was useful in enhancing their approach to clinical emergencies on the ward, and that simulation is a useful educational tool.

40% were satisfied with the amount of simulation training offered during their intern year, while 60% felt they would like more sessions. Scenario-based simulation training was rated significantly more effective than a number of other listed common hospital teaching methods including clinical ward rounds, registrar tutorials and lectures.

From suggested learning outcomes, the majority of participants agreed the simulation sessions served especially to clarify the appropriate early management of certain medical emergencies and reinforce the importance of both teamwork and a systematic approach when dealing with medical emergencies.

Discussion. Whilst the data is encouraging, the relatively low response rate to the questionnaire is a limitation. We plan to repeat the questionnaire with the current cohort of interns and are developing strategies to enhance the rate of response.

Further areas of research would include information gathering and comparison of our simulation programme against similar programmes locally and interstate, especially with regard to how they are received by participants.

Given the positive attitudes of interns towards simulation there is scope to increase exposure to simulation throughout postgraduate medical training, although funding and access to resources and staff to provide adequate fidelity needs to be addressed.
**Conclusion.** In a postgraduate medical population (hospital interns) we have shown that well-organised scenario-based simulation training is a useful tool to both maintain and enhance knowledge and approach with regard to the management of medical emergencies in a hospital setting. Indeed simulation training is broadly perceived as superior to various other educational methods. Provision of a quality simulation training programme to interns likely helps to improve patient care while contributing to the professional development of these junior doctors.
Development And Implementation Of A Sustainability Blueprint For Clinical Training Assets And Programs

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Introduction. In 2011 and 2012, the Australian Government Department of Health in partnership with the Victorian Department of Health and Human Services (the department) funded 146 stakeholder-led Victorian projects to the value of $34.7 million. The projects aimed to contribute to enhanced clinical placement capacity and quality in Victoria.

The 2011-12 funding was spread across six project streams with over 50% of the total funding provided through the simulated learning environments stream. Since then, the programs and projects have positively impacted clinical training capacity within Victoria. However, without external support the ongoing sustainability of many programs and projects may be at risk. For many programs and projects establishing a sustainability plan independent of significant government funding was a challenge.

Methods Adopted. In March 2014 the department engaged Evans & Peck Pty Ltd (now known as Advisian Pty Ltd) to undertake the Sustainability Blueprint for Funded Clinical Training Assets Project. The project aimed to develop a sustainability blueprint (the blueprint) to provide a framework and practical tools to support the sustainability of programs and projects in Victoria. These projects included rural accommodation for students, physical infrastructure to support clinical placement activity, and simulation resources. As a result of the stakeholder driven approach to the development of the blueprint, Evans & Peck undertook over 30 face-to-face and telephone interviews with stakeholders from across Victoria. This resulted in the blueprint including guidance on optimising costs, enhancing revenues, planning for sustainability and example strategies.

To assist funded projects and interested parties in identifying the tools and resources that would best suit their sustainability aims, the department held eight master classes across Victoria and interstate. These sessions provided valuable feedback, enabling the tools and resources to be further refined. Subsequently, a number of simulation-specific projects approached the department for additional support and two personalised workshops were delivered utilising the blueprint. All master class and tailored workshop attendees completed an evaluation form.

Results. The stakeholder response to the blueprint and associated tools has been overwhelmingly positive. Master class attendees found the blueprint and resources extremely valuable, with 94.7% of attendees (n=75) either strongly agreeing or agreeing that they received information that will assist them in their work. Further, the masterclass approach was an excellent way to highlight the tools and resources available, with 88.0% of attendees (n=75) strongly agreeing or agreeing that they would attend a subsequent master class of a similar nature.

Consistent with these findings, the preliminary findings from individual simulation-specific sustainability workshop evaluations show participants valued the sustainability blueprint tools and resources.

The tools and resources have enabled projects to assess current circumstances and model the impact of initiatives or changes on sustainability. To this end, 100% of attendees (n=12) strongly agreed or agreed the ideas generated were practical, considered and realistic, while 100% of attendees (n=12) strongly agreed or agreed they would attend or recommend a workshop of this type to other projects or programs.

Summary. The blueprint and tools have been extremely successful in enabling organisations and projects to undertake structured and targeted sustainability business analysis. The success of the blueprint has been a result of ongoing engagement with stakeholders to ensure the product met their needs. This has enabled projects and programs to “jump in” at the appropriate stage depending on their planning and strategic review cycle. The blueprint and associated tools provide a practical, accessible and high-quality resource for programs and projects to consider and address their ongoing sustainability. Attaining long-term sustainability ensures the positive results achieved by a program continue into the future within an environment characterised by change.
Preparing Simulated/Standardized Patients For High Stakes Assessments: Strategies And Tools To Achieve Assessment Readiness

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Presenter Details. Cathy Smith, PhD, is a Lecturer in the Faculty of Medicine at the University of Toronto and the National Standardized Patient Training Consultant for the Pharmacy Examining Board of Canada. Debra Nestel, PhD, is Professor of Simulation Education in Healthcare at the School of Rural Health, Faculty of Medicine, Nursing and Health Sciences, Monash University, in Victoria, Australia.

Overview. Simulated/standardized patients (SPs) are the human exam question in high stakes assessments. SPs need to present the question, or patient portrayal, in a standardized manner to provide the opportunity for reliable assessment inferences, ensuring the defensibility of the assessment. In this workshop, we demonstrate scholarly and practical approaches to preparing SPs for high stakes assessments. We use Objective Structured Clinical Examinations (OSCEs) as the assessment context.

Expected Outcomes. After the workshop, participants will be able to:
1. Identify theories and principles relevant to standardized SP performance for high stakes OSCE purposes
2. Apply specific training strategies and tools to enhance standardization of SP performance
3. Reflect on applications in their own practice

Detailed Description. In this workshop, we present a systematic approach to ensuring assessment readiness of SPs, based on the concept of deliberate practice. Participants will work with tools that support standardization including a training protocol, a scenario training video, and an assessment readiness evaluation form. We provide a structured yet interactive flexible format in which to meet specific learning objectives, featuring discussions, training simulations using a ‘fish bowl’ approach and opportunities for individual reflection.

Evaluation. At the conclusion of the workshop, we will ask participants to complete a course evaluation. Questions asked will include: To what extent did you meet the learning objectives? To what extent were the educational methods (e.g. slides, discussion and practical activities) helpful in meeting the learning objectives? How satisfied were you with the facilitators? In addition, we will invite free text responses to questions: What aspects of the workshop worked well? Were there any aspects that could be improved? For longer term evaluation, we will ask participants to commit to a development in their practice relating to the workshop and email each other in 3-6 months to see if they implemented the development.

Timeline. Part 1 (15 minutes): Introductions and goal setting; workshop learning objectives and individual learning objectives outlined. Part 2 (15 minutes): Interactive discussion of key background concepts including a definition of standardization and its relevance to SP based high stakes assessment; the role of SPs in the process of standardization; challenges for SPs and trainers; current findings on standardization of SP performance and the application of the theory of deliberate practice. Part 3 (45 minutes): Strategies and tools for preparing SPs to ensure standardization of SP performance for high stakes assessments. Training tools such as a scenario training video and an assessment readiness evaluation form will be used in a small group discussion. A role-play exercise using a “fish-bowl” approach will elaborate on the video experience and provide everyone an opportunity to actively participate (from perspectives of SP and SP trainer). Part 4 (15 minutes). Summary of key messages of workshop, including linking of learning objectives linked to workshop activities; practical applications to own practice reflected on; future action plans reviewed; final opportunity for check-in and questions provided; course evaluation forms completed. Throughout the workshop, we will facilitate discussion, drawing on participants’ experiences, which will be revisited as we progress through the workshop.
SimHealth

Posters - Technology and Innovation

Intubation Impossible

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Aim. To outline a specific technique used to create a difficult airway (grade 4 view), to use in high-fidelity healthcare simulations.

Background. Delivering simulation in a high-fidelity mode has been well-validated as an educational tool in healthcare training. However, the ability to suspend disbelief and engage in simulation often still presents as a significant obstacle for individuals. This has been attributed to the mind-set that it is ‘not the real thing’ (DeCarlo, et. al., 2008:94). A number of authors make the reasonable assumption that simulation is likely to be most effective when individuals perceive it to be legitimate and authentic (Dinker and Singh, 2012; Hotchkiss, et. al., 2002). Developing and applying a difficult airway tourniquet, is one method of achieving an elevated level of realism in viewing a difficult airway in a SimMan 3G or essential manikin.

Materials and Methods.

1. To ensure that there are no attempts at intubation, make a tourniquet by combining a common clinical airway adjunct and Velcro strap.

2. Apply to the manikin to create the view of a grade 4 difficult airway.

3. Cut back the clinical airway adjunct to remove the flange and then slide it over the Velcro strap.

4. Mark out the placement of the first clinical airway adjunct so that when the strap is tightened, the rough end of the Velcro meets the smooth side.

5. Feed the Velcro strap behind the manikin’s neck, ensuring that the tubing from the fluid system is not crushed.

6. Use the two clinical airway adjuncts to help guide the tourniquet up and over the thyroid shroud. This will allow clear access to the carotid pulses and increase the resistance to the pharynx.

Evaluation of the Innovation. The difficult airway tourniquet has been incorporated into multiple immersive scenarios within the Clinical Skills Development Service. Simulation staff have observed that the immersive simulations were successful on each occasion. This has been primarily due to the tourniquet providing the appropriate clinical and physical cues which allowed participants to rapidly and accurately assess the patient’s condition and plan their care accordingly.

Lessons Learnt and Recommendations for use. An individual who is able to apply a difficult airway tourniquet can be expected to have a greater perception of realism within the simulated learning environment. As a result of this, they are more engaged and subsequently have a learning experience which aligns more with the planned objective. In this instance, two easily-sourced products were able to be creatively applied to achieve a realistic grade 4 difficult airway view.
References.


Tissued Drip

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Aims.

To develop an intravenous injection site that will simulate a tissued drip. The drip will allow fluids to run initially, then slow and stop as the tissuing occurs. Some visible swelling will be seen at this time. The system will allow participants to inject fluids and drugs, e.g. Propofol, which will then show more swelling and increase the resistance to injection.

Background.

Several scenarios require that a tissued drip be in situ. The usual method presents as a drip that is not running. Participants will then ‘pretend’ that fluids are running and drugs are being injected. To prevent this, a running drip is preferred that will then stop as fluid or drugs are infused.

Method.

A Pneumothorax bladder is attached to a drip setup. The outside appearance looks like a normal functioning drip. Under the surface of the ‘skin’ the intravenous cannula is connected to a Pneumothorax bladder rather than the usual drain tube.

Evaluation.

Initial trials have worked well, with the desired effect being achieved. The system is easy to clean with repeated flushing with water. Some of the areas that need improvement are the size and shape of the swelling. A smaller round bladder is currently being investigated to achieve this. Also, a one way valve needs to be installed to prevent flow back into the IV when the pressure becomes too high. A more difficult objective would be to create a ‘blanching’ effect on the skin.

References.

This method is has been found to support the increase in fidelity in scenarios that require a tissued drip. Adding a similar device to a cannulation course could also be of benefit for teaching correct protocols for care of tissued drips. Further development will add more realism and provide a greater level of fidelity.
A Program Of Integrated Problem Based Learning And Simulation

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Aim of the education program.
The aims of this program are to enhance problem based learning (PBL) by making cases more real to students, to develop their PBL from the experiential learning of simulation and to enhance simulation scenarios with the multifaceted details of PBL.

Simulation and PBL in the Bachelor of Nursing (BN) program were implemented independently to teach different aspects of the 3rd year. Simulation was used to integrate discrete clinical skills into clinical practice, for example students practiced caring for a patient receiving intermittent positive pressure ventilation. While, in PBL they learnt about intensive care nursing through a head injured person case. The two teaching strategies had similar content but were not connected. The intention of a combined PBL-simulation program is to reinforce connections between these teaching methods.

Methods adopted.
Within the school of nursing PBL is a method in which students create their own learning objectives from a scenario that is presented to them (1). A scenario is presented over several weeks, with more details being presented as the case unfolds. This process requires our students to construct their own knowledge (Gijselaers1996).

Simulation in the BN program is experiential learning that promotes clinical competence (2, 3). The objective is to replace or develop clinical events with situations that engross participants in an interactive experience (4). The integration of simulation with PBL occurred by using the PBL cases to create simulations. Each simulation was constructed to emphasise particular clinical components of the PBL scenario, the objectives of the simulation matched particular PBL objectives. There were three cases: A Peri-operative Case, an Intensive care case and a Paediatric case.

After the students had completed all 11 PBL tutorials and 11 simulations they were surveyed about their experiences and beliefs using 14 Likert scale statements and 4 open-ended free text questions. As the survey was not the usual student evaluation of learning and teaching (SELT), ethical approval from the University of Adelaide human research ethics committee (HREC) was obtained. A student distributed and collected the completed forms. Responses were anonymous. All students attending the clinical skills simulation class in week one of semester two (n=59) completed the survey, 14 students were absent from this class.

Evaluation data from the program.
Students supported integrated PBL - simulation with 95% of participants agreeing or strongly agreeing with the following statements:
- Overall I feel that combining PBL and clinical skill simulation classes assisted me to develop competence as a year 3 student nurse.
- I believe that the combination of PBL and clinical skills simulation classes enabled me to learn more than I would have by just undertaking PBL on its own.”

They also wrote that:
‘Yes definitely combining PBL and clinical skills classes really enabled me to practice skills and relate all the information from PBL during skills session.
‘Not only are we reading, talking and writing about different cases and practical skills, being able to do them and practice puts everything into perspective and when I see patients on the ward I think back to what I physically did or discussed not what I read or wrote.’
Conclusions and recommendations for future use and development.
For students the combination and integration of PBL with simulation improves their experience and enhances their learning. This integrated approach needs to be developed across all years of the program and is recommended for other programs that use PBL. Development should see the creation of PBL scenarios and simulation occurring together. This program needs to be measured for its effectiveness.

References.
Using Simulation To Evaluate Clinical Skills As Part Of The Recruitment Process In Speech Pathology

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Background: Recent expansion in the number of Speech Pathology graduates has resulted in a significant increase in applicants applying for the annual new graduate position at Central Coast Local Health District (CCLHD). Applications are difficult to cull as there is little difference in the qualifications and experience of each applicant. Standard face-to-face interviewing of multiple applicants can be time intensive and costly. This approach is also ineffective in determining an applicant’s clinical capabilities as it typically only assesses knowledge base and the verbal fluency of an applicant.

Using simulation technology has the potential to reduce the time required to assess clinical skills with the view to employment. Simulated Learning Environments (SLE) or Objective Structured Clinical Examinations (OSCE) are an effective and reliable method of assessing clinical competence across key learning areas (1,2). No previous allied health study has investigated the value of utilising simulation technology in the recruitment process. This project aimed to explore whether the use of simulation could be used as an adjunct to traditional interviewing, thus enabling the assessment of clinical skills in a large number of applicants in a time efficient manner.

Materials and Methods: Thoroughly planned simulated scenarios were incorporated into the interviewing process. This involved the use of the simulation laboratory and standardised patients to replicate clinical Speech Pathology scenarios. Applicants assessed the patient, whilst interviewers observed and evaluated their practical skills (including discussion with a doctor or carer and written reporting). Applicants then participated in a brief face-to-face behavioural interview. Weighted scoring criteria for each interview component was utilised to ensure that the objectives of the assessment were clear and inter-rater reliability was high (4,5,6).

Interviewees completed a feedback form (5 point Likert scale) regarding the interview process and the incorporation of simulation. Interviewers also provided feedback on the process. Additionally, time spent by interviewers involved in the process was recorded and a cost analysis conducted.

Evaluation of the Innovation: Qualitative data from interviewee feedback indicated that 12/15 applicants felt the process enabled them to demonstrate their skills and knowledge, was less intimidating than traditional interviews and that their preference would be this style of interview in the future.

The simulation process also proved more cost effective and time efficient ($2294.20 for six interviewers for 7 hours of interviewing) compared to ($2527.92 for three interviewers for 16 hours of interviewing) than the traditional face-to-face interview process.

Anecdotal evidence regarding the competence shown during their subsequent employment and referee reports suggested that the clinical skills demonstrated by the chosen applicants in the simulated environment correlated with their actual skills.

Lessons Learnt and Recommendations for Use: Assessing clinical skills in simulated clinical scenarios has proven to be an effective adjunct to the conventional interview format for interviewing Speech Pathology graduates at CCLHD. It has enabled the panel to evaluate a range of clinical skills in a large number of applicants in an identical simulated scenario. Preliminary analysis of qualitative feedback and cost effectiveness has shown that the use of simulation yields benefits for both the employer and the applicants.

Using simulation in the recruitment process presented challenges such as the need for the simulated scenario to be identically replicated for each applicant which can be difficult when using actor-based simulation as the scenario is inherently dynamic. Ensuring the scenario is extremely well planned and has clear objectives so that all assessors are aware of what skills are being targeted is also essential.
The use of simulation in selecting the most appropriate candidate during recruitment has been successful in the Speech Pathology setting at CCLHD. Wider piloting of the recruitment model will be required across multiple disciplines to further validate its efficacy.

References.


Recruitment And Management Of Volunteers In Simulation

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Aims.

- Address issues related to the use of volunteers in simulation
- Disseminate information about initiatives developed to enhance recruitment and organisational management of volunteers in simulation

Background.

Simulated patients, also known as patient actors are used to enhance fidelity and the quality of simulation learning experiences. Actors are particularly useful in complex communication scenarios that require students to draw on attributes of emotional and social intelligence. A considerable amount of organisation on the part of faculty is required to prepare volunteers for simulated patient roles and organise their participation. This presentation addresses challenges associated with engagement of the public in simulation activity. It reports an interdisciplinary initiative involving the extension of an education program designed to train drama students for simulated patient roles in health care simulations for Nursing and Midwifery to include members of the general public.

Materials and Methods.

A suite of recruitment documents including: advertising materials, application and consent forms were developed to manage recruitment process, address health and safety requirements and associated legal issues related to engaging the public in simulation. Information gathered from prospective volunteers was entered into a data base specifically designed to cater with the requirements of managing large numbers of volunteers in simulation across a number of disciplines.

Evaluation of the Innovation.

Key issues requiring consideration when using volunteers will be addressed. This will include the development of a simulated patient management data base used to facilitate administrative functions associated with recruitment and the day to day management of volunteers participating in simulation. Factors influencing the success of the programme and the implementation of the data base will be highlighted including lessons learnt and recommendations for use.

Lessons Learnt and Recommendations for Use.

This presentation will be of interest to academics and technical support staff who wish to develop simulated patient programs to augment simulation activity and who seek to streamline organisational tasks surrounding recruitment and preparation of actors. While established for Nursing and Midwifery the information provided in this presentation is transferable to other disciplines.
A Standardized Approach To The Evaluation Of Simulation Equipment

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Background. This paper presents an evaluation process and set of tools that can be used to determine the suitability, functionality and sustainability of simulation products. The tools are designed to give rigor and rationale to the evaluation process. With a standardised process simulation products can be purchased that suit the learner's needs, meet course requirements, are easy to use, sustainable and cost effective. With the data obtained cost-benefit and cost-effectiveness analysis can lead to informed decision making pertaining to the choice of simulation products by simulation providers, business managers and other executives.

Materials and Methods. A set of evaluation tools was produced that covers key aspects of a simulation product. Consideration was given to all products that a simulation provider may encounter. These include products such as software, part task trainers and full body manikins. The process was developed in collaboration with subject matter experts and product manufacturer's specifications for the equipment. The evaluation takes into consideration the functionality, 'realism', general features, maintenance and repair, and cost.

Specialty groups were then invited to evaluate a product, using the tools that had been developed. A diverse team of interested parties from as many specialties, experience, and backgrounds are invited e.g. technicians, nurses, doctors etc.

The data is then manually entered into a spreadsheet, tabulating the data in such a way as to give immediate feedback to the reviewer.

From this document, reports are generated that stakeholders can peruse to assist in the procurement decision-making.

Evaluation of the Innovation. Provides instant visual feedback on evaluators response

Reports are able to be produced more easily that can be used to present reasons for and against the purchase of a particular product.

Availability of evaluators can be problematic

Availability of review equipment few extended periods can be problematic

Time consuming to produce the document and enter data.

Requires database program to manage and analyse the data.

Lessons Learnt and Recommendations for Use. This enables a comprehensive and thorough peer evaluation of equipment

A uniform assessment is achieved as all participants involved in the process are evaluating using the same criteria, ie suitability, functionality and sustainability etc.

It is recommended that all new equipment be evaluated using a systematic approach such as this.

References.
1. http://www.uwex.edu/ces/tobaccoeval/pdf/MethodsTable.pdf
Coaching and Checklists - A Model For Real Case, Low Resource Simulation Team Training

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Dr Stuart Dilley, Emergency Physician and Simulation Education Instructor;
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Presenter Details.

Neil is an Emergency Physician and simulation education instructor. He is active in the field of junior doctor education and supervision, working as the Pre-vocational Training Supervisor at St Vincent's. An expert in simulation and debriefing, Neil's focus is on teaching technical and non-technical skills to emergency consultants, trainees, and nursing staff. He is involved in instructor training and teaching for the ACME (Advanced and Complex Medical Emergencies) course for the Australasian College for Emergency Medicine (ACEM), and the TIPS course (Training in Professional Standards for the Royal Australian College of Surgeons).

Overview.

Multi-disciplinary team training is beneficial to the development of efficient, highly functioning teams but scheduling multi-disciplinary teaching sessions can be a challenge. The use of standardised team structures and checklists allows a consistent team approach to complex scenarios. Using this as a basis, participant’s recent real-life difficult scenarios can be quickly transformed into “second run” simulated scenarios. This gives them the opportunity to lead a team in a highly relevant complex scenario, with an expert questioning and challenging at defined stages.

Expected Outcomes.

This workshop uses the example of low resource simulation scenarios and the embedding of airway checklists into practice for Emergency Medicine trainees. It is designed to show you how to get the most out of your training sessions, and how to make meaningful changes to clinical practice in your departments.

Timeline. 90 minutes.
SimHealth

Works in Progress

Does Authenticity In Moulage Matter? Exploring Participant Engagement In Simulation

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Research Question.

Simulation provides the opportunity for learners to deliberately practice skills, gaining experience in a realistic environment. It is impacted by the learners prior knowledge (constructivism); perception of the activity is impacted by personal and peer knowledge. Beyond perception, the learners interaction with the environment is influenced by pre-conceived thoughts and expectations. The success of simulation is dependent upon the degree of participant engagement and successful debrief strategies. Participant engagement is enhanced by fidelity, realism, authenticity and the presence of ‘cues’ in the simulation setting – such as moulage techniques. Moulage in medical teaching originated in the late 17th century with the use of wax replicas. Currently moulage is used to describe techniques in simulation used to add reality to the environment; it is presumed that moulage adds fidelity, realism and authenticity to simulation. Literature on moulage focuses on techniques and some practical application. There appear to be gaps in literature on the rationale for use in simulation and degree of authenticity required to create a meaningful learning experience.

Research in film/media discusses authenticity, proposing complete authenticity is not required; only first impressions contribute to engagement of the viewer. Other research suggests that no similarity at all is required to establish a relationship of resemblance; whilst others disagree stating that each generation expects a higher level of realism than the previous. In context of learning, authors identify that emotional impact of the experience is directly related to engagement, which is linked to learning. With these concepts in mind, one would then hypothesise that just as the apparent reality of artistic media directly impacts engagement, the apparent reality of moulage is vital to the engagement of learners in simulation.

Simulation literature on moulage and the degree of authenticity required is minimal. To assess the extent of impact moulage has on participant engagement, a theoretical classification of authenticity in moulage must be developed.

Methodology (proposed).

Develop a theoretical system of classification in moulage to depict or reflect authenticity

A systematic review will be undertaken to attempt to analyse empirical evidence on the use of moulage. Outcomes of this review will guide development of the qualitative survey to develop a classification system of moulage. The outcomes of the literature review will guide the development of the qualitative survey to develop a system of classification of moulage. Using Rules’ Framework of Authenticity (2006), I will hold individual interviews with a purposeful sample of simulation experts (including clinicians and educators). Interviews will be recorded and participants will receive verbatim copies of the interviews to verify their comments (member-‐check). Independent coders will use a thematic analysis approach to code and arrange the primary data. A draft model of the classification system will be circulated to all participants for validation.

Analysis (proposed).

The fit of this theoretical model will be verified in a series of trials, whereby moulage items with a range of authentic and inauthentic features will be rated for authenticity by simulation experts, clinicians and students.

Results.

Systematic Review – Pending
Authenticity Rating Tool Draft – pending.
Questions for the Audience.

As key stakeholders in the simulation industry, I am seeking validation of the draft classification system.
1. As a moulage user, are the areas addressed in the rating tool relevant?
2. Is the tool user-friendly?
3. In your opinion, will it provide a realistic rating of authenticity?

References.


Is Simulation A Viable Alternative To Placement For Students Studying A Certificate IV In Mental Health?

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Research Question.

Is simulation a viable alternative to placement for students studying a certificate IV in Mental Health?

Background

Finding high quality Mental Health placements for Victorian students is becoming a difficult task, (Cleary & Happell, 2005). This is complicated by changes in government funding to Mental Health services and the resultant recent restructuring required within the field, (Department of Health, 2014). To compound this, increasing competition for these placements from the ever increasing numbers of private providers entering the educational domain, safety concerns for both students and clients, disparities in learning experiences from one placement to another and restrictions on student experiences due to confidentiality necessitates that the industry look for ways to replace placement (Aled, 2007; Massias & Shimer, 2007). The answer to this may be found in the simulated learning environments that the health industry is embracing at an unprecedented pace (Health Workforce Australia, 2010).

June 2013 saw fifty first and second year Swinburne University undergraduate psychology students undertake studies in a certificate IV in Mental Health. Despite vigorous efforts from students and the placement team at Swinburne, quality mental health placements for the undergraduate psychology students were unable to be secured. The aim of this study is to establish if simulation is a viable option in replacing mental health clinical placement hours with the result being to enable these students to gain their vocational qualification.

Methodology (proposed).

The program’s theoretical content was delivered intensively for six weeks the online activities and placement component was to be completed by the end of the year.

By the beginning of 2014, with students unable to gain their qualification, a placement alternative was established. The solution saw the development of an intensive three day simulation experience, designed to allow the students to be assessed on the required skills for their vocational learning.

Twenty-five students elected to attend this program at Swinburne’s Wantirna Campus. It incorporated two days of simulated experiences and one day of assessment.

Standardized patients were utilized in the program, two mental health teachers facilitated the simulation and three invigilators the assessment. The learning outcomes established

• Perform an assessment of the patients’ mental state

• Determine risks and establish recovery goals.

• Develop communication skills,

• Establish therapeutic rapport,

• Demonstrate sensitivity, compassion and empathy,

• Establish interviewing techniques

• Formulate questions in language that was meaningful to the patients.

• De-escalate a potentially explosive situation utilizing communication skills.
The standardized patients portrayed the mental illness symptomology of schizophrenia, bipolar affective disorder, depression and borderline personality disorder, demonstrating thirteen different presentations in all. Peers, standardized patients’ and facilitators’ provided feedback after each simulation and each day ended with a facilitated debrief utilizing a combination of GAS, Plus Delta and Advocacy-Inquiry debriefing techniques.

Analysis (proposed).

Twenty-one students completed an evaluation of the simulation experience under the following headings: the ability to create clinical reasoning and critical thinking; fidelity, variety of learning experiences; interaction with peers, feedback and confidence. Student evaluations overwhelmingly supported the use of the program.

Results.

The simulation program was seen by the students as a viable alternative to placement and they reported gains in confidence, clinical skills, critical thinking and clinical reasoning. All but one student were successfully able to obtain the vocational qualification and meet the requirements of the training package.

Questions for the Audience.

What percentage of placement should be replaced by simulation?

What would be the best evaluation tool to assess the outcomes of simulation?

How many hours of high fidelity simulation equates to how many placement hours?

Can simulation totally replace placement?

Any other similar studies?

References.


Using Simulation To Facilitate IPL And Teamwork

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Background.

Development of effective teams in health care is critical to achieving care that is patient centred, safer and efficient. Most would agree that effective communication, respect, shared understanding of roles and responsibilities optimise team function and are necessary for effective functioning of interdisciplinary teams. While the notion that disciplines work together, the education of the health care workforce often happens in isolation of other disciplines and students have little opportunity to learn teamwork and there is little literature available about how IPL outcomes can be achieved. This presentation reports a partnership initiative between a University of XXX and XXX Health which resulted in the development of an interdisciplinary model for simulation that brings students from different disciplines together, and which is designed to facilitate a better understanding of roles and provide students with strategies to work effectively together as graduates.

Methods.

Subsequent to ethics approval a sample of fourth year Medical, third year Bachelor of Nursing Science and Physiotherapy students (n = 20) were recruited to participate in a pilot study that utilised a series of simulations based on the National Safety Standards as a catalyst to explore factors influencing interdisciplinary teamwork, and evaluate a professional education initiative designed to accommodate the learning needs of an interdisciplinary team. A mixed method approach utilising a survey and focus group interviews were employed to gather data. The Satisfaction with Simulation Experience Scale (SSES) (Levett-Jones, et al., 2011) 24 item questionnaire using a 5 point Likert scale was used to gather participant perceptions about the simulation learning process. Focus groups interviews provided more in-depth accounts of experience. Data were analysed using SPSS Statistics for windows and a content analysis.

Results.

At the time of submission of this abstract the IPL project was in process. Results of the pilot study including student perceptions, satisfaction scores will be reported.

Discussion.

An overview of the initiative including simulation design for IPL will be presented. Implementation process and key issues impacting on the success of IPL simulation, lessons learnt, recommendations and plans for expansion of the research will be reported.

Conclusion.

This presentation will be of interest to academics and clinical staff who wish to develop simulation scenarios for interdisciplinary teams. While established for Medicine, Nursing and Physiotherapy information provided regarding the framework used in the simulation in this research is transferable to other disciplines.
Synthetic Training – Providing Operational and Commercial Value in Equal Measure

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Abstract. The challenge was to prepare a new generation of submariners to crew a new class of submarine. The shore training environment needed to be as vibrant and modern as possible whilst maintaining the traditions of the service and imbuing the students with naval and submarine ethos in preparation for their time in the service. Although the trainees would have limited or no access to a submarine due to essential operational commitments, the training must still equip them with the requisite skills and knowledge to be able to continue their submarine training at sea during the “wet” phase in a safe and competent manner. Could the use of multimedia, in a truly blended learning sense, provide the cost effective throughput of trained personnel to achieve operational capability?

1. INTRODUCTION

Can a synthetic training solution using a range of media provide measurable benefits in terms of the learning outcomes and cost savings that it delivers and what issues need to be overcome to successfully deploy that solution? How can this be effectively deployed and be learner centric in a training environment that is largely based on a didactic approach?

Our discussion will be based on experiences from Astute Class Submarine Qualification (SMQ) training where a synthetic training solution was developed using a combination of media including a full 3D-Walkthrough of the whole submarine. This approach, where access to the submarine was not assumed, was a first for the Royal Navy and has generated lessons learned which can be applied to new submarine programmes.

We recognise that you cannot completely replace real experience but we have identified some interesting benefits during our experience of developing and delivering this training course.

2. THE OPERATIONAL AND BUDGETARY CHALLENGE

With the increased national and global economic constraints being imposed on budgets, governments are coming under pressure to deliver increased capability whilst reducing their costs. Many submarine operating organisations face similar issues around platform availability for operations which in turn impacts on ability to support training activities in port and at sea.

The Royal Navy highlight the fact that operational demands coupled with challenging Force Generation Cycles place a premium on every sea-going berth. This exacerbates the issues they face in the sustainment of Suitably Qualified and Experienced Personnel (SQEP) to meet current commitments. It has therefore been deemed imperative that wherever practicable, the sea-based training burden is minimised.

Yet the global security threat remains ever changing and the operational tempo high. Additionally, in this safety critical environment there is no room for shortcuts. Poor delivery or mistakes can be costly. Therefore the submarine community needs training which is both effective whilst agile enough to respond to emergent operational demands.

3. SYNTHETIC TRAINING – WHAT IS IT?

The authors are not academics but aim to offer practical insight based on experiences. Our view is synthetic training is quite simply the ability to reproduce real life working environments and situations that allow the trainee to learn without having to be in-situ.

4. TRAINING SOLUTION DEVELOPMENT

The task set was to deliver a submarine qualifying course that would have to be sufficiently effective to allow us to be confident of achieving the contracted 100% pass rate requirement whilst acknowledging that there would be no or limited access to a submarine.

To deliver this output, the course would have to effectively impart a significant volume of information over a ten week period whilst capturing the imagination of the trainee and ensuring significant levels of knowledge retention.

To make this happen, a wide-range of multi-media training resources were developed to complement a didactic approach to training delivery. The classroom sessions were brought alive by high quality and interactive flash animations, video and 3D-Walkthrough.

Strong team work between the training design / delivery organisation and the media provider was key to project success by ensuring alignment of the synthetic training to the training needs. This was done by working within an analytical framework that allowed methods and media analysis to happen alongside the training design ensuring that the media was appropriate to the Training Needs Analysis (TNA).

 Appropriateness is a key word – with modern digital media there are almost no limitations to what you can achieve and the realism with which this can be done, but it needs to be appropriate to the needs of the learner and the training. To be immersive it doesn’t need to be
something that you go and sit in. This was by far the most difficult part of the project but is the most important.

Another consideration was the culture change that had to be considered when implementing synthetic training such as this, moving away from traditional chalk and talk to a more blended solution. The first stage was the classroom set-up - dual screen and ‘Xbox’ controller for the trainees, interactive whiteboards and multiple screens for the trainer. When both the trainer and trainee enter the classroom for the first time they are immediately aware that they are entering a different training environment.

The media developers then worked very closely with the trainers to ensure that they were comfortable with the solution that was provided. Again it could be the most brilliant piece of media but if it is not designed appropriately to the trainers’ needs it will not be used effectively. A significant amount of time was invested in ensuring that it met their needs as well as those of the trainee.

5. TRAINING DELIVERY

The course is delivered with an approximate balance of 60% ‘chalk and talk’ and 40% multimedia. A variety of media and training aids are utilised throughout this course including: video clips, PowerPoint, 3D-Walkthrough, Computer Generated Imagery (CGI), Part Task Trainers, weapon handling and loading rigs, and both static and full motion simulators.

As part of the course the trainees spend time in the simulators within the Training Facility which allows the trainees to consolidate some of the theory they have been taught thus far. The timing of these visits to Astute Trainers is dependent upon the training load of the simulators, however, trainees’ comments have highlighted these ‘hands-on’ visits as extremely beneficial in helping them understand the complexities of systems and how it all fits together. Every attempt is made to ensure that the visits are tailored towards the particular specialisation of the trainee to maximise the realised benefits.

The basis for the provision of a 3D-Walkthrough for Astute Class SMQ has always been predicated on there being no platform availability and so the course is taught to Training Performance Statement (TPS) without dedicated platform time. That said, every attempt is made to visit the platform should it be available. The 3-D model itself is utilised in various guises: initially as an instructor-led layout familiarisation in week 1, progressing onto specific equipment layouts for system tracing, followed by scenario training (e.g. fire in ship’s office), and finally at the end of the course a 3D-Walkthrough assessment. Since simulations are optimised for learning, the scenario training allows the trainees to repeatedly practice their drills, honing their responses, within a risk-free environment.

The modes developed are all linked to the training need so that the walkthrough is used throughout the whole spectrum of the course. Such is the accuracy of the model that the 3D-Walkthrough is also used as the media for final assessment of the trainees.

6. OUTCOMES

The Royal Navy have stated that “the use of the multimedia approach during shore training, in particular the 3D-Walkthrough, reduces the time trainees require to familiarise themselves with the layout of the submarine and key equipment onboard, compared to previous training methodologies used on other classes of submarine”. Reference (FOST TC SM, Applying Best Practice From Astute-Class SMQ Training, 27th January 2012).

They also flagged that a major advantage of synthetic training is the ability to: interrupt, improve and repeat procedures, until the required proficiency has been achieved within an environment that such actions have no detrimental effect upon the trainee or to the actual platform.

Additionally trainees praised the use of the delivery methodology. The key benefit with regards to output was the way that the 3D-Walkthrough provided critical contextualisation to learning in the classroom. This led to more consistent trainee performance in assessment compared to similar courses using a different delivery methodology.

To date, 10 courses have been run and so clearly it is early days in statistical terms. However, with a 100% pass rate, the successes cannot be ignored. In terms of feedback, 92% of the trainees have described the training very positively; external audits have been very complimentary regarding the learning environment; the Royal Navy have reported circa 50% reduction in OJT which can be turned into tangible operational benefit.

The training solution as developed has sustainability designed in as it is not dependent on platform access.

7. THOUGHTS AND LESSONS

Whilst it is clear that synthetic training will never replicate first-hand operational experience, advancements in the serious games industry have presented opportunities to re-examine the virtual–live balance for some training.

From a personal perspective the lessons learnt for any project such as this are:

- Don’t let the tail wag the dog; Training must lead the media, not the other way round. By aligning with the TNA the media can be appropriate in scale, fidelity and functionality.
- Achieve buy-in; in order for the synthetic solution to work not only must the learner be at the heart of the process (so access must be a priority) but the trainers and end customer must also buy in.
- Have clear requirements and objectives; you can do almost anything with digital media these days - it doesn’t mean that you have to.

But hopefully we have shown that if created effectively:
- It is highly sustainable.
- It minimises the need to use multi-million pound training environments such as a ship, rig or a boat.
- It can be used for delivery and consolidation and most importantly assessment.

The clear benefit of this immersive training is that it is not dependent on service assets whilst still ensuring that high levels of training performance standard are consistently achieved, which by definition will reduce the transition time to becoming fully operational. In short, immersive synthetic training is:
- Effective
- Efficient
- Engaging

8. HUMAN FACTORS

As well as training the individuals within a team to perform their duties, for a submarine crew to work effectively together they need to be trained as a team. To achieve this on the Astute Class, behavioral markers were identified in the soft skills areas of leadership and management, situational awareness, decision making, co-operation and effective communications. Team behavioral markers were then used to focus on the cognitive and interpersonal skills essential for working effectively in a team. This method of team training draws on the experiences of Crew Resource Management (CRM) and Threat and Error Management (TEM) training in the airline industry and other sectors where human error can have devastating effects. Using CRM and TEM behavioral markers across the synthetic environments has allowed the Astute Ship Control Team to successfully identify threats, communicate these and use all the available information, equipment and personnel to maintain safe and efficient submarine operation. At the end of the training period, each Ship Control Team is better integrated and functions as a cohesive team.

9. THE FUTURE

During a period when there was little or no Trafalgar and Vanguard Class platform availability, the Royal Navy found that courses of trainees who had performed well in class, and had excellent written exam results, conversely had very poor oral boards. This being not isolated to an individual trainee, and being consistent across 2 separate units, supports the notion that the trainees may have suffered from a lack of contextualisation from the classroom theory; something that platform time during the training course provides. This is further supported through evidence of trainees struggling with the classroom theory elements, however when given platform time, have been able to grasp the subjects taught and subsequently successfully complete the course. A recent independent report highlighted this issue commenting that the equivalent Astute Class training was less affected owing to the high quality of the simulation and learning technologies utilised.

Thus, accepting that platform availability directly affects SMQ training as a whole, the Royal Navy is now implementing the blended synthetic approach taken on Astute Training for legacy Trafalgar and Vanguard Class Training. From discussions in Australia we know that implementing more synthetic solutions into training is under consideration.

By its nature SMQ training engenders ethos and understanding in addition to the more procedural style of training; thus it incorporates knowledge, skills, and attitudinal training. Within the Astute Class Training Service the Royal Navy expects industry to innovate throughout the service period. To enable this and stay in the forefront of technology based training a comprehensive training media strategy has been developed. The strategy looks at developing and immersing technologies over the 2015 to 2040 timeline and their progressive introduction with each stage enabling later developments. This agile approach ensures that our customer receives the latest technologies and training techniques in a timely fashion.

There is a wider shift in the landscape of education with a refocus on technology and its implementation in the classroom. Consequently students are being encouraged, by these technological advancements to take a more active role in their own education. This will be increasingly so within the 2015 to 2040 timeline because of how these new educational technologies are used in everyday modern daily-life.

By making better use of and developing the existing training systems to create an ‘enhanced shore training’ capability there is an opportunity to bring about a reduction of the at-sea burden. The tasks will be achievable ashore using a combination of:
- Astute SMQ(D) courseware and media (including but not limited to the 3D-Walkthrough).
- Astute Ship Control Simulator.
- Astute Manoeuvring Room Simulator.
- Astute Weapon Handling and Loading Trainer.

The creation of an ‘enhanced shore training’ capability allows trainees to repeat complex and safety critical tasks, procedures, and activities in safe classroom environments ashore. Synthetic environments are especially suited for training situations which are impractical, difficult, dangerous or expensive to reproduce in a live environment. These environments also form part of the approach to the delivery of Human Factors training in the form of CRM and TEM.
There are many potentially dangerous situations that trainees may only encounter infrequently, if at all. Nonetheless, when these situations are encountered they need to be dealt with efficiently to avoid serious consequences. These environments can be used to present trainees with such unusual scenarios in a repeatable and controllable fashion.

The current plan to introduce gamification capability and future technology enablers into the current Astute Class 3D-Walkthrough clearly demonstrate the full benefit of synthetic and virtual environments. This, together with greater use of the shore training environment and other synthetic training will reduce the period for at-sea qualification and increase the throughput of trainees. From the initial analysis carried, the at-sea training burden could be reduced by a further 80%. third section

10. SUMMARY

The submariner must be educated as well as trained. The 3D-Walkthrough is an excellent tool, but it is not a training solution. Unlike other virtual reality simulations where attaining a skill is the goal, the 3D-Walkthrough assists the trainee in developing the behaviours and self-confidence to become a safe submariner, and a military asset in the complex and hostile operating environment of the submarine.

We have only scratched the surface and there is an envelope which needs to be pushed. The art of the possible needs to be explored in the search for new training solutions that are both future-proof and agile enough to respond to emergent operational requirements.

The next evolution for submarine training needs to transition the benefits achieved on Astute Class training into other submarine classes and include TEM within CRM in the complex team environments of today’s modern submarine. With multiple team environments, each with their own operational and engineering complexities, a significant reduction in at-sea training will only be achieved through a holistic approach to training. Maximising training credits from the complete range of synthetic devices available will be key to achieving positive results in the recommended enhanced shore training pilot or proof-of-concept on Astute Class and the desired reduction in at-sea training.

Virtual training is being developed for operational, maintenance and military team training in the areas of bridge watch keeping, submarine ship control, diesel engine operation and maintenance, and on board electrical and mechanical equipment fault diagnosis and repair. Recognising that well designed and developed virtual training improves operational availability, compresses trainee throughput, improves training contact time and counteracts skill fade, the migration from traditional media is becoming culturally acceptable and a financially necessary.

We need to provide training that can balance effectiveness and cost. A solution that is created once but reused many times, in the classroom, through virtual learning environments and mobile devices is the aim, providing better Return On Investment (ROI) and learning outcomes. Simulated training is interesting and stimulating and encourages learning and retention which is particularly relevant for a 10 week course with a wide range of abilities.

The clear operational benefit from our efforts is a form of immersive Submarine Qualification training with no impact on service asset availability, that maintains high standards and pass rates, allows emergency procedures to be practiced in the safety of the classroom and also reduces the sea qualification time.
A Case Study of Construction Equipment Training: From the Simulator to the Real-World

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Abstract. Simulation is being used to support construction equipment training in the civil construction industry. It is widely believed that this training is effective but there have been no published studies, to our knowledge, comparing simulator training and real-world performance on construction equipment. Consequently, research is still needed to validate the efficacy of simulator training for construction equipment. This paper addresses this gap and reports a case study into the use of simulation for construction equipment training. Seven members from the Australian Army School of Military Engineering took part in the study and undertook simulation training prior to completing a 16-week construction plant course. Simulator training was conducted over three days and delivered by a commercial training provider. Participants completed a range of scenarios on excavator, loader, and dozer simulators, and performance feedback was provided by instructors and the simulator software. Surveys and focus groups were used to elicit participants’ perceptions of the simulator training. Participants then undertook live training the following week on the same three platforms. Results showed that (1) participants were generally positive about their experience of simulator training but also highlighted areas for improvement, and (2) participants’ performance in the simulator was consistent with their real-world performance on several key measures, suggesting that the simulator data was a valid measure of subsequent performance. Specifically, results showed that simulator scenario completion times, time spent using multiple functions, and number of errors were consistent with participants’ real-world performance. The findings are discussed in relation to previous research and best-practice training principles. Implications of the findings for the simulation community are presented and potential areas for future work are outlined.

1. INTRODUCTION

Simulation is being used to support training in a variety of industries, including aviation, business, defence, education, health, medical, mining, and transport (Salas et al, 2009). The investment in simulation is primarily driven by economic and safety considerations and the ability to provide unique training experiences not possible using traditional instruction methods.

One area where simulation is being used to provide training is the civil construction industry. Many commercial training providers are using simulators to train personnel in the use of construction equipment such as dozers, excavators and loaders. The main drivers for this training are the ability to provide realistic training experiences in a safe environment, to accelerate skill acquisition and competency levels, and to reduce live training costs (Dunston et al, 2014). It is widely believed that this simulator training is effective but there is a lack of research evaluating the efficacy of simulator training in the construction industry.

In the following sections, we provide an overview of construction equipment operations and operator skill requirements, followed by a summary of research into the use of simulation for construction equipment training. We then present the results of a case study examining the use of simulation for construction equipment training.

6 Simulation is also being used to screen the suitability of applicants to operate heavy machinery in the mining industry.

1.1 Construction equipment operations

Construction equipment is commonly used to perform earthmoving operations in the civil construction, defence, and mining industries. There are various types of construction equipment but we focus on those involved in dozing, loading, and excavation operations. Dozing operations generally involve using a bulldozer to excavate and push soil over short distances while reshaping the ground surface to a specified level. Loading operations typically involve using a front end loader to scoop material and transport it to a stockpile, such as the bed of a dump truck. Excavation operations involve using an excavator or backhoe to dig soil (trenching) from its native location and place it to the side or into the bed of a dump truck. Other commonly used equipment in the construction industry are graders and skid steers.

1.2 Operator skill and proficiency

Typically operators must become proficient at operating several machine types, including excavators, loaders, and dozers, and be able to switch between them (Dunston et al, 2014). Operation of construction equipment involves tasks such as cutting, moving and processing material using the machine’s implements. These tasks place several demands on the cognitive and motor skills of the operator.

The main skills required are coordinated and smooth operation of the moving parts, while driving and navigating the equipment, in a safe manner. According to Dunston et al (2014) operator skill is reflected in
terms of productivity (units of material transported per unit of time) with effective energy consumption (amount of fuel consumed) while operating safely (proper care of the equipment and other nearby equipment and workers). However, these are considered to be gross measures of skill, and it is the efficient handling of the machine’s implements that are the true mark of a skilled operator. Others have noted that operator proficiency is affected by personal disposition, years of work experience, and operator reliability (Cabahug et al, 2004), and essential skills include: common sense, experience, smoothness of operation, and good work ethic/attitude (Bhalerao, 2007; cited in Dunston et al, 2014).

1.3 Previous research on simulation-based training for construction equipment

To date, there has been limited research into simulation training for construction equipment (Dunston, et al, 2014). Research has examined differences between novice and expert operators (Bernold, 2007), simulator fidelity (Bhalerao, 2009; Hildreth & Stec, 2009), operator performance measures (Dunston et al, 2014), training principles (Dunston et al, 2010), skill retention (So, Proctor, Dunstan, & Wang, 2013), and skill transfer from one simulator platform to another (So, Proctor, & Dunston, 2014). While these studies have enhanced our understanding of operator characteristics and simulation training requirements, there have been no published studies, to our knowledge, comparing operator performance on simulated and real-world construction equipment. Such data would provide evidence of the validity of simulator performance measures, as well as identify factors affecting skill transfer and areas for improving simulator training. There is some evidence that simulator training is beneficial for heavy vehicle driver training (Mitsopoulos-Rubes, Lenne & Salmon, 2013), but there remains a lack of studies evaluating simulator training on construction equipment.

1.4 Construction equipment training in Defence

Construction equipment such as dozers, excavators and front-end loaders are used by military engineers to conduct earthmoving tasks in support of defence operations. Each year the Australian Army School of Military Engineering runs a Civil Construction Plant Course (CCPC) to train personnel in earthmoving equipment. The course is conducted over 16 weeks during which students are taught knowledge of plant equipment and safety procedures, and trained to operate different platforms (CATC, 2013). At the end of the course, successful students undertake on-the-job training in their unit to further develop their skills.

1.5 Current Study

The current study was conducted in support to a request from the Australian Army School of Military Engineering to examine the utility of simulator training as preparation for the CCPC. Due to sample size limitations, it was not possible to conduct a ‘transfer of training’ study with experimental and control groups. Instead a case study methodology was employed using a convenience sample.

The study had three aims: (1) to examine trainee perceptions of the utility of simulator training on construction equipment, (2) to compare operator performance during simulator and live training on equivalent platforms, and (3) to identify lessons and implications for using simulation for construction equipment training. In doing so, the study addressed the previously noted gap in the literature.

2. METHOD

2.1 Participants

The participants were 7 students paneled onto the CCPC. All students were male, full-time members of the Australian Army. Students varied in age from 21 to 36 years (mean age=26.4 years), with military service ranging from 3 to 6 years. Five of the students had prior experience operating construction equipment; this ranged from on-the-job training in their military unit to previous employment in the civil construction industry. None of the students had previously completed any simulator training on construction equipment.

2.2 Study design and procedure

A case study design was employed wherein the performance of individual students was compared across the two training environments. Each student’s simulator performance data was compared with their live training data on comparable measures. Qualitative data in the form of student feedback, and our direct observations, was also collected to allow a richer assessment of the simulator training.

Simulator training was conducted over three days at the facilities of a commercial training provider. The total training time was approximately 21 hours, over which time students rotated between the excavator (8.75 hours), front-end loader (8.75 hours) and dozer (3.5 hours) simulators.

All students undertook live training as part of the CCPC the following week. In addition to the excavator, loader and dozer, students received training on backhoe, grader, roller, skid steer and mounted earth auger over a 16 week period. Each student spent between 30 and 40 hours operating each machine during the CCPC.

2.3 Simulator training

Simulator training was delivered by two civilian instructors from the commercial training provider. The training was delivered using a sub-set of the available scenarios provided by the simulator manufacturer; these were selected based on consideration of their relevance for the military customer. The simulator training scenarios covered: machine knowledge,
changing attachments, driving, ditch digging, leveling and loading.

The scenarios were completed by students in a self-paced manner with supervision and intervention by the instructors as required. The scenarios were designed to progress the students’ learning by providing an introduction at the start of each scenario, and appropriate instructions at various stages during the scenario to guide their progress.

The excavator and front-end loader were 2 degree-of-freedom motion-based simulators manufactured by Volvo, where vehicle motion was simulated by means of actuators to provide greater realism (see Figure 1). The dozer was a fixed-based simulator based on the Caterpillar D9.

**Figure 1:** Volvo excavator simulator.

### 2.4 Measures

To address the study aims, several data collection methods and measures were employed based on Kirkpatrick’s training evaluation framework (Kirkpatrick, 1994). These included:

- **Student feedback.** This included measures of students’ attitudes and experiences regarding simulator training, which was captured using surveys and focus groups. The focus groups discussed the following areas: simulator design and feedback, simulator scenarios, and training design and delivery.

- **Simulator training data.** This included simulator data logs captured during training to provide an objective measure of students’ performance on each of the scenarios.

- **Live training data.** Instructors rated student performance on each week for a given platform during the CCPC on pre-defined criteria (e.g., speed of operation). This data was compared with students’ simulator training data.

- **Direct observations.** The authors observed the simulator training sessions and made notes based on their experience with evaluating training. The observations were compared with best-practice training principles in the literature (Salas & Burke, 2002; Salas et al, 2009).

### 3. RESULTS

The results from the study are outlined in the following sections. Student feedback data is presented first, followed by the live training data, then the simulator data. The live training data is presented before the simulator data to establish a basis for comparison and, in our opinion, better logic flow. Error bars have been omitted from all figures.

#### 3.1 Student feedback

**3.1.1 Prior expectations of simulator training**

Prior to simulator training, students completed a survey regarding their expectations of training and levels of confidence. The survey items were rated on a 5-point Likert scale from Strongly Disagree (1) to Strongly Agree (5). The survey results are presented in Table 1; the findings were positive and suggested that students expected the training to be useful. This is consistent with subsequent discussions with the students, who indicated that they had approached the simulator training with an open mind. In discussions with the students’ supervisor, it was apparent that he also had an open attitude towards simulation-based training; this appeared to reinforce the students’ attitudes towards training. Students were also asked to indicate the frequency with which they played computer games. There was some evidence that students that regularly played computer games were more confident of performing well during the simulator training. However, this trend was only based on a small number of data points.

**Table 1:** Mean ratings for student expectations of simulator training on a 5-point Likert scale\(^7\). Standard deviations in brackets.

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am confident of performing well during the training</td>
<td>4.4 (0.8)</td>
</tr>
<tr>
<td>I expect this training will improve my knowledge of plant equipment operations</td>
<td>4.6 (0.5)</td>
</tr>
<tr>
<td>I expect this training will improve my ability to operate live plant equipment</td>
<td>4.1 (0.9)</td>
</tr>
<tr>
<td>Overall I think the training will be useful</td>
<td>4.3 (0.8)</td>
</tr>
</tbody>
</table>

#### 3.1.2 Perceptions of simulator training

Another survey was administered to students at the end of simulator training to capture their perceptions of the training. The survey outcomes are presented in Table 3.

\(^7\) 1 = Strongly Disagree, 2 = Slightly Disagree, 3 = Neutral, 4 = Slightly Agree, 5 = Strongly Agree
2; in general the students were satisfied with the training and believed it had improved their knowledge of equipment procedures and operations. The positive responses were supported by subsequent discussions with the students, who indicated that the training provided good exposure to equipment and tasks they would use in live training, but in a stress free and low-risk environment that would allow learning through mistakes. It was also felt that the simulators allowed students without any prior experience to start the course with greater knowledge and skills, as well as being useful when poor weather prevented live training.

Table 2: Mean ratings for student perceptions of simulator training on a 5-point Likert scale. Standard deviations in brackets.

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>The simulator controls were easy to learn</td>
<td>4.6 (0.5)</td>
</tr>
<tr>
<td>The simulator controls were easy to use</td>
<td>4.9 (0.4)</td>
</tr>
<tr>
<td>The training has improved my knowledge of plant equipment procedures</td>
<td>4.4 (0.8)</td>
</tr>
<tr>
<td>There was enough time to practice the skills required</td>
<td>3.4 (1.0)</td>
</tr>
<tr>
<td>The training improved my knowledge of plant equipment operations</td>
<td>4.0 (1.2)</td>
</tr>
<tr>
<td>I am confident about operating real plant equipment as a result of this training</td>
<td>4.0 (0.8)</td>
</tr>
<tr>
<td>I am satisfied with the training I received</td>
<td>4.3 (0.8)</td>
</tr>
</tbody>
</table>

Notwithstanding the survey responses, students were unsure whether the simulator training would actually result in them being a better operator of the actual equipment, particularly for students with previous on-the-job training experience. Additional feedback regarding the simulator training is presented in the following sections.

Simulator design and feedback features
Student feedback regarding the simulators included both positive and negative comments. Students found the feedback features (e.g., the average % time using different excavator functions and the automatic warnings) to be useful, as well as encouraging a good attitude to safety. Negative aspects included the lack of (1) depth perception, (2) 360-degree view and (3) peripheral vision. The first factor impacted on tasks requiring execution of fine motor skills and the other two factors tended to focus students’ attention to the front of the vehicle and prevented adequate checking for hazards to the rear. Students also identified a number of features not present, but potentially useful, including the ability to observe the excavator bucket angle, the ‘4-in-1’ bucket features for the loader, and additional real-time feedback.

All students found the dozer simulator difficult to operate due to the lack of depth perception, ‘poor graphics’ and absence of hydraulic movement, which made it difficult to judge the levelling process. There was also limited performance feedback, beyond noting whether students had passed or failed, which meant students had to restart a scenario without knowing where they had made mistakes.

Scenarios
The excavator and loader scenarios were viewed favourably by the students, with scenarios progressing from easy to difficult and including a good variety of tasks. There were no positive comments from the students regarding the dozer scenarios due to the issues with the simulator noted previously.

The ‘whack-a-mole’ excavator scenario was considered particularly valuable for developing hand-eye coordination and learning how to use multiple controls simultaneously. However, students thought that scenarios where the tasks relied heavily on depth perception (e.g., picking up excavator attachments) were of limited utility because of perceived limitations in the simulator’s fidelity.

Several students indicated a preference for less repetition and greater exposure to different tasks. However, some students indicated they would have liked more time to focus on practicing specific tasks, which indicates that the choice of scenario and training may need to be tailored to individual students depending on their rate of learning. This is an important point because students will invariably come onto courses with different levels of ability and prior experience. Such individual differences will impact on the rate at which they learn and achieve competency. Given the number of platforms to be learned in a short period of time (16 weeks), combined with the limited number of platforms available, this is where simulator training could provide opportunities for ‘slower’ students to develop their skills without consuming valuable live resources.

Training design and delivery
The simulator training was delivered by the commercial training provider as part of a one week civilian plant training course (which also includes live training). Positive aspects of the training identified by students included (1) the initial briefing on safety and operation of the simulators, (2) the opportunity to repeat scenarios, and (3) debriefs at the end of each

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8 1 = Strongly Disagree, 2 = Slightly Disagree, 3 = Neutral, 4 = Slightly Agree, 5 = Strongly Agree

9 Live training was not provided as it was delivered on the CCPC.
session to identify learning points and receive performance feedback. Areas for improvement identified included (1) training delivery being matched more closely to the military training course (e.g., greater focus on safety and standard operating procedures), (2) tailoring scenarios to student needs and (3) more one-on-one instruction. The instructors did provide useful feedback to students when requested, however this could have been improved with more active monitoring and intervention. For example, we observed one student continually using the overhead and side views of the loader to judge the position of the vehicle when driving past obstacles and parking, rather than learning these skills using the first-person view (as would be required on the real vehicle). Such behavior should be corrected by the instructor.

Simulator training was delivered in a single block for all three platforms prior to live training. This meant that in some cases, there was a considerable time delay (several weeks) between simulator and live training for a given platform. This was unavoidable as simulator training and the live training course were conducted in different geographical locations and due to limited numbers of live platforms10. Students also reported that the amount of simulator training (7 hours a day) was tiring, despite being given regular breaks. This may have impacted on students’ overall learning. The flipside is that it provided good experience for them because operators are expected to work for long shifts in the real world.

3.2 Utility of simulator data for predicting live training performance

If an operator’s performance in the simulator is a reliable measure of their real-world performance, then we should expect a good match between performance across the two environments. As mentioned, no previous studies to our knowledge have compared operator performance in the simulator and real-world on construction equipment. Given that efficiency of operation has been identified as a key skill for construction equipment operators, we focused on ‘speed of operation’ and ‘overall performance’ during live training as key measures for comparison. We did not have the opportunity to observe students or collect timing data during the live training phase.

3.2.1 Speed of operation and overall scores

Mean scores from live training for each student, S1 to S7, are presented in Figure 2 (overall scores) and Figure 3 (speed of operation). The mean scores are based on the average of instructor ratings collected at weekly intervals across the live training program. The scores are based on the following rating scale: 1=well below average, 2=below average, 3=average, 4=above average, 5=well above average. In both figures, there is noticeable variation between students’ performance. For example, mean scores in Figure 3 range from 2.75 for S2 and S6 up to 4.25 for S5 and S7. In contrast, there is a trend for each student’s individual performance to be similar across platforms, consistent with similar skills being required for the three platforms. The data also provides some evidence that performance on one platform transfers to other platforms. Previous research has found skill transfer across different simulator platforms (So, Proctor & Dunston, 2014), so this explanation is plausible.

The mean scores are consistent with observations made by the CCPC instructors. For example, student S5 was described as a good operator, but sometimes overconfident, consistent with high scores for overall performance and operating speed, but needing to take greater care on occasion. In contrast, S2 was observed to be very cautious, lacking in confidence, and consistently needing to use more than one control at a time. Finally, S6 was noted as taking pride in their work (i.e., careful and fastidious) but needing to work more quickly.

10 As mentioned, the option of live training was available from the commercial training provider but was covered on the CCPC.
3.2.2 Mean scores for simulator scenarios

The mean scores across all scenarios were similar for all students, with all students achieving scores between 80 and 87% (Figure 4). This is in contrast with the live training data in Figure 2, as well as instructor observations, which highlighted performance variability between students on excavator scenarios. The algorithm used to calculate simulator scores is based on factors such as time taken, number of errors/warnings and amount of material moved/loaded. However, the data in Figure 4 suggests the scenarios may be scored too easily and that the score is not a reliable measure of their performance.

While there is value in training to a criterion (or standard) when conducting simulator scenarios, mean scores appear to be inadequate. For example, student S2 had the highest mean score but was the poorest performer during live training. Furthermore, this criterion should be multidimensional, rather than just pass/fail, and would need to be validated against live performance. In theory, the total score for each scenario is supposed to incorporate several performance criteria, but our data suggest that the algorithm may not do this adequately.

![Figure 4: Mean scores for all excavator scenarios (expressed as percentage) for each student.](image)

3.2.3 Errors and completion time

When examining the mean number of errors (Figure 5), there was better agreement with the live performance trends. Student S2 made the highest number of errors, consistent with their lower live training scores in Figure 2. In contrast, S6 made the fewest errors, consistent with their careful approach during live training. Total completion time for all excavator scenarios in the simulator (Figure 6) was also indicative of speed of operation in live training (Figure 3). Students S5 and S7 had the fastest scenario completion times during simulator training, and the highest scores for speed of operation during live training. Student S2 had the lowest score for speed of operation during live training and took by far the longest time to complete the simulator scenarios. Student S1 was also slow in completing the simulator scenarios; however, he achieved a high score for speed of operation during live training. This could be due to the fact that he conducted excavator training more than 13 weeks after simulator training. Consequently, the time spent training on other equipment may have helped with operating the excavator. Students S3 and S4 were mid-range performers in terms of scenario completion time; this was consistent with their mid-ranked ‘speed of operation’ during live training (see Figure 3). Overall this data suggests that total time to complete excavator scenarios in the simulator was a good indicator of students’ speed of operation during live training on the same platform.

![Figure 5: Mean number of errors across all excavator scenarios for each student.](image)

![Figure 6: Total time in minutes to complete all excavator scenarios for each student.](image)

3.2.4 Simultaneous use of different functions

The percentage of time spent using different functions in the simulator (Figure 7) also correlated with live performance. For example, student S2 used one function 70% and two functions 23% of the time; this was consistent with instructor observations during live training that S2 needed to use more than one control at a time. In contrast, students S5 and S7 used one function the least amount of all students; these students were two of the top performers on excavator during live training (Figure 2). Student S1 was the other good performer but had a high percentage of using one function during simulator training; a potential reason for his subsequent good performance has already been outlined (i.e., time between simulator and live training on excavator).

Overall, with the exception of mean scores, there was a general trend for students’ simulator performance data to be representative of their real-world performance. In the mining industry, the simulator data would be used to screen out unsuitable applicants. For the military and other users of simulation, the utility of this data may lie...
in early diagnosis of ‘good’ and ‘poor’ performers, and therefore support talent identification (in the former case) and remedial training (in the latter case). The data from ‘good’ performers could be used to develop ‘performance benchmarks’ that are used as criterion measures of competency. This data could be used as a ‘standard’ that students need to achieve in the simulator, either prior to commencing live training or as part of remedial training during the course. It could also be used to assess the performance levels of operators in units who may have little access to real platforms.

Based on our observations, many of these principles were applied during simulator training. For example, instructions were embedded into the simulation (1), students were given guided instruction and performance feedback (2/3), the physical fidelity of the simulators was matched to several elements of the real platform (4), and the students’ supervisor had a positive attitude towards simulator training.

Notwithstanding, there were some areas where the training could have been improved relative to these principles. Firstly, training instruction could have been more guided; in some cases students were left unsupervised for long periods and allowed to develop bad habits (e.g. relying on augmented feedback). While some students will inevitably require more assistance than others, instructor intervention should be equitable to help all students to improve. Secondly, the choice of scenarios could have been more closely matched to the course training requirements; this relates to the simulation fidelity matching task requirements. Thirdly, the simulator fidelity of the dozer did not match the real platform, which was reflected in the negative comments from students; the need for motion is an area for future inquiry. Finally, to ensure that training objectives meet customer requirements, more time needs to be allocated to developing the training scenarios and tailoring training to individuals; when training is delivered by an external provider, this requires a reciprocal partnership with the training customer. Overall, there were many positive aspects to the simulator training but also several areas for improvement. The lesson here is that adherence to training principles can be valuable when designing and delivering simulator training.

4. DISCUSSION

To recap, the current study had three aims: (1) to examine trainee perceptions of the utility of simulator training on construction equipment, (2) to compare operator performance during simulator and live training on equivalent platforms, and (3) to identify lessons and implications for using simulation for construction equipment training. The following sections discuss the findings in relation to these aims.

4.1.1 Perceptions of simulator training

Overall, the students’ feedback provided support for the utility of the simulator training. While some limitations with the training were identified, the feedback was mostly positive, with participants believing that the training was useful. We believe that the positive feedback can be attributed to several features of the simulator training.

Previous authors (e.g., Salas et al, 2009; Salas & Burke, 2002) have highlighted that simulator training is effective when the following key principles are adhered to: (1) instructional features are embedded within the simulation, (2) the simulation provides opportunities for performance measurement and diagnostic feedback, (3) the learning experience is guided, (4) simulation fidelity is matched to task requirements, and (5) there is a reciprocal partnership between subject matter experts and training specialists. In addition, research has highlighted that training transfer is more likely to occur when supervisors of trainees are supportive of the training (Galanis, Stephens & Temby, 2013).

Based on our observations, many of these principles were applied during simulator training. For example, instructions were embedded into the simulation (1), students were given guided instruction and performance feedback (2/3), the physical fidelity of the simulators was matched to several elements of the real platform (4), and the students’ supervisor had a positive attitude towards simulator training.

Notwithstanding, there were some areas where the training could have been improved relative to these principles. Firstly, training instruction could have been more guided; in some cases students were left unsupervised for long periods and allowed to develop bad habits (e.g. relying on augmented feedback). While some students will inevitably require more assistance than others, instructor intervention should be equitable to help all students to improve. Secondly, the choice of scenarios could have been more closely matched to the course training requirements; this relates to the simulation fidelity matching task requirements. Thirdly, the simulator fidelity of the dozer did not match the real platform, which was reflected in the negative comments from students; the need for motion is an area for future inquiry. Finally, to ensure that training objectives meet customer requirements, more time needs to be allocated to developing the training scenarios and tailoring training to individuals; when training is delivered by an external provider, this requires a reciprocal partnership with the training customer. Overall, there were many positive aspects to the simulator training but also several areas for improvement. The lesson here is that adherence to training principles can be valuable when designing and delivering simulator training.

4.1.2 Comparison of simulator and live training performance

The results showed that measures of scenario completion time, number of errors, and time spent using multiple functions in the simulator were indicative of students’ performance on the CCPC; this outcome suggests that performance in the simulator is representative of real world performance. It also suggests simulator training has utility in diagnosing operator skill levels and identifying remedial training needs, before valuable live training resources are expended.

The results also showed that global measures of performance, namely simulator scenario scores, did not appear to be useful in discriminating between student performance levels during simulator training, nor live training for that matter. Consequently, simulator manufacturers may need to review the algorithms by which these scores are generated in order to improve their utility for performance assessment and feedback; this is an area where industry and human factors researchers could collaborate. As mentioned, it is recommended that performance criteria be multidimensional, rather than just pass/fail, and be validated against live performance.
4.1.3 Implications for simulation community

The study findings have some important implications for manufacturers of simulators, simulation training providers, and training researchers.

- For simulation manufacturers, the results imply that not all performance measures embedded in simulators have utility for training and feedback. By the same token, the results from this study suggest that several of the measures in the simulator were reliable indicators of real-world performance. Where possible, these metrics should be readily extractable from simulator logs to support trainee development and assessment, as well as evaluation studies. The ability to provide these metrics in real-time to trainees is also a consideration for industry. While other authors (Dunston et al, 2014) have highlighted a range of measures that might be used, our experience suggests that instructor observation and feedback may be just as effective.

- For training providers, our observations reinforce the importance of implementing best-practice training principles when conducting simulator training. We believe adherence to these principles contributed to students’ positive perceptions of simulator training. In addition, training providers may wish to engage with researchers and industry to start establishing performance level standards that can be used to better inform assessment of operator skill level during simulator training.

- Finally, for training researchers, the outcomes reinforce the importance of critically assessing simulator performance measures against live training data, rather than assuming that they provide a reliable measure of performance. In addition, the findings highlight the benefits of adopting a case study approach and analysing training data at the individual level. While a case study approach may limit generalizability of the findings, it can provide valuable insights into student performance and take into account individual differences.

4.1.4 Comparisons with previous research and study limitations

The findings from this case study, specifically the students’ perceptions of simulator training, are broadly consistent with other studies that report positive reactions to simulation training (e.g., Morgan et al, 2011; Whitney et al, 2011) but also limitations in simulator fidelity (Dunston et al, 2014).

This is the first study, to our knowledge, to compare simulator and live performance data for construction equipment operators. Consequently, the ability to compare the outcomes with other studies is limited at this time. However, it is possible to comment on the utility of specific measures previously identified in the literature.

In the current study, several simulator performance measures (completion time, errors, and time spent using multiple functions) were indicative of live training performance. These findings are consistent with literature that proposes these as being important measures of operator skill (Dunston et al, 2014). The same researchers recommend additional measures (e.g., attack angle error, bucket travel) that provide more granular assessment of operator skill. These measures were not examined in the current study, and would be an area for future research.

A limitation of the study was the small sample size. This factor precluded a more rigorous evaluation of the simulator training and limits the generalisability of the study outcomes. Despite this, the case study approach we employed allowed a detailed analysis of student performance as part of our broader inquiry into simulator training effectiveness. Given that small sample sizes are quite common in training research, we recommend that researchers consider using the case study method in future studies. Over time, a series of case studies may yield greater understanding of phenomena of interest, such as training efficacy. Notwithstanding this last point, further studies based on larger samples will be needed to validate the current findings.

Another limitation was the different time points at which the students conducted live training on platforms during the course. This was a constraint associated with the number of students and the number of machines available for live training. This is likely to be an ongoing challenge for researchers. It highlights the need to consider other approaches that can support training evaluation studies; this is where a combination of laboratory and field studies may be required.

Overall, while there are challenges with evaluating simulator training on construction equipment, we have shown that studies in this area are possible and can provide useful insights, particularly for performance measurement and diagnosis.

4.1.5 Additional considerations

It is worth noting that we do not promote simulators as a replacement for live training. Furthermore, to our knowledge, the Australian Army is not currently planning to replace live construction equipment training with simulation-based training. Rather it is exploring the benefits that simulation might add to current methods. The CCPC is a 16 week course where students must learn to safely and effectively operate multiple platforms. Given the number of platforms and the time available to train, it is unlikely that simulation training can lead to significant resource savings in the short term.

Simulation can provide opportunities for students to practice requisite skills prior to operating real equipment; this could lead to reduced training costs (e.g. less fuel consumption, less wear and tear on equipment) and greater productivity and quality (i.e.
more efficient operations, and better quality job. However, additional time is likely to be required to achieve these better training outcomes, except in cases where inclement weather precludes live training and simulation training is conducted as a substitute.

The best point in training programs to employ simulation is another issue. In this study, simulator training was delivered prior to the course but there may be greater utility if employed during live training. This is an area for future research to investigate.

The question of whether there is a genuine need to change the current training paradigm is beyond the scope of this study. Due to the challenges in measuring transfer of training (Dunston et al., 2014), a rigorous cost-benefit analysis will be difficult to conduct. Instead, the costs of acquiring, running, and maintaining the simulator(s) would need to be balanced against the benefits of simulator training identified in this study. While this may not be a trivial exercise, it would certainly be worth conducting.

5. CONCLUSION & RECOMMENDATIONS

This case study has provided some useful insights into the use of simulation for construction equipment training. The study makes a significant contribution to current knowledge for two reasons. Firstly, the study addresses a gap in the published literature on real-world performance data from operators of construction equipment. Secondly, the study has provided some preliminary evidence for the validity of simulator performance metrics embedded in commercial simulators. Future research based on more controlled study designs and larger sample sizes will be needed to validate these findings.

Based on the findings, we have outlined implications for manufacturers of simulators, training providers and training researchers, along with areas for future inquiry. There are several potentialities that have yet to be explored, including the development of operator performance standards, and investigating the use of simulation for remedial training on construction equipment. The study findings also reinforce the importance of adhering to established simulation training principles, and the need for partnerships between training specialists and providers to enhance training delivery. Finally, we believe the methods, findings and implications herein have broad relevance to the simulation community, particularly those with an interest in performance measurement, training principles, and evaluation of simulator training.

REFERENCES


Open Source AV solution supporting In Situ Simulation

Kristian Krogh; Gintas Pociunas; Mads Ronald Dahl; & Eivind Ortind Simonsen

Abstract. This paper describes the successful development of an open source AV solution supporting in situ simulation in the effort of incorporating video assisted debriefing (VAD) in rural and remote areas or in hospital based simulation where hardwired AV solutions are not applicable.

1. INTRODUCTION
Simulation based education (SBE) and indeed in SBE within healthcare use of audio visual (AV) capture have being emerged as supporting tool for the after simulation session review with the intent to give constructive feedback and support the reflective process to close potential performance gaps. This type of feedback is known as debriefing a defined as “...a discussion between two or more individuals in which aspects of a performance are explored and analyzed with the aim of gaining insights that impact the quality of future clinical practice” (Cheng et al., 2014)

The use of video assisted debriefing (VAD), is where AV recording from the simulation session is used to inform a verbal discussion (Fanning & Gaba, 2007; Grant, Moss, Epps, & Watts, 2010). The capability to do AV recording in dedicated simulation centers worldwide have increased as advances in technology have made recording, playback and cost more accessible and the possibility to intergrade VAD have become reality.

With an increased need for on the site training and focus on realism the need to deliver SBE in situ in the actual workplace have emerged, this being in rural and remote areas or in hospital based in situ simulation (Miller, Riley, Davis, & Hansen, 2008). Taking simulation directly to the Emergency Room, down the elevator, the intensive care unit (ICU), and the CT scanner room exceed the simulation immersion compared to that of the embedded simulation centers and facilitate an increased realistic learning experience. Doing this without compromising (all) the educational principals used in simulation centers the inclusion of a mobile AV system for VAD was requested by the faculty running in situ simulation at the emergency department (ED).

An AV system for in situ simulation has some requirements that are not necessarily available in a purpose build setup for a simulation center. In an AV system for in situ simulation components must be portable and adaptable to a range of clinical environments. A mobile AV system would ideally feature:

- Non-cabled AV recording
- Simple, reliable set up and operation
- High mobility

The result of the review of commercial AV solutions that met our needs was Nonexistent in meeting all our requirements. iSimVid an Australian developed product which use have been described in rural Victoria (Beardmor, Timms, & McNeil, 2013) came closest to meet the features described above with one important feature lacking; time tagging was not available. This is a feature highly valued by simulation faculty using VAD (Krogh, Bearman, & Nestel, 2015) and therefore it was pertinent that time tagging was incorporated.

2. DESCRIPTION
Ultimately, a clean sheet approach was adopted and a programmer was hired to design and program the software to meet our expectations for a portable AV system for VAD. The system would make use of widely available hardware components that are easily replaced and fairly affordable. The developed AV software is contracted to be “Freeware” and the coding behind it available as “Copyleft Open Source” to ensure low cost and a potential continues improvement and expansion of the AV system.

2.1 Gintasview – technical
From a pure technical viewpoint, in situ simulation offers some novel challenges. Having an ongoing simulation in an environment, where sensitive equipment resides, instantly limits the available options, e.g. the usage of anything that emits a strong signal is not permissible. Therefore the technical solution for this in situ simulation system could not rely on wireless technology, since the signal would interfere with possible life-saving equipment. This is one of the more obvious restrictions enforced by the circumstances relating to in situ simulation. Furthermore a wireless setup would require additional technical support to ensure setup and functionality.

Other restrictions were self-imposed. We wanted the system to be low-cost (cost being a relative term) compared to the more traditional cost of equipment required for simulation based education. At the same time we wanted the equipment to be as accessible as possible, which meant we had to rely on more general
purpose equipment. In the end we choose to base our video assisted debriefing equipment on the GoPro camera. These cameras have won much acclaim for their robustness and ease of use, while at the same time generating videos of a high quality. These cameras are available for buying both online and in stores.

To ensure, that the system could run on as many platforms as possible, we opted for a browser-based solution. This way we could ensure that the system could run regardless of the underlying operative system. In hindsight, a native application would have given us more flexibility, but programming a native application requires more insight into programming languages than programming for a browser-based solution.

Next we wanted the solution to be based upon open source software. PHP was chosen as our server script, and MySQL (MySQL: The world’s most popular open source database,” 2012) was chosen as our database engine. Apache webserver is the last cog in this well-known machinery, which runs equally efficient on Windows (WAMP), Linux (LAMP) or MacOS (MAMP).

At the center of the setup is a laptop computer running on Windows with the WAMP stack installed. On this machine there is a possibility to connect up to four GoPro cameras at the same time. When the cameras are connected, the system will recognize how many cameras there connected, and will load the files from the camera and into the application running through the browser on the laptop.

In order to time tag the sessions, there is a small web based application made in JavaScript (jQuery) which makes it possible to use any smartphone as the time tagging device. This phone is then connected to the laptop, and the tags are transferred to the database. The system will then read the database, and set the time tags on a slider under the videos.

All the videos are stored on SD cards on the GoPro cameras. When videos are stored on an SD card during recording, and recording last for more than 17 minutes, the videos will automatically be divided into two separate files. The application knows this, and will automatically load the next files when required.

![Figure 1: Screen shot of the GintasView software](image)

### 2.2 Gintasview – usage

The system setup is decentralized, where each component of the system (cameras and timetagging) is running independently. The cameras are mounted at strategic positions and start recording at the same time by using the remote for GoPro cameras. As the session moves along, there will be points in time, that provide teaching or discussion points or during the debriefing phase. These points in time can be tagged by using a web application, which can run on any computer, tablet or smartphone with a browser.
When the session is over, the components are brought together, and the cameras are connected to a laptop, and the timestamps from the timetagging device are stored in a database on the same laptop. When the cameras are connected and the timetags are stored, the system is ready to play the files in the browser on the laptop. There are four different video screens allowing up to four videos to be executed at the same time. At the bottom there is a timeline, where the stored timetags are visualized for easy identification. That ensures that it is easy to jump to the parts of the session, which require extra attention.

3. DISCUSSION

GintasView has successfully been taken into use by the faculty running in situ simulation at the ED and delivery ward. Faculty was positive with regards to the initial trails. However, further familiarity with the system is required. Though the AV system is fairly easy to set up and use, the process of gathering the cameras for VAD proved to be distraction for the faculty depriving them of their debriefing momentum when technical assistance was not present. These Issues are expected to be solved with further practice and familiarity with GintasView or with additional faculty support during in situ simulation.

4. CONCLUSIONS

We have successfully developed and implemented an open source AV solution with time tagging capabilities supporting in situ simulation.

It has been found that it is possible to deliver multi-camera video assisted debriefing in a mobile, in situ simulation environment using an AV system constructed from widely available hardware components and “Freeware” software.

REFERENCES


Assessing the Need to Accredit Healthcare Simulators: Lessons from Flight Simulation

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Abstract. In the aviation domain, flight simulators have to undergo an accreditation process that certifies the capability of the simulator based upon conformance with an approved standard. Accreditation allows pilots to be certified on a simulator, with the assurance that they are not learning skills that are not representative of a real aircraft in flight. In the healthcare domain, simulators do not have to undergo an accreditation process and with the growing trend of using simulation based hours to replace clinical hours, there is a risk that simulators are being used to train skills that are not representative of the real-world. This paper investigates whether a simulator accreditation framework should be applied to healthcare simulators to address this risk.

1. INTRODUCTION

In the aviation domain, the ability to certify pilots on their ability to fly an aircraft is only made possible by the establishment of an accreditation framework that ensures flight simulators perform to an approved standard. The simulator accreditation framework allows for a clear definition of the learning outcomes that can be achieved, and also allows for the boundaries of the simulator to be clearly identified (i.e. the learning outcomes that cannot be achieved through use of the simulator). The output of simulator accreditation can be used by course developers to tailor their courses such that simulators are only used for approved training sequences and gaps can be addressed via alternative means. Such courses have been implemented in the aviation domain by integrating the accreditation framework into aviation training courses. This has allowed for a reduction in real world flight time hours, resulting in reduced costs and time to train.

In the healthcare domain, there has been a growing prevalence of the use of simulation based education in the training for both nurses and anaesthetists (McFetrich, 2006). The key driver for this was originally due to the rise of mannequin based simulators providing a means of simulating the human patient, with more recent advancements providing simulators for all equipment used in the operating environment. Now, healthcare based simulators have been used in a number of courses to certify healthcare professionals and replace a portion of their clinical time (Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries, 2014). As this trend continues, it is important to ensure that the underlying simulators used for this certification are valid for this purpose and the boundaries of these simulators are clearly identified.

This paper will first establish common terminology. Second, the paper will provide an overview of the simulator accreditation process. Third, the paper will establish the current state of play for accreditation standards in both domains. Fourth, the paper will formulate a business case for accreditation of healthcare simulators, in terms of a qualitative cost benefit assessment. Fifth, the paper will identify lessons learned from the aviation domain. Finally, the paper will propose a set of implementation guidelines on how the healthcare community could develop a simulator accreditation framework.

2. TERMINOLOGY

In order to ensure that this paper is read in the way it was meant to be written, the first step is to establish a common terminology. The establishment of such terminology is important, since the same word in different domains can have different meanings. The following references will be used to demonstrate different simulation terminologies that are being used across aviation and healthcare simulator domains:

- "Reference for Generic Methodology of Verification and Validation (GM-VV) to Support Acceptance of Models, Simulation and Data", published by the Simulation Interoperability Standards Organization (SISO) in 2013, that provides the generic terminology for a ‘broad range’ range of simulation domains (GM-VV Product Development Group, 2013).
- “Standards of Best Practice: Simulation”, published by the International Nursing Association for Clinical Simulation and Learning (INACSL) in 2013, that provides the terminology used in nursing clinical simulation and learning (Meakim et al., 2013).
- “Accreditation Standards and Process”, published by the Society for Simulation in Healthcare (SSH) in 2014, that provides the terminology used for accreditation of healthcare simulation based courses from an anaesthetists perspective (SSH, 2014).

2.1 Fidelity

The fidelity terminologies used by the three references are as follows:

- Fidelity defined by SISO is “The degree to which a model or simulation reproduces the state and
behaviour of a real world object or the perception of a real world object, feature, condition, or chosen standard in a measurable or perceivable manner; a measure of the realism of a model or simulation; faithfulness. Fidelity should generally be described with respect to the measures, standards or perceptions used in assessing or stating it”.

- Fidelity defined by INACSL is (also known as Realism/Authenticity): “Believability, or the degree to which a simulated experience approaches reality; as fidelity increases, realism increases. The level of fidelity is determined by the environment, the tools and resources used, and many factors associated with the participants. Fidelity can involve a variety of dimensions, including (a) physical factors such as environment, equipment, and related tools; (b) psychological factors such as emotions, beliefs, and self-awareness of participants; (c) social factors such as participant and instructor motivation and goals; (d) culture of the group; and (e) degree of openness and trust, as well as participants’ modes of thinking”.

Further, the INACSL includes specific terminology for High, Moderate and Low Fidelity as follows:
- High Fidelity being “Experiences using full scale computerized patient simulators, virtual reality or standardized patients that are extremely realistic and provide a high level of interactivity and realism for the learner.”
- Moderate or Midlevel Fidelity being “Experiences that are more technologically sophisticated such as computer-based self-directed learning systems simulations in which the participant relies on a two dimensional focused experience to problem solve, perform a skill and make decisions or the use of mannequins more realistic than static low fidelity ones having breath sounds, heart sounds and/or pulses”.
- Low Fidelity being “Experiences such as case studies, role-playing, using partial task trainers or static mannequins to immerse students or professionals in a clinical situation or practice of a specific skill”.

The terminology above implies that the training medium determines whether it is considered High, Medium or Low Fidelity. This does not align with the SISO definition, as the SISO terminology for fidelity is related to how well a model or simulation reproduces the real world. Whilst for most cases a well designed simulator should be of higher fidelity then a role playing activity, depending on the realism of the underlying models this may or may not be the case. If for example the needle insertion functionality of a high fidelity Human Patient Simulator (HPS) was non-representative (i.e. needle insertion can be entered at any point easily), then this model and potentially the simulator should be considered low fidelity. In a similar vein, if a role-play was based on real world data, and re-enacted in a simulated environment with no HPS, this could be of high fidelity. In these instances, healthcare programs may acquire a HPS and assume high fidelity, without the knowledge that some underlying models may not be accurate.

The United States Department of Defense (DoD) Instruction 5000.61 (2009) has cautioned the usage of the terms low, medium, or high fidelity: “While fidelity is a unified concept, it has little or no meaning when expressed as a single point or qualitative description (e.g., low, medium, or high). Simulation fidelity can and should be decomposed into its constituent components of resolution, error/accuracy, sensitivity, precision, and capability. What the model or simulation can do in terms of functional representations, behaviours, relationships, and interactions... They all should push toward specificity in representational requirements, which will inevitably address resolution, error/accuracy, sensitivity, precision, and capability needed, rather than requiring “goodness”.”

Based upon this reasoning, the terminology of High, Medium and Low Fidelity will not be used in this document.

- Simulation Fidelity defined by SSH is “the physical, contextual, cognitive, and emotional realism that allows persons to experience a simulation as if they were operating in an actual activity.”

The SISO terminology is a generic term for fidelity and relates to the realism of a model or simulation; hence it can be applied generically to the fidelity of the simulated experience, to the fidelity of individual simulators, or to the fidelity of underlying models that exist.

The INACSL terminology for fidelity relates to the fidelity of the simulated experience only. The fidelity of the individual simulator cannot be easily determined using this terminology, because the fidelity of individual simulator is only one of the factors considered in the fidelity of the simulated experience.

The SSH terminology for fidelity is somewhere in between the terminologies used by SISO or INACSL, however it still basically relates to the fidelity of the simulated experience only. The fidelity of the individual simulator cannot be determined using this terminology, due to the use of the word ‘operating’, which implies that the realism is tied to the simulated experience whilst conducting an activity (i.e. operating a simulator).

As this paper will be discussing the fidelity of the underlying models of a simulator, the SISO
terminology for fidelity will be used throughout the document.

2.2 Validity
The validity terminologies used by the three references are as follows:

SISO defines validity as “The property of a model, simulation or federation of models and simulations representations being complete and correct enough for the intended use.”

INACSL defines validity as: “The degree to which a test or evaluation tool accurately measures the intended concept of interest.”

SSH defines simulation validity as “The quality of a simulation or simulation program that demonstrates that the relationship between the process and its intended purpose is specific, sensitive, reliable, and reproducible.”

The terminologies used by SISO and SSH are related to the validity of a model or simulation for the intended use, whilst the terminology used by INACSL is more specific in regards to the validity of a course evaluation tool. This paper will not be discussing the validity of course evaluation tools, so the terminology of SISO will be used.

2.3 Verification
The verification terminology is used by SISO only. Noting the lack of definition for Verification, the SISO terminology will be used.

2.4 Validation
The validation terminology is used by SISO only. Noting the lack of definition for Validation, the SISO terminology will be used.

2.5 Accreditation
The accreditation terminology is used by SISO and SSH and the definitions are as follows:

SISO defines accreditation as “The official certification that a model or simulation and its associated data are acceptable for use for a specific purpose.”

SSH defines accreditation as “A process whereby a professional organization grants recognition to a simulation program for demonstrated ability to meet pre-determined criteria for established standards.”

The key elements from these definitions are that accreditation requires an official certifying body, applies to models, simulations and programs, targets a specific purpose and is based upon the ability to meet established standards. The definition proposed in this paper is as follows:

“The official certification that a model or simulation, and its associated data, are acceptable for use for a specific purpose based upon its ability to meet an established standard.”

2.6 Summary
In summary the terminology that will be used throughout this document is outlined in the following table:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fidelity</td>
<td>The degree to which a model or simulation reproduces the state and behaviour of a real world object or the perception of a real world object, feature, condition, or chosen standard in a measurable or perceivable manner; a measure of the realism of a model or simulation; faithfulness. Fidelity should generally be described with respect to the measures, standards or perceptions used in assessing or stating it.</td>
</tr>
<tr>
<td>Validity</td>
<td>The property of a model, simulation or federation of models and simulations representations being complete and correct enough for the intended use.</td>
</tr>
<tr>
<td>Verification</td>
<td>The process of determining the degree that a model, simulation, or data accurately represent its conceptual description and its specifications.</td>
</tr>
<tr>
<td>Validation</td>
<td>The process of determining the degree to which a model, simulation, or data is an accurate representation of the real world, from the perspective of the intended purpose of the model, simulation or data.</td>
</tr>
<tr>
<td>Accreditation</td>
<td>The official certification that a model or simulation, and its associated data, are acceptable for use for a specific purpose based upon its ability to meet an established standard.</td>
</tr>
</tbody>
</table>

Having defined the various terminologies to be used in this paper, the explanation of the simulator accreditation framework used in the aviation domain, is given in the next section.
3. VERIFICATION, VALIDATION AND ACCREDITATION (VV&A)

The simulator accreditation framework consists of the following three questions (adapted from MSCO, 2011):

Verification – Did I build the thing right?
Validation – Did I build the right thing?
Accreditation – Is it certified for use?

3.1 Verification

Verification aims to answer the question of whether the model or simulation accurately represents its conceptual description and specification. This process is performed iteratively throughout the design process straight through to build. This is of benefit, in that it ensures all design requirements have been addressed prior to the start of validation activities. This in turn, reduces the amount of time required for re-work and re-test of missed requirements. As the scope of verification covers the requirements, it provides information on elements of the simulation that are not planned to be tested during validation. To assist in the conduct of verification, simulator developers normally complete a matrix that maps the design requirements against the simulator specification.

3.2 Validation

Validation aims to measure the level of fidelity of a simulator and its underlying models. This is of benefit, as it provides evidence on how well the simulator matches the real world it aims to simulate. The validation consists of two parts:

- The first part is a data analysis that compares real world data against the output data in a simulator. An example of this could be checking the output simulator flight data against the flight dynamic model of an instrumented aircraft.
- The second part is generally a series of tests that aims to check a set of objective and subjective tests. An example of an objective test could be checking whether the tension in a flight control lever matches the tension levels of the real world system specification. An example from a similar subjective test could be to ensure that the ‘feel’ of the flight control lever is correct. This would need to be confirmed by an operator who was familiar with the real world system.

Ideally, all tests would be objective, since it removes the element of bias, however objective tests can only be performed on those elements where the outputs can be measured form; hence elements that do not have this data cannot be assessed objectively and must be assessed subjectively.

3.3 Accreditation

Accreditation aims to answer the question of whether the degree of accuracy found by the verification and validation activities is deemed sufficient to approve it for official use. This activity needs to be completed by a governing body to ensure that they have the authority to certify the associated learning outcomes and that it adheres to a particular standard. This is of benefit, as it informs users about what can and cannot be completed using simulator.

If deemed satisfactory, the output of accreditation is a fidelity baseline that defines specifically the configuration; performance characteristics; and learning outcomes that the simulator can and cannot be used for. This allows the users of the model or simulation to tailor their training programs to match the capabilities appropriately, such that they are only used to certify learning outcomes that it can achieve, whilst using an alternate trainer, real-life instruction, or gap training to cover elements that it cannot achieve.

Once the fidelity baseline has been established, it can also then be used as a benchmark to ensure that the simulator is performing as well as when they were originally accredited. This is particularly important, as if there has been degradation, then the originally accredited learning outcomes may no longer be valid.

For the flight simulator, this is performed through Recurrent Fidelity Checks (RFCs), which are subsets of the tests used during VV&A that are performed on a regular basis, to ensure that the simulated performance remains matching that of the real world data. This is done via auto fidelity tests for the flight simulator however, this functionality would need to be in-built to the simulator itself. In lieu of built in tests, the ability to ensure that the fidelity baseline is maintained could be achieved via a set of regular test procedures.

3.4 Simulator Accreditation and Training Effectiveness

It is important to note that simulator accreditation certifies the ability to train a set of learning outcomes, but does not identify how effective that training is.

Training effectiveness is a field of research that aims to measure whether a simulator (or which particular simulator features) provides a positive transfer of training into the operational context. This determination is made via a comparison of a control group against a simulator trained group and consists of three major categories (Bell & Waag, 1998):

- Utility Evaluation. Effectiveness of training specific tasks in the simulator by Subject Matter Experts (SMEs).
- In-Simulator Learning. Effectiveness of performance improvement within the simulation.

The reason that simulator accreditation is unable to assess training effectiveness is due to the timeframe from which it is performed. Accreditation is conducted prior to the start of training on a simulator, and therefore no data is available at the time of accreditation for how effective the training provided is.
However, the efforts of training effectiveness and simulator accreditation go hand in hand. Training effectiveness identifies the simulation features that should be accredited. Whilst accreditation ensures that a simulator adopts these simulation features to a sufficient level of fidelity.

4. ACCREDITATION STANDARDS

4.1 Civil Flight Simulator Standards

The cornerstone flight simulator accreditation standard was borne from a concern by the civil flight simulator community that there was no common measure or framework to assess the different flight simulators on the market. This concern was raised at a number of international working groups and led to the development of the cornerstone flight simulator accreditation standard released by the International Civil Aviation Organization (ICAO) in 1992. Since then, it has undergone subsequent updates in 2003 and 2009 (Royal Aeronautical Society, 2009). The Manual of Criteria for the Qualification of Flight Simulation Training Devices (2009) forms the basis of flight simulator accreditation.

The standard defines a series of tasks that can be trained on a flight simulator. The level of fidelity required by each of these components is dependent upon the task being trained, and for the level of training that is aimed to be achieved. If the trainer is to be used for familiarisation, then a reduced level of fidelity will be required, whereas if it is used for certification than an increased level will be required. Once the learning outcomes are known, the accreditation requirements will be tailored based upon the intended usage of the simulator.

4.2 Military Flight Simulator Standards

In Australia, the military flight simulator community did not adopt a simulator accreditation framework until the Boeing 707 crash of 1991. In this incident, the Board of Inquiry found that “The B707 simulator did not adequately reflect the aircraft in this flight regime.” (Directorate of Defence Aviation and Air Force Safety, 1994) This crash was important, as it was one of the first incidents attributed to negative training transfer resulting from a flight simulator. As a result of this review, there was a recommendation to conduct a “review of B707 training needs and the suitability of the simulator as an alternative to actual flight or particular sequences”.

The B707 simulator in this incident had a flight model that was based upon real world flight data. This approach matches the validation activity described previously; however without a standard defining the scope of the data collection required, the data that was actually collected would be decided by the developer. In this incident, the flight manoeuvre performed was outside of the scope of the collected data, and as such the accuracy of this flight manoeuvre could not be verified. Hence an important part of the military accreditation process, is to understand both what can and what cannot be trained in the simulator.

As a result of this incident, the Australian Defence Force (ADF) needed to develop a set of standards to ensure that such an incident would not happen again (Defence Aviation Authority, 2014). The civil accreditation framework was used as the initial basis for developing the required set of standards, and is now a mandated requirement for all military flight simulators. However, when applying the developed standard, it is important to note that since the accreditation framework was developed for civil airliners, it is only able to certify training that is common with civil airliners.

4.3 Healthcare Simulators

The healthcare community has established an accreditation framework around the simulation organisation. This was taken up by a number of international bodies, who each have their own standards for accreditation. As of January 2009, the American College of Surgeons (ACS) (ACS, 2013), American Society of Anesthesiologists (ASA) (Steadman, 2008) and SSH (SSH, 2014) have simulation accreditation standards that are in place. Fernandez et al (2010) conducted an analysis on these accreditation programs and identified that each of these standards focuses on four key areas.

1. Curriculum;
2. Instructor/personnel qualifications;
3. Equipment and technology; and

The key area that should include the fidelity of simulators is Area 3 – Equipment and Technology. However, whilst there are requirements for tying technology to the learning outcomes, there are no standards for how technology is confirmed to meet the associated learning outcomes. As such, there is still a gap in the accreditation standards for ensuring that the simulators are at a suitable level of fidelity to achieve the learning outcomes that they are acquired for.

This gap has been noted by some members in literature, with Cumin, Weller, Henderson & Merry (2010) noting “The absence of standards undermines confidence in the results of any simulation based endeavour and increases the risk of negative learning.” Cumin et al. (2010) proposed a starting point for an accreditation standard that followed a similar framework as the ICAO standard, by defining fidelity of components as either specific, representative or absent. This however has not yet been further developed within the healthcare community, but provides a basis for future work in this area.

This is becoming important, as there have been two major studies that have identified that simulation based education can be used to replace a portion of clinical hours. The first study is by the National Council of State Boards of Nursing (NCSBN) (2014), who
conducted a four year national study, which found that high quality simulation experiences could replace up to half of traditional clinical hours and produce comparable end-of program educational outcomes. The second study was a three year project funded by the British Heart Foundation (Alnieri, Hunt & Gordon, 2003), which found that simulation allowed students to improve their Objective Structured Clinical Examination (OSCE) performance by 6.67% over the control group.

With these studies, it is likely that an increased use of simulation based education is likely to occur in the near foreseeable future.

4.4 The Problem with Accreditation of the Simulation Program

The B707 example provided earlier, shows the importance of understanding the capabilities and limitations of the simulator being used. This raises the question of whether the validity of healthcare simulators has been assessed, such that they are able to achieve the associated learning outcomes.

In the NCSBN study above, training effectiveness was noted with a specific course and set of simulators. In theory, if this same set of simulators is used to achieve the same set of learning outcomes in the study, then their use may be valid. If however, a different set of simulators is used, it cannot be ascertained that they will perform in the same way. Therefore it cannot be assumed that this level of training effectiveness will be achieved.

An accreditation framework for healthcare simulators will confirm that the relevant simulation features perform to a minimum level of fidelity and can therefore claim the same level of training effectiveness. This will in turn mitigate the risk of negative or nil training benefit from the use of these simulators.

5. LESSONS FROM AVIATION

In order to assist the introduction of an accreditation framework to the healthcare simulator domain, it is important to look at some of the lessons that can be learnt from the aviation domain.

The first lesson relates to overregulation. In the aviation domain, the original ICAO standard was developed around flight simulators with a high level of fidelity. This in turn drove industry to focus their efforts on similarly high fidelity flight simulators. Whilst this design philosophy allowed for the maximum level of learning outcomes to be certified, it stifled development of lower fidelity training devices. Since then, the latest ICAO standard now covers a diverse range of flight training devices, with varying levels of fidelity. In the healthcare simulation space, as there currently exist devices of varying levels of fidelity this caution should be noted.

The second lesson relates to functional versus physical fidelity. Different tasks require differing levels of fidelity for different subsystems or sensory inputs. Current research (Hays, Jacobs, Prince & Salas, 1992) suggests that for a majority of tasks, reducing physical fidelity had a lesser impact on the ability to achieve learning outcomes, as compared with functional fidelity. If this is the case, and further research will still be required, than accreditation standards may be able to reduce the threshold for physical fidelity requirements.

The third lesson relates to training effectiveness. If training effectiveness research can be conducted prior to development, or in conjunction with these standards, then it can inform the level of fidelity that is required to accredit the certified learning outcomes. One particular example from the aviation space, is the finding that motion systems have minimal training benefit for training of fixed-wing pilots (Hays et al., 1992). If subsystems can be removed, or reduced, from the standards, then cost savings can be seen for both procurers and developers.

The fourth lesson, relates to completing a Training Needs Analysis (TNA). For simulator acquisitions, a TNA identifies where training is needed, what needs to be taught and who needs to be trained (Salas & Cannon-Bowers, 2001). With the output of the TNA forming part of the specification for the simulator program. In relation to establishment of an accreditation standard, it may be worthwhile to conduct a TNA type activity on the individual simulators, to determine the validation requirements based upon the learning outcomes, Knowledge, Skills and Attributes (KSA) and cognitive task analysis.

6. BUSINESS CASE FOR ACCREDITATION OF HEALTHCARE SIMULATORS

In order to obtain backing from the healthcare community, it is important that a business case be established for the accreditation of simulators that identifies both potential costs and benefits. Note that this is not a cost-benefit analysis in the truest sense, as no monetary values have been provided (Walsh, Levin, Jaye & Gazzard, 2013). Instead, the goal of this business case is to provide the initial justification for whether this path is worth investigating. The potential costs and benefits should be quantified in future studies once the planned scope of simulator accreditation is clearly defined and known.

6.1 Costs

Five key cost drivers for the implementation of an accreditation framework for healthcare simulators are identified below.

The first is the cost of establishing the accreditation standards. The development of these standards is a long process that requires input and agreement from a wide range of stakeholders. The resource costs for such meetings will be high, but will be a once off cost that will need to occur at the beginning of the process.

The second is the cost of paying an organisation to conduct the accreditation activity. The cost for
accrediting healthcare simulators however is likely to be significantly lower than that of flight simulators, since it will be performed on a per product basis. Healthcare simulators are designed such that a product has a set configuration, so once the first of a product is accredited, all products with that same configuration will be considered accredited. This is different for aviation simulators, where flight simulators are type specific which requires a number of ‘one-off’ configurations to be separately accredited.

The third is the cost of collecting real-world data. Research notes that real world data for some procedures is available, such as Cardiopulmonary Resuscitation (CPR) (Meaney et al., 2013). This however, is only one procedure of many, and the ability to collect real world data for patients with adverse conditions may be difficult for both moral and cost reasons.

The fourth is the cost of collecting simulated data. In order to ensure that the fidelity baseline is maintained, it is important that simulators are able to provide a measure of their performance. If simulators cannot currently report on their performance, additional costs may be required to develop this built capability.

The fifth is the cost of handling legacy simulators. Even if an accreditation framework is established, legacy simulators will not be accredited and may either need to be re-purchased or have an accreditation process applied to them. Due to the prevalence of simulators in education facilities today, this could be a large cost driver if existing users are required to upgrade their simulators.

6.2 Benefits

Six key benefits for the implementation of an accreditation framework for healthcare simulators are outlined below.

The first is the benefit of understanding what learning outcomes can and cannot be trained on the simulator. This is particularly important, as it mitigates the risk of negative training. This knowledge can be implemented into training programs, such that when a simulator is used, instructors can advise the students of these differences, or completely remove that training element from the course (Maran & Glavin, 2003). The magnitude of this benefit will be dependent on the criticality of the tasks being trained. If the simulator is used only for familiarisation, then this may only be a small benefit, however if it is used to train critical tasks then the benefit is significant.

The second is the benefit of reduced insurance premiums. By mitigating or eliminating the risk of negative training, insurers have increased confidence that healthcare professionals have received training that will reduce instances of malpractice, or complications. In the aviation space, this confidence has allowed for reduced insurance premiums to be offered, and a similar benefit is likely to occur for healthcare if the reduced risk can be proven.

The third is the benefit of being able to determine the correct combination of simulators to complete a training program. As the learning outcomes that each simulator can train is known, these can be mapped to the requirements of a training program, such that the optimal mix is procured. In such a way, costs can be saved, and training effectiveness increased.

The fourth is the benefit of freeing up the time of healthcare professionals. Traditional clinical training requires the time of mentors to teach trainees. By maximising the training that can be certified by a simulator, clinical hours can be reduced, which will free up time previously dedicated to mentoring. This time can be used to perform other tasks required in the hospital.

The fifth is the benefit of a predictable time to train. In the aviation domain, one of the key factors for training is the time to train. Training in a simulator is predictable and will allow for learning outcomes to be achieved in a set period of time. This is not the case if clinical hours are required, as this will be dependent upon availability of patients and mentors.

The sixth is the benefit of providing baseline data. If real world data is collected and made available to simulator developers, this will provide baseline data for all simulators to be built from. This is beneficial for developers, in that it provides consistent data to work from. In such a way development costs can be reduced, as individual companies will not have to collect data.

6.3 Business Case Summary

In summary, there are costs and benefits associated with the implementation of an accreditation framework for healthcare simulators. The initial cost may be high; however this cost will only need to be applied once per product, so the cost can be spread across a large quantity of simulators. The key benefit lies in understanding what learning outcomes can and cannot be trained in the simulator, which in turn will provide a number of benefits to the healthcare community.

Since there is a cost and resource impost to implement simulator accreditation, the cost will need to be measured against the benefits to determine whether it is worthwhile to accredit each particular type of simulator.

7. IMPLEMENTATION GUIDELINES FOR INTRODUCING AN ACCREDITATION FRAMEWORK

Whilst the need to introduce an accreditation framework for healthcare simulation is still debatable, the introduction or otherwise would primarily depend on backing from the healthcare simulation community. Community backing will be dependent on the perceived benefits that have been outlined above, and the ease of introduction of the process itself. If the process is too onerous, then it is unlikely that a rigorous accreditation framework would be adopted.
due to the limited resources available to healthcare educators. In order to address this question, the following guidelines are suggested below.

7.1 **Understand the business case for simulator accreditation**

The first step in pursuing an accreditation framework for healthcare simulators is to ensure that the business case is well understood. The framework cannot be developed, or gain traction in isolation, so it is important that any pursuit is combined with the knowledge of both the costs and benefits of adopting such an approach.

7.2 **Start Simple.**

The design of a simulator accreditation framework should be around a particular type of simulator for a particular purpose. A starting point is required, otherwise the scope of accreditation will be too large, and may no longer be feasible. The healthcare community uses the HPS to certify a number of healthcare professionals. As such, a direct benefit can be gained by confirming the learning outcomes that the HPS is currently being used for.

7.3 **Specify the learning outcome.**

It is important to ensure that healthcare professionals understand what the learning outcomes they want to be able to train with a particular simulator. Since not all learning outcomes are planned to be completed with a simulator alone, the learning outcomes that can and cannot be performed on the health care simulator will need to be specified. The required learning outcomes may be identified via a TNA type process as earlier described. This process should include both education providers and simulation developers.

7.4 **Collect Real World Validation Data.**

A key element of the accreditation process is the ability to be able to compare the real world data against the simulated data to determine how well the simulator replicates the real world. For the flight simulator, this data is normally collected through instrumented flights that collect flight data for particular flight regimes. In the healthcare domain this is more of a challenge, for a number of reasons shown below:

- Instruments are not readily available to track all elements required for the replication of the human patient;
- Attaching instruments to adverse condition patients is potentially unethical;
- Adverse conditions for training are not necessarily seen regularly;
- Instrumented data collected from a healthy volunteer may not represent the reactions of a patient suffering from adverse conditions;
- Each human is different, and may react differently even with the same applied conditions.

Because of this, the ability to collect real world data from a human patient is difficult, but having such data would be of great benefit to the accreditation process. Due to the nature of this data collection activity, the responsibility should lie with the research community.

A report written by the American Heart Association (Meaney, et al, 2013) outlines that tools are available and are being used to monitor the performance of the patient and resuscitator during real world CardioPulmonary Resuscitation (CPR) events. Whilst collected to assist the training itself, the data from these tools (if releasable) could be used as source data for design of CPR models in healthcare simulators.

Once real world data can be obtained, then this data (if releasable) can be provided to healthcare simulator developers to ensure a common basis of design between healthcare simulators.

7.5 **Develop simulator specific accreditation standards.**

A starting framework has been proposed (Cumin, Weller, Henderson & Merry, 2014) for the objective criteria for validating health care simulators to meet accreditation standards. It is up to the community to decide the best way forward for determining what the make-up of this standard should be. Ideally this community should include healthcare professionals, academic researchers and industry bodies. This standard will take a significant time to develop and for agreement to be achieved on the best way forward. The simulator accreditation standard should cater for different levels of simulators, but also for other simulated equipment trainers that are being used for training.

7.6 **Determine the accreditation agent.**

In the aviation space, certain organisations are assigned the responsibility of analysing the data for accreditation. If healthcare simulators are to remain a Commercial of the Shelf (COTS) product then there will need to be a governing body to verify, validate and accredit the product. The ideal governing body would be one that already has an established accreditation framework for the healthcare simulated experience, such as ACS, ASA, SSH.

7.7 **Include simulator accreditation requirements in organisational accreditation standards.**

If there is no requirement to actually accredit simulators within an overarching standard, then it is unlikely that simulators will undergo accreditation. The accreditation standards for the simulation programs currently include criteria for suitable equipment, which could be made more specific to include an accreditation requirement dependent upon the intended usage.
7.8 Decide how to handle legacy simulators.
Accreditation is based on the principle of being embedded throughout the simulator design process. The reason for this is that it allows for checks on the validity of the design throughout development. The ability to trace the original data used to develop simulator models is often not available due to poor configuration management processes, and without this data it is hard to verify the simulator design. Since healthcare simulators have been widely used, the phasing out of legacy simulators would not be an attractive option. Hence a plan forward will need to be developed on how legacy simulators will be handled. One way of handling legacy simulators would be to conduct a series of tests to ensure the validity of training on these simulators. Once the validity of a simulator is known for particular learning outcomes, then any gaps can be appropriately addressed through real-world gap training.

7.9 Plan the Implementation.
In order to ensure that accreditation standards achieve the goals that they seek to obtain, a pilot project will need to be conducted to ensure that the analysis is of sufficient rigor to determine how well the simulator suits the learning outcomes. If an incorrect standard is adopted, then there could be an additional impost with no value added benefit to the community itself.

7.10 Training Effectiveness Program
In the healthcare domain, research exists for the training effectiveness of healthcare simulation programs. By using these results as a starting point, it can assist in development of the initial accreditation standards. Similarly, once an accreditation standard has been established, it will also be important to put in place a program to measure training effectiveness. Any findings from this program can then be used to refine the accreditation standards via subsequent revisions.

8. CONCLUSION
The simulators used in healthcare education have been evolving and offer considerable potential for training the modern day healthcare professional. As the use of these simulators becomes more ubiquitous, there is a desire to use them for certification in replacement of more traditional methods. In order to ensure that the simulators can be used for certification, it is important that the community understands whether these simulators are valid for this purpose.

Cautions to use simulators for certification have been raised in a few reported literatures, as there is currently no requirement to validate healthcare simulators. A starting point has been proposed in the literature, which outlines the objective requirements that could be used in the assessment of breathing capabilities of a HPS.

Lessons learnt from the aviation domain have been presented, with the goal of assisting the healthcare domain to not relearn the same lessons if they choose to introduce a simulator accreditation process.

A business case has been raised that outlines the costs and benefits of implementing a simulator accreditation framework. This business case can be used by the healthcare community, to determine whether a simulator accreditation framework should be applied to the healthcare domain.

Guidelines for the implementations of an accreditation framework for health care simulators have been proposed. Ultimately however, the healthcare community will need to back the implementation, in order for a simulator accreditation framework to be established.

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Your Workshop To Find The Balance: One Health Service Experience In Simulation Delivery

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Background and Aims of Workshop.

Mater Health Services (MHS) is a complex tertiary level teaching health service operating 3 hospitals at South Brisbane campus incorporating private and publically funded beds. Within MHS, simulation activities are conducted within Mater Education Practice Improvement Centre (MEPIC) through to point of care (in-situ) simulations. The aim of the workshop is to facilitate participants to find their own simulation program ‘balance’, using facilitation strategies and shared experiences to gain this insight.

The learning objectives for this workshop are:

1. Determine the key drivers for using simulation across a variety of educational and process issues within healthcare/education.
2. Identify common simulation issues and generate potential solutions to these issues applicable to a variety of contexts.
3. Reflect on current simulation practice, acknowledge successes and seek to improve in identified areas.
4. Network opportunities with like-minded simulation educators facing similar issues in their own context.

Workshop Content Outline.

Participants will have the opportunity to hear five short (5 minute presentations) including the following topics:

1. How do you get point of care (in-situ) simulation ‘off the ground’? Implementing a point of care simulation program across 2 hospitals (Recognition of the Deteriorating Patient).
2. How to use simulation to engage those clinicians embracing the unknown? Utilising simulation to provide knowledge and skills in Paediatric Life Support (including process simulations) to clinicians following a large organisational change (transition of Mater Children’s Hospital to Lady Cilento Children’s Hospital).
3. How do I know what type of simulation activities to use for Interprofessional Education? Finding the simulation balance when implementing Interprofessional Education (IPE) activities for allied health, medicine, nursing and pharmacy.
4. When is enough simulation, enough? An established maternity emergency management program that has seen exponential growth and is now faced with so many great ideas for future development – how do you know which is going to give you the best bang for your buck?
5. How do I engage and develop simulation faculty? How do you train the expert clinician in simulation as a teaching methodology? How do you engage ‘in-kind’ clinicians to participate in faculty development?

These presentations reflect common, real-life program difficulties from simulation educators seeking to achieve ‘the balance’ in their programs. The presentations are designed to generate discussion rather than to
provide solutions. Each of these educational programs is driven by different organisational requirements and therefore has their own unique issues, despite originating from the same health service. Following the presentations, participants will be able to indicate which of the 5 issues above they would like to brainstorm in small groups.

Within these faculty-facilitated small groups, participants will have the opportunity to reflect on their own programs and similar issues facing their health/academic environment, and generate potential solutions to the arising issues.

Participants will be asked to consider the following:

- What are the drivers of your simulation program?
- What are you seeking to achieve with your simulation program (learning objectives)?
- Who do you need to get involved?
- What are your perceived and actual barriers for success?
- What are some lessons learnt to improve your success?
- How are you going to evaluate your success?

Participants will have 20 minutes to share successes and lessons learnt to further simulation activities across one of these five areas. Additional areas may also be explored depending on participant desire.

Following brainstorming, groups will report back to the larger group. At this time, the larger group will be able to comment further and develop strategies to improve simulation outcomes in all five areas. This facilitated discussion will promote deeper thinking into perceived and actual program barriers and strategies to overcome these.

**Workshop Outcomes.**

At the conclusion, workshop facilitators will compile a list of identified issues and proposed solutions/local successes from all groups that will be distributed to the larger workshop group following the workshop’s completion. This formal dissemination will allow participants to link with fellow simulation educators who have had successes in an area that they may be finding difficult to promote further networking.
SimHealth

Posters - Education Delivery Methods

Simulation Training In Obstetrics And Gynaecology: What’s Really Going On?

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Aims. To evaluate the utilisation of simulation in training by Obstetrics and Gynaecology Specialists and Trainees across Australia and New Zealand, and to assess the attitudes towards simulation training and define factors that encourage or prevent simulation training.

Background. Reduced opportunities exist for surgical training in Obstetrics and Gynaecology (O&G) owing to increased trainee numbers, reduced working hours and increased medical management of gynaecological conditions. Laparoscopic simulation training has been demonstrated to improve real surgical performance and reduce operating time in General Surgery and is now a recommended part of surgical training in many countries, including Australia. While there is level one evidence supporting simulator training for improving live surgery, simulation training is not currently part of the O&G training curriculum and there is no existing understanding of the extent to which simulation is used for training in gynaecological surgery. It is likely that a substantial discrepancy exists between the known benefits of simulation training and the uptake of this form of pedagogy.

Methods. An online survey was designed for distribution to approximately 3500 Trainees and Specialists in Obstetrics and Gynaecology in Australia and New Zealand. The survey includes demographic data, current use of simulation, attitudes towards simulation, and barriers and enablers of simulation training. A five-point scale was used by respondents to rate their beliefs about what factors motivate trainees to participate in simulation training, what the obstacles may be to participation, and whether they believe simulation training improves surgical performance and should form part of the formal training curriculum. Responses will be collated and analysed to evaluate the current state of simulation training within O&G.

Result. The results of this survey will be collated following the distribution of the survey, which is planned for circulation to O&G Trainees and Specialists in the coming months.

Discussion. In order to further the use of simulation in a formal capacity within an O&G training curriculum, it is essential to understand the current utilisation of simulation and attitudes towards this modality. Ultimately, the information from this survey will serve as a starting point for the development of a simulated skills curriculum to augment the surgical skills development of O&G Trainees.

Conclusions. The results of this survey will provide valuable insight into the current utilisation of simulation training and attitudes towards simulation training in Obstetrics and Gynaecology in Australia and New Zealand.
A Preliminary Look: Scaffolding Simulation Through The BN Curriculum – 3rd Year Perspectives Of A Reflective Re-Do Station

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Aim of the Education Program.
Aim: to explore the impact two new elements had on teaching simulation and the student’s ability to reflect upon their learning experience.

1. A reflective repeat station (‘re do’) post simulation scenario
2. Lab Logs for documenting reflective learning at the end of the station

The aim poses two research questions

1. Does introduction of a ‘re do’ simulation station aid in reflection and enhance students’ learning knowledge?
2. Does introduction of personal Lab Log reflections in addition to the group debrief on completion of a simulated activity improve student’s learning and reflection?

Methods Adopted.
Discourse between educators on methods to enhance reflection within the student cohort led to the trial of the ‘re-do’ station. This learning activity was programmed to follow a high fidelity simulation and debrief experience, with the view to provide students an opportunity to repeat the scenario activity outside the simulation suite. It was hoped peer driven reflections started in debrief would be continued and explored.

The first 150 student intake (January-February 2015) is now complete and students were invited to participate in an anonymous and voluntary online survey exploring individual immersive high-technology and fidelity simulation experiences. Data collection and analysis will occur over three intakes and across 450 students in total: intake 2 March-April 2015, and intake 3 April-May 2015. Each intake consist of 5 classes with 6 groups per class. These groups vary from 2 to 5 members depending on the overall class numbers (max 30 students per class as influenced by school policy).

Evaluation Data from the Program.
‘Re-do’ station

Initially a fixed rotation (see table 1) offered the reflective ‘re-do’ station prior to the Sim session for one group only, and post simulation and debrief for five of the groups. The group rotation required alteration halfway through the 4 week programme, as students felt it was inequitable to ‘always be doing it first’. Group order was consequently modified. The change elicited positive feedback although, some groups in the ‘after’ schedule wished they had it earlier so they could practice (the grass is always greener syndrome).

Data about the reflective re-do station showed that students used this opportunity to revisit the scenario as a group. They documented discussing knowledge deficit areas, accessing web resources for learning to clarify understanding such as pathophysiology, reviewing procedures and equipment.

Lab Log reflections

A degree of variation in the amount and quality of reflection is evident in this data set. Some students’ provided a summary of activities with limited or no insight whilst others display a high level of insight into their own performance and needs. Reflection on the various weeks showed growth in learning for several students with clear statements about increasing knowledge, confidence and understanding.
Conclusions and Recommendations for Future Use and Development.

The first cohort has provided responses allowing development of further direction and guiding questions to be established in the ‘re-do’ station to encourage natural group reflection. Future cohort rotations will ensure groups experience the ‘re-do’ station after their debrief. Unfortunately class numbers dictate one group will do this station prior to Sim.

Lab log reflections completed on iPads at the end of each station highlighted a deficit in students understanding and ability to professionally reflect on their practice. As a consequence, clearer information and examples directing this activity will be provided to students earlier.

Changes resulting from the initial feedback will be made before the next group allowing a direct comparison and further develop and enhance the topic and student learning.

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<th>Station 3 Break</th>
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<td>Station 1 (redo SIM)</td>
<td>Station 2</td>
<td>Station 3</td>
<td>Station 4</td>
<td>Station 5</td>
</tr>
</tbody>
</table>

Table 1: Nursing skills laboratory: Clinical skills stations 1-7, where of station 6 was always simulation, station 7 was always debrief, and station 1 was always the reflective re-do station.
The Use of Simulation Exercises in Teaching Mental Health Nursing

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Aims. The aim of this study was to determine second year mental health students’ perspectives on the effectiveness of immersive and observational simulations for confidence and learning in mental health nursing.

Background. Students completing a Bachelor of Nursing at Victoria University complete two units of mental health nursing. Each of these units uses simulation to teach the practical skills required, complementing the theory taught in combination of lectures and tutorials. Although simulation exercises are used by most universities in teaching undergraduate nursing courses, only 21% have been found to be formally evaluating the effectiveness of the simulation activities conducted (Nehring & Lashley, 2004). Brown (p. 639, 2008) reports that methods for simulation are often chosen without any evidence to support their effectiveness. When working well, simulation can provide students with the opportunity for “sustained deliberate practice in a safe environment, access to expert tutors, reflection of real life practice and a supportive, motivational learner-centered [learning] milieu”. However, without formal evaluation, academic staff will not be able to determine the effectiveness of their model of simulation or determine areas for improvement.

Whether simulation exercises improve student learning remains unclear, in part due to the number of variables that can affect simulations. When compared with the ‘usual didactic method of instruction’ in learning communication skills, (Becker, Rose, & Berg, 2006) found no significant differences in achievement of learning outcomes. Others have found no impact on graduation rates (Massey & Warblow, 2005). In contrast, Alininer, Hunt and Gordon (2006) found simulation activities greatly increased students’ clinical skills and competence. A meta-analysis of the effectiveness of simulations as a teaching tool is, however, near impossible due to the different possible combinations of teaching activities and methods that are encompassed under the umbrella term ‘simulation’.

To date, there were no studies that had investigated the effectiveness of immersive and observational simulation activities for improving confidence and clinical skills when using live and recorded case studies for teaching second year mental health nursing students.

Methods. Participants were asked to complete two copies of the Simulation Effectiveness Tool (‘SET’): once to evaluate the immersive simulations and once to evaluate the observational simulations. The SET was created and tested for reliability and validity by Elfrink, Leighton, Ryan-Wenger, Doyle and Ravert (2012) for the purpose of evaluating students perceptions about the use of simulations. The tool assesses students’ confidence and learning from the simulation class. The questionnaire contains thirteen questions on a three point Likert scale (do not agree, somewhat agree, strongly agree). Elfrink et al. (2012) found the tool to be reliable in determining simulation effectiveness (Chronbach’s alpha of 0.88). In addition to the SET, students were asked an additional six qualitative questions in order to provide students with an opportunity to provide additional feedback about their experiences. The qualitative data was explored using thematic analysis.

Result. A total of 128 students completed the questionnaire out of a total of 180 invited to participate. The qualitative revealed a number of themes. Students reported that they felt the simulation activities “helped with their critical thinking skills” and “helped to link the theory to the practice”. Six students reported that they found the simulations “boring”, qualifying this by stating that they felt the actor “wasn’t real enough”. Despite this, a small number of these students felt that the simulations improved their skills, knowledge and confidence in mental health nursing. The quantitative data showed that 60% of students agreed that the simulation activities were at least “somewhat” useful in helping critical thinking, preparatory for real patients; challenged their decision making and improved their confidence and skills.

Discussion. The results of this study revealed a number of areas of simulation use that could be improved. Students made constructive criticisms about the length of time, the organization of simulations amongst other learning activities and the choice of topics used in simulation that can be incorporated into future simulation planning. The results of this study also confirmed what has been reported in previous literature regarding the importance of preparation, debriefing and discussion in achieving learning outcomes. This study has proven valuable in providing information about student perceptions of the utility of simulation activities in mental health nursing education.
Conclusions. There are a number of variables which may affect the effectiveness of simulations for clinical learning, such as the experience of the simulation actor, the quality of the script and how the simulation is supported by theoretical learning and its integration into the larger curriculum. This may be an area for future research and is a limitation of the current study. Simulation exercises may be useful in teaching practical, clinical skills for undergraduate mental health nursing students. Careful consideration, however, needs to be given to ongoing evaluation of simulation activities.

References.


Stimulating Students In Simulation: Undergraduate Nurses’ Self - Reported Satisfaction Responses From An Experience With Mid-Level Fidelity Student Led Simulation

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Aims. The aim of this study was to evaluate self-reported perceptions of satisfaction with learning from undergraduate nursing students’ following mid-level fidelity, student led simulation-based learning experiences.

Background. Simulation-based learning experiences have been widely reported on as one method that could achieve improved levels of confidence and competence in nursing students (1;3;5;6;7). There is little evidence in the literature to say nursing students are satisfied with simulation as a teaching pedagogy. If nursing students are not satisfied with this teaching pedagogy are they really going to value the learning experience. It is important to answer this question as there have been many identified barriers in relation to academia using simulation as a teaching pedagogy (4). More importantly simulation has been highlighted as essential in the much needed reform of nursing education (1;8). Levels of student’s satisfaction with learning may be what is required for nursing academics to fully embrace simulation as a pedagogy.

Methods. A quantitative cross-sectional study using a paper-based Simulation Questionnaire was administered to second and third year Bachelor of Nursing students; post a simulation-based learning experience. A 16-items simulation questionnaire adopted from a validated simulation experience instrument was used to collect the data. The satisfaction items in section one included a 6-item, 6-point Likert scale designed to measure participants’ level of satisfaction with the simulation experience. The items were adopted from satisfaction with simulation scale adapted from (6). The items were anchored 1 = strongly disagree to 6 = strongly agree.

Result. The overall mean for the satisfaction subset was (M=4.42 SD=0.93) with the highest means recorded for item Three (M=4.48, SD=1.18) and item Five (M=4.48, SD= 1.01). All remaining means scores were above M= 4.32. This equates to combined percentage results for the somewhat agree, agree and strongly agree responses of over 77.5% for all items in the satisfaction subscale.

Results presented here have provided convincing evidence across a large sampling number (n=509) that undergraduate nursing students at a regional Australian University are very satisfied with learning achieved in mid-level fidelity student-led simulation experiences. The participants in this study have overwhelmingly reported the simulation exercise as a valuable learning experience. This is encouraging as the literature indicates students who are satisfied with their learning may be more engaged and stimulated in their learning (Biggs& Tang, 2011; Ramsden 2010). This may result in student nurses who are more confident in the clinical setting and produce eventual neophyte Registered Nurses who provide improved patient care thus meeting industry expectations.

Discussion. Overall results presented here have provided convincing evidence across a large sampling number (n=509) that undergraduate nursing students are very satisfied with learning achieved in mid-level fidelity student-led simulation experiences. The participants in this study have overwhelmingly reported the simulation exercise as a valuable learning experience. This is encouraging as the literature indicates students who are satisfied with their learning may be more engaged and stimulated in their learning (Biggs& Tang, 2011; Ramsden 2010). This may result in student nurses who are more confident in the clinical setting and produce eventual neophyte Registered Nurses who provide improved patient care thus meeting industry expectations. Nursing faculty too may be convinced by these results and begin to implement simulation of this kind in clinical courses.
Conclusions. Limited research is available on student nurses’ satisfaction with simulation as a learning pedagogy, in particular using mid-level fidelity, student led simulation. Overall results presented here have provided convincing evidence across a large sampling number (n= 509) that undergraduate nursing students are very satisfied with learning achieved in mid-level fidelity student-led simulation experiences.

With convincing results in regards to satisfaction in learning it is recommended that student led medium fidelity simulation experiences be further developed in order to be implemented into nursing curricula. Developing resources to support academia implementing simulation is also recommended. There are limited findings about lecturers’ experiences in teaching and learning with simulation and how the barriers to implementation can be destigmatised this needs further investigating.

Continued research into nursing students’ experience with simulation pedagogy is required to support the findings of this study. Using a longitudinal study to compare groups of nursing students over the course of their undergraduate studies could describe differences in acquisition of clinical practice, theoretical knowledge and satisfaction with simulation for learning between the groups.

References.

Development Of A Novel Simulation Training Course For Timely And Safe Delivery Of Nitric Oxide In The Clinical Environment

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Aim of the Education Program

Nitric oxide (NO) delivery, through a specifically designed delivery system (iNOmax DSIR) is a unique pharmaceutical product that requires the clinician to be familiar with the drug and delivery device. Due to its physiology, short interruption to the delivery of inhaled nitric oxide (iNO) is likely to lead to serious adverse effects, making iNO a particularly high-risk therapy that needs careful mitigation and management. Clinical training has traditionally focused on either the drug or the delivery device, leaving clinicians with limited experience and confidence in the set up and management of NO. Initiation of NO is usually required in the context of an acutely unwell or deteriorating neonate or child. Real-life opportunities to practice the set-up of the device are therefore, relatively infrequent; hence Ikaria Australia identified the need for an “Advanced Super-User Training Day”. This incorporated simulation to provide an appropriate context and realism for nurses to apply relevant knowledge and practice clinical skills with a focus on communication and crisis resource management to enhance the efficiency of care, as well as patient and user safety.

Our key objectives included, attaining a shorter time period to set up the iNOmax DSIR; improved recognition and management of common alarms and situations with a high risk of interruption to the delivery of iNO, and; improved clinician-equipment-patient evaluation and troubleshooting in the context of clinical conditions commonly managed utilising iNO therapy.

Methods Adopted

A mixed method teaching course was designed to ensure an adequate base of knowledge and clinical skills were to be applied in the clinical environment. Simulated patient events incorporating appropriate realism and real-time clinician-equipment-patient interactions were utilised to provide repeated practice opportunities. Concurrent scenarios in two simulation rooms replicating a NICU/PICU environment were run. SimNewB™ was utilised to simulate a term newborn infant with signs of persistent pulmonary hypertension, requiring ventilation and NO therapy. Participants were required to set up and connect the iNOmax DSIR to the ventilator in a safe and timely manner and in subsequent scenarios, to troubleshoot and manage common patient events and equipment alarms.

A questionnaire using a five-point scale (1-strongly disagree and 5-strongly agree), with specific reference to presentations, coursework, skills stations and simulations was used to ascertain participants’ views on the effectiveness of the training program. Time to achieve safe delivery of iNO in the scenarios was noted.

Evaluation Data from the Program

Of 19 participants, 80% (n=15) of participants completed the evaluation with 100% in agreement that the training increased their knowledge and confidence in setting up and using the INOmax DSIR and that the content was relevant. 100% of participants felt that patients in the NICU and PICU would benefit from the simulation based training. All teams of participants successfully achieved the clinically relevant aims of the scenarios. Average time to safely commence iNO therapy in both scenarios was greater than 10 minutes.
Conclusions and Recommendations for Future Use and Development

This multidisciplinary approach, including the pharmaceutical company Ikaria Australia in collaboration with a simulation education center (Kids Simulation Australia (KSA)), has resulted in the design of a novel mixed methods training program that utilises simulation to provide practice opportunities to improve iNO delivery and patient care. Appropriate realism in the simulation environment allows for the observation of the clinician-equipment-patient interface and testing of recommended operating procedures. It is hoped that the reported improvements in user confidence will translate to safer and more efficient delivery of this potentially life-saving drug to critically ill patients. This collaborative partnership between KSA, Ikaria Australia, and end-users, with clinically meaningful learning objectives and outcomes, may serve as a model for the future introduction of novel high-risk and complex therapies in the clinical environment.

References

Teaching With Portable Simulation in Low-Middle Income Countries.
Emergencies In Anaesthesia Course – Myanmar.

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Aim of the Education Program.

The aim of the Emergencies in Anaesthesia Course is to upskill anaesthetists in Low Middle Income Countries (LMIC) in dealing with time-critical and crisis situations in the theatre environment, using lectures and workshops with portable simulation equipment and basic manikins to facilitate a practical hands-on approach to teaching.

Methods Adopted.

The Emergencies in Anaesthesia course has been delivered in both Mongolia and Myanmar. Conducted in English, it involves a series of 6 lectures and 14 workshops run over 2 days. Our 2015 workshop had 28 participants, comprising 24 anaesthesia trainees or consultants, and 4 theatre scrub nurses. Lecture topics included crisis management and human performance, difficult adult and paediatric airway management, basic and advanced life support, trauma, and common intraoperative problems. Workshops covered management of intraoperative problems, such as management of difficult airway, can’t intubate can’t oxygenate protocol, high airway pressure, tachycardia, cardiac ischaemia, hyper and hypotension, burns, hemorrhage, intraosseus access and paediatric airway.

Three workshops used simulation to teach skills – basic/advanced life support, intraoperative critical event, and primary trauma survey. An iPad, using the iSimulate ALSi app, was used to simulate a monitor/defibrillator, with another iPad used as the controller via a local wifi network. A basic life support manikin was used to simulate the patient. During the BLS/ALS workshop, participants practiced the ALS algorithm, identified shockable and non-shockable rhythms, charged and discharged or disarmed the defibrillator, and practiced chest compressions. In the intraoperative critical event scenario and trauma primary survey, ALSi was used as a patient monitor, with vital signs changing as per the participants’ management of the patient. It was converted to a defibrillator if the patient went into cardiac arrest.

Participants received a printed course manual at the start of the first day.

Assessment of the course was via pre- and post-course MCQ papers, and evaluation forms.

Evaluation Data from the Program.

The pre-course MCQ paper consisted of 14 questions, and the post-course MCQ paper consisted of the same 14 questions with an additional 9 new questions, for a total of 23 questions. There is strong evidence that candidates scored higher in the post-course MCQ test, with a mean score of 83%, compared to the pre-course MCQ test, with a mean score of 59% (t27 = 7.2; p<0.001). The mean difference is estimated at 24%, with a 95% confidence interval of 17% to 30%. Twenty-six out of 28 participants received a higher score in the post-course test.

The participants rated all lectures and workshops as very good to excellent. The difficult airway workshops and the basic/advanced life support stations received particularly positive feedback.

Conclusions and Recommendations for Future Use and Development.

The use of the iSimulate app with 2 iPads, a router, and a BLS manikin, is a portable and effective way of using simulation for teaching in Low Middle Income Countries. The equipment carries lightweight and non-bulky. The iPads and router need to be charged overnight and can then run on a battery supply, which make them ideal for use in environments where electricity supply is not constant and reliable. Set up time for this configuration is minimal, as the iPads, router and manikin require no physical wiring connections. Although the BLS manikin has no voice or breath/heart sounds, the
instructor can give these cues. The course was successful in teaching principles of management in anaesthetic crises, as demonstrated by a mean difference in pre and post-test scores of 24% (95% CI 17% to 30%). We would recommend this method of using simulation where a portable and basic simulation setup is required for teaching.

References.

iSimulate Pty. Ltd. Unit 17 Molonglo Mall, Fyshwick, ACT 2609 Australia. www.isimulate.com.au
Using Eye Tracking, Continuous Heart-Rate And Perceived Task Difficulty To Assess The Effects Of Low- Versus High-Environmental Fidelity Simulations On Performance Of Entry-Level Paramedicine Students

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Aims.

To determine if early-stage students perform worse in HFS (high fidelity simulation) than LFS (low fidelity simulation).

Background.

It has been suggested that amongst entry-level students, greater psychological fidelity may be inappropriate when the goal is to maximise learning of a skill in its initial stages [1]. For more experienced students, having already mastered a basic skill, a higher level of psychological fidelity may be more suitable.

The Challenge Point Framework (CPF) supports this progression of low- to high-fidelity simulation, as it recommends an appropriate level of challenge aligning with student experience to maximise experiential learning [2]. Early-stage students should be provided new information in limited amounts in a controlled practice area, with minimal extraneous distraction, so as to avoid ‘cognitive overload’ (i.e., LFS). However, students later in their training should be able to process information more efficiently and are better suited to more dynamic learning environments more closely emulating real-world settings (i.e., HFS).

While this contention makes intuitive sense, the evidence supporting this progressive continuum of low- to high-fidelity simulation remains in its infancy. This project received funding from the Australian Government.

Methods.

Participants were 39 first-year paramedicine students from Edith Cowan University. Students were randomly assigned to HFS or LFS groups. The clinical scenario involved a man (SimMan 3G manikin) collapsing in a nightclub with an obstructed lower airway, non-responsive and not breathing. Laryngoscopy revealed the obstruction and removal was achievable with Magill forceps. Equipment fidelity remained constant between study conditions but environmental fidelity was extensively manipulated in the HFS with multiple extraneous distractors designed to draw focus away from the patient including: a darkened setting, loud music, flashing lights, projected background dancers and multiple interactive bystanders played by live actors, including a distressed girlfriend, a bouncer and a cantankerous drunk. In contrast, the LFS environment was in a well-lit room devoid of environmental distractions.

Measures of psychological fidelity experienced by students included visual fixations of clinically relevant and non-relevant stimuli measured via eye-tracking goggles (MobileEye, see Figure 1), continuous heart-rate (HR) data (Polar), a perceived task difficulty survey tool (NASA-TLX) and finally an unstructured, face-to-face interview with each student immediately following a simulation. Student performance was inferred by a dichotomous measure of whether students successfully located and removed the obstruction and a continuous measure of time-to-completion.

Results.

Our measures consistently suggested students in the HFS group experienced greater psychological fidelity than the LFS group. Amount of time students fixated upon stimuli extraneous to the clinical treatment of the patient was significantly higher in HFS than LFS (31.5 vs. 4.4 seconds, p<.001). HFS participants rated the ‘mental demand’ of the scenario significantly greater than LFS participants (15.74 vs. 13.75, p<.05). HR for the HFS group increased by an average of 11.92 bpm from baseline compared to a decrease of 2.43 bpm for the LFS group (see Figure 2). This difference was statistically significant (p=.001).
The proportion of students who revived the patient was greater in the HFS than LFS group (58% vs. 30% respectively). However, this difference only approached statistical significance ($p=.076$). Time-to-completion was significantly quicker for students in the HFS condition compared to those in the LFS condition (6.4 vs. 7.9 minutes respectively, $p<.01$). This difference remained significant when isolating those that removed the obstruction (5.8 vs. 7.9 minutes in the HFS and LFS scenarios respectively, $p=.034$).

Participants in the HFS condition confirmed bystanders, loud music and flashing lights forced their attention away from the primary patient. In the LFS condition, participants remarked that the simulation could have benefited from a heightened level of environmental fidelity and commented they experienced low psychological immersion. Participants in both conditions felt stressed; HFS participants attributed this to the realistic nature of the scenario while LFS participants seemed to focus more on assessment anxiety. HFS participants generally considered the simulation to be challenging and stressful but welcomed the opportunity to practice in a highly realistic simulation. LFS participants on the other hand seemed to be less concerned with helping the patient in a timely manner than ensuring stringent application of processes due to the ‘assessment’ type feel of the simulation.

**Discussion and Conclusions.**

Our data do not support the suggestion that high environmental and psychological fidelity is inappropriate for early-stage students. Students appreciated the highly immersive nature of the HFS environment thereby facilitating timely performance of clinical skills. The LFS on the other hand too closely resembled regular clinical assessments which appeared to lessen the need for students to perform tasks quickly, but heightened the incentive to perform tasks thoroughly. The results of the present study have implications for curriculum design, particularly for early-stage students, suggesting that the inclusion of HFS may not hinder learning through cognitive overload, but can work to facilitate increased psychological immersion in simulated scenarios expediting timely performance of clinical skills.

**References.**

Innovation in Simulated Patient Programs – The Simulated Patient Rating Tool

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Aim of the Education Program.

Simulated Patient Program use is high in undergraduate medical education. Commonly used for teaching communication skills and to increase complexity in hybrid simulations, the methodology has been widely discussed across literature. Methodology and approach is a common issue. Reports by Nestel et al (2011) and others discuss the complexities of recruitment, training and assessment. Common measures of quality assurance include compulsory training sessions, standardisation of training and including session evaluations. At our individual institution a review of practice was undertaken. Key findings resulted in the need to develop a Simulated Patient Rating Tool to enable a standardised approach to performance review.

Methods Adopted.

Based on concepts used in behaviourally anchored rating scores, the tool was designed to address fundamental elements considered by literature, methodology and key stakeholders within the Simulated Patient program. Four broad domains were established, with specific categories grouped within the respective domains. Each category is scored individually in a simple likert scale. Unsatisfactory scores zero, Borderline scores one and Satisfactory scores two. An additional column was added to the right to identify additional desirable skills (no score attracted) – for more complex scenarios. Each score per category contains descriptions detailing the expected behaviours. Categories covered attitude, conscientiousness, interpersonal skills, availability, memory, multi-tasking, acting skills and professional role. Conscientiousness, memory, acting skills and professional role were ‘weighted’ in bold to indicate that Simulated Patients must achieve satisfactory in these areas to be considered for the program, highest score of 18 achievable. Results of scoring indicate whether Simulated Patient is suitable for lower or higher level roles. In addition to the objective scoring, the user has the ability to subjectively rate the Simulated Patient based on the user having concerns. The user is asked to circle ‘Concerns’ or ‘No Concerns’ following the objective rating, with room to identify the behavioural elements that cause concern. The tool was designed for use at initial contact and then for each session the Simulated Patient participates in. It is multi-user designed so that facilitator/faculty, student and peer review can be used.

Evaluation Data from the Program.

The tool was piloted on a convenience sample of 12 new simulated patients at an orientation/audition session. Simulated Patients were given 10 minutes to preview the Rating Tool. Faculty users scored independently and compared results. Results between Faculty were similar. Three of the candidates did not meet all essential criteria. Only one Simulated Patient attracted a subjective rating of ‘Concern’ due to extreme shyness.

Users commented descriptors were clear and it was easy to distinguish who would be suitable for lower and higher level Simulated Patients. Of the responses received from the Simulated Patients, 75% strongly agreed and 25% agreed that the tool was helpful. 50% of respondents strongly agreed and 50% agreed that they would feel comfortable to use this tool to rate their peers. Results from the facilitators indicated that the tool would be helpful to rate Simulated Patients (100%) and the essential categories were relevant (100%). Some small user flaws were identified that made certain elements of scoring unclear.

Conclusions and Recommendations for Future Use and Development.

Overall the Simulated Patient Rating Tool was effective and worked well. Recommendations for further advances include separating desirable scores clearly away from essential criteria. Further pilots will be commenced at other sites and universities, firstly with facilitator/faculty use, then progressing to student and peer use (following ethics approval).
References.


