Virtual Immersive and 3D Learning Spaces:

Emerging Technologies and Trends

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Chapter 14
Crouching Tangents, Hidden Danger:
Assessing Development of Dangerous Misconceptions within Serious Games for Healthcare Education

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ABSTRACT

In this chapter, the authors examine different types of serious games for healthcare education and pose some hard questions about what they know and do not know about their effectiveness. As part of our analysis, the authors explore general aspects of the use of educational simulations as teaching-learning-assessment tools, but try to tease out how to study the potential such tools might have for leading students toward developing misconceptions. Being powerful instruments with the potential of enhancing healthcare education in extraordinary ways, serious games and simulations have the possibility of improving students' learning and skills outcomes.Their contribution is an overview of current education technologies related to serious games and simulations with a perspective of potential development of misconceptions in the healthcare education community, with a special focus on millennial students. In addition, the authors provide insight on evidence-based learning and give a perspective of future trends.

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INTRODUCTION

Our work in the health sciences identified a number of issues in the literature that raise concerns about possibilities of health sciences students developing misconceptions while working within certain types of instructional modalities. Some of these misconceptions could have deadly consequences as these students progress into positions of healthcare providers and become engaged in patient care. Misconceptions can be defined as students' mistaken thoughts, ideas, notions, an underdeveloped pattern recognition (Balkissoon, Blossfield, Salud, Ford, & Pugh, 2009), and can develop before, during, and after learning, leading to erroneous concepts in conceptual and performance competencies (Ozmen, 2004). A number of students' mistaken beliefs about the sciences are present in incoming student population, which affect students' performance in undergraduate and even graduate courses (Halloun & Hestenes, 1985; Ozmen, 2004). Literature describes a number of studies regarding students' misconceptions in the health sciences, including students' erroneous concepts, such as in respiratory physiology (Michael et al., 1999). Emerging computer simulations have been used to uncover and address serious health science students' misconceptions, such as erroneous preconceptions in clinical digital rectal examination (Balkisoon et al., 2009), a critical procedure used in the detection of colon cancer that needs to be properly learned and practiced.

In this chapter, we argue that serious games (video games whose main objective is educational in contrast to entertainment) and computer simulations appear to have a high potential for shifting the way content and skills are taught and possibly improving higher order reasoning. However, we also point out that evidence is lacking for a generalized theory of how and why to build serious games so that they "really work" to improve learning in predictable ways and so that they do not promote development of misconceptions. We feel there has been very little attention given to how misconceptions are developed. Certainly, there are some interesting and important contributions to research on misconceptions. As mentioned above, there have been studies of misconception development by medical students, undergraduates working in respiratory therapy, and a major review of misconceptions developed by students studying chemistry (Balkissoon et al., 2009; Michael et al., 1999; Ozmen, 2004). And, we note very interesting work by Barab and colleagues related to conceptual understanding and consequential engagement in virtual, immersive learning environments (Gresalfi, Barab, Siyahhan, & Christensen, 2009; Barab, Scott, Siyahhan, Goldstone, Ingram-Goble, Zuiker, & Warren, 2009; Hickey, Ingram-Goble, & Jameson, 2009). Even so, given the importance of misconception development in healthcare training, the paucity of research is surprising.

What Really Works in Education

Over a decade ago, Tashiro & Rowland (1997) published a challenge to educators and researchers, posing the confounded questions of: What really works in instructional approaches and materials, for whom, when, why, and with what outcomes? At the time, they were focusing on biological and environmental sciences domains, but they extended their work to look more broadly into a variety of disciplines. In particular, they began to focus on essential problems related to how undergraduate students learn and what types of instructional materials are likely to address seven questions, first posed as an integral set by the United States National Research Council (2000, 2001, 2005):

1. How do instructional materials enhance disposition to learn?
2. How do the materials provide multiple paths for learning?

3. How does an instructional package help students overcome limitations of prior knowledge?
4. When, how, and why do the educational materials provide practice and feedback?
5. Can the instructional materials help students develop an ability to transfer knowledge acquired by extending knowledge and skills beyond the contexts in which they were gained?
6. How will the instructional package incorporate the role of social context?
7. How and why will the instructional materials address cultural norms and student beliefs?

Analyses of instructional materials during the past decade reveal that few address all seven questions.

Interestingly, in the decade since the National Research Council (NRC) posed these questions, there has been increasing interest in use of gaming technologies and simulations as well as publication and use of a diverse array of electronic instructional materials. Certainly, recent syntheses by the Federation of American Scientists (2006) and the American Association for the Advancement of Science (AAAS) Invention and Impact Conference (2004) provided convincing evidence for exploring the use of educational technologies. In particular, advances in artificial intelligence algorithms as well as advances in gaming and simulations open important opportunities to build educational materials that might improve learning and skills development. Educational publishers are already re-organizing to support development of serious games for teaching and learning at all academic levels. Major conferences in education and gaming have been focusing a large percentage of their sessions on papers related to the use of serious games in science, technology, engineering, mathematics, and health sciences education. Yet, there are still few well-developed frameworks for evidence-based learning that might provide guidance for development of serious games and simulations that really work to improve educational outcomes.

During the past year, we synthesized a better understanding of what we do not know about "what really works" in educational simulations and serious games. In particular, our work in the health sciences raised some concerns about the possibility of health sciences students developing misconceptions that could have deadly consequences as these students made the school to work transition and assumed responsibilities for patient care. Consequently, we conducted a comprehensive literature review of educational simulations and serious games (Tashiro, 2009, Tashiro & Dunlap, 2007). This review revealed there are important gaps in our knowledge about effective use of educational simulations and serious games:

1. How does a simulation or serious game enhance disposition to engage in a learning process?
2. What are the relationships between the level of realism in a simulation or game and learning outcomes?
3. How do you define the threshold of experience within a game or simulation that leads to measurable learning outcomes?
4. What are the cognitive processes being developed during learning while working within a game or simulation?
5. In what knowledge domains is learning being retained and how stable is the retention?
6. What is the disposition to act on the knowledge gained during work within a simulation?
7. How well can the knowledge gained within a game or simulation be transferred?
8. What are the differences in learning that manifest as conceptual competencies and performance competencies?

The results of this literature review led us to conclude that many studies of simulations and serious games reporting improved learning and skills development had methodological flaws. Furthermore, the sample sizes were often small and limited attention was focused on the multitude of variables shaping learning, and how so many of these variables are confounded. In brief, we were left still fretting about "what really works" in the use of educational simulations and serious games. We also became more interested in the shifting technological savvy, but not necessarily literacy, of students entering undergraduate institutions. In addition, there appears to be differentials between students and faculty members with respect to adaptability to and usability of education simulation and serious gaming environments. As we continued to look at simulation and serious game environments, we could not escape the gnawing uncertainties about what is being learned in such environments, how learning progresses, and what opportunities there are for following tangents to the educational objectives that lead to inculcation of misconceptions, some of which could be quite dangerous in health-related disciplines. Of course, we have no illusions about more traditional methods and materials of education being free of potential for developing misconceptions. Even so, the tremendous emphasis on simulation and serious game usage in education ought to be tempered by the same kinds of standards for evidence-based practice used in healthcare, which led us to promote the idea of evidence-based learning.

We started our path towards evidence-based learning by re-examining what some have called the millennial students and also more critically examining educational publishers' roles in creating electronic educational materials as well as faculty members' roles in using such materials. We present some thoughts on these areas of student and faculty technological literacy, because they serve as a foundation for the rest of the chapter, which unfolds in four additional sections. Following this introduction, we explore types and impacts of emerging educational technologies. Building on such technologies, we go more deeply into an analysis of serious games and simulations in healthcare education, where misconceptions could have more immediate and deadly impacts during patient care planning and delivery. The next section provides a synthesis of how and why misconceptions could develop and how clinical judgment might be impaired. We then turn to an analysis of why we have had so little evidence-base learning in education and how evidence-based frameworks could sensibly be developed. In this context, we offer some thoughts on future trends and conclusions we have drawn from studying serious games and simulations developed for education.

Millennial Students

A great deal of discussion has surrounded the generation called the "millennials," also known as Gen Y and Generation Next. Strauss and Howe probably give the best summary description of the millennial generation in the course of four books (Strauss & Howe, 1991, 1997; Howe and Strauss, 1993, 2000; and references therein). Traditional teaching-and-learning environments are often quoted by the millennial generation as "boring" and not addressing the unique learning needs of this generation (Hanna, 2003 p. 44). According to Oblinger (2003), millennials exhibit distinct learning preferences. They prefer team work, experiential activities, structure and the use of technology. Millennials are very technologically literate and see technology as a necessity, both in life and in learning (Mangold, 2007). The fact that the millennial generation has always been digitally connected has led to a mindset unlike any that educators have ever seen. Understanding this mind set is an important aspect of educational planning and course development. This generation highly regards "doing rather than knowing," making interactive, experiential learning, a necessity for their educational success. They self-report that they do not appreciate or learn as much from passive learning which most often occurs in lecture style teaching. Instead, they want to be actively involved, preferring, expecting, and appreciating the use of technology in learning (Sinclair & Ferguson, 2009). However, the use of such technology has not been widely adopted to address the learning needs of today's students.

Virtual environments and video games offer students the opportunity to practice their skills and abilities within a safe learning environment, perhaps leading to a higher level of self-efficacy when faced with real life situations where such skills and knowledge are required (Mitchell & Savill-Smith, 2004). Virtual reality and videogame technologies have been noted as some of the most effective means of promoting interactivity and active involvement in learning (Cowen & Tesh, 2002). Gaming and interactive simulation environments support learner-centered education in which learners are able to actively work through problems while acquiring knowledge through practice. Students can engage with the problem, perform research, gather information, perform analysis and evaluate hypotheses through experimentation. Such environments may be more effective for engaging the current generation of students (Annetta et al., 2006).

With these experience-based, instructional methods, faculty can work as facilitators, attending more closely to the experience and subsequent knowledge acquisition. These experience-based methods: (1) incorporate more complex and diverse approaches to learning processes and outcomes; (2) allow for interactivity; (3) allow for cognitive as well as affective learning; and (4) perhaps most importantly, foster active learning (Ruben, 1999). The active learning inherent in games is believed to be a more effective method of obtaining and retaining information than traditional passive forms of learning (Sprengel, 1994).

Yet, we are still faced with the uncomfortable question of "what really works" to improve higher order thinking without instilling misconceptions. For example, even given the propensity of millennials (perhaps because of the propensity) to engage in new models of instructional environments, how do we know if misconceptions are developed. What are the potentials for embedded interactions to lead students on tangents in their development of cognitive schema? Such cognitive schema may have flaws in pattern recognition and so lead to misconceptions. Misconceptions can lead to incomplete understanding of complexity in many discipline areas and certainly to the possibility of adverse medical effects and possible death of patients when health sciences students become healthcare practitioners.

The Ethics of Building and Using New Educational Technologies

As our appreciation grew for millennial students' attributes and their preferences for teaching-learning environments (Pew Research Center, 2007), we turned to studies of publishers of electronic instructional materials at the undergraduate level. What were publishers producing for student consumption as educational materials? In addition, how were faculty members shaping publishers' development of electronic materials such as educational simulations and serious games? Furthermore, how are faculty selecting and then implementing instructional methods and materials based on simulations and serious games?

Educational materials are developed by publishers and educational methods utilizing these instructional materials are developed and implemented by faculty members. We examined the ethical issues of developing and using electronic educational materials designed for healthcare education at the undergraduate level. Our approach used an ethical framework called "the four principles with attention to scope" in order to examine the roles of publishers and faculty members in development and usage of electronic healthcare educational materials (Tashiro, 2009). In particular, we focused on the extent to which publishers and faculty achieve the four ethical principles of autonomy, beneficence, non-maleficence, and justice. The results of our study suggested that both publishers and faculty members do not achieve what is required by these four principles. However, the story is complicated by the confounding of publishers' and faculty members' roles in developing educational materials and then selecting these materials for students as well as implementing them in teaching, learning, and learning assessment environments. We concluded that an ethical analysis must be coupled to an evidence-based learning framework. From such coupling, we argued that it would be possible to define praxis frameworks for evidence-base learning that would delineate ethical strategies for developing, choosing, and using instructional materials.

Finally, faculty members select and implement the educational materials for their respective courses. It is possible that some electronic educational products actually could improve learning, but only if properly implemented in a course. What responsibility does a publisher have? What responsibility does a faculty member have in selecting and implementing a set of educational materials? Importantly, the diversity of electronic instructional materials is growing rapidly. Almost none of these materials have an evidence base for how and why they really work to improve learning. Thus, educational materials developers and faculty do not have a sound research foundation for estimating the potential of an educational instructional package for helping students learn. Furthermore, as a concomitant, developers and faculty have "virtually" no adequate measures of an instructional packages potential for inculcating misconceptions, some of which may be dangerous when applied by students in real-world settings.

We can obtain a sense of the complexities of understanding development of learning and misconceptions by first examining the diversity of educational technologies now being applied to teaching, learning, and assessment in education.

Chapter Overview

The objective of this chapter is to analyze the potential of serious games and computer simulations to improve learning in predictable ways, and so that they do not promote development of misconceptions in health science students. In this **Introduction** section, we have outlined some of our concerns about what we might know and do not know about "what really works" in educational simulations and serious games. We included reflections on millennial students' experience with videogames. This introduction section also briefly addressed ethical aspects of building and using new educational technologies.

In Section 2, **What is Possible: Emerging Educational Technologies** we, provide an overview of recent and novel educational technologies that use different human sensory modalities, such as haptics (related to the sense of touch), smell interfaces for learning, and augmented reality. In brief, we explore combining various human sensory channels to support learning. This section also poses a number of questions about how to build those emerging educational technologies to improve learning and skills development, leading ultimately to overcome students' misconceptions.

For Section 3, we explore **Serious Games and Simulations in Healthcare Education**. In this section we outline a general description of research and applications of serious games, the 3D social network called Second Life, and simulations in healthcare education. We examine how games and simulations could support development of skills training and learning in healthcare education.

Section 4, **Exploring Potential for Development of Misconceptions in Clinical Judgment**, offers a vision of the possibility of health sciences students developing misconceptions that could have deadly consequences if these students became healthcare providers and engaged in patient care.

We close the chapter with Section 5, **Evidence-based Learning and Future Trends**. In this last section we examine some of the literature that converges on the idea that there are educational benefits to electronic educational materials that use simulations and gaming technology. In addition, this section points out the important opportunity to build evidence-based frameworks for learning, based on serious gaming and simulations.

WHAT IS POSSIBLE: EMERGING EDUCATIONAL TECHNOLOGIES

Tactile Interfaces for Training

A number of tactile interfaces have been developed to help develop psychomotor skills, often with coupling of tactile manipulation to problem-solving or decision making while implementing a complex procedure. Although simplified somewhat, tactile interfaces are generally the integration of a haptic device with a suite of expert algorithms or knowledge systems that allow an end user to manipulate the haptic device and receive tactile and visual feedback on manipulation outcomes. An interesting evidence-based approach was taken by Reznek, Chantal, & Krummel (2002) in their study of a virtual reality intravenous insertion simulator. These researchers explored the construct and content validity of the experience of virtual IV insertion and also studied end users' perceptions of the simulator. This simulator allows the user to see the patient on a computer screen and through a haptic device allows one hand to apply traction to the skin of the virtual patient while using the other hand to insert the catheter. Tactile, visual, and auditory feedback is provided.

A diverse array of tactile interfaces are now being studied in surgery, diagnostic imaging, laboratory techniques, dentistry, and other domains in which tactile feedback and complex decision making must be coupled (as a starting point the reader might be interested in Akkary, Bell, Roberts, Dudrick, & Duffy, 2009; Desser, 2007; Souza, Sanches, & Zuffo, 2009). A growing literature is examining how and why such interfaces work to improve learning and development of skills that require physical manipulation coupled to complex reasoning.

Olfactory Interfaces for Training

Although visual, auditory, and tactile human sensory channels have been successfully researched in virtual reality settings for training, there is emerging research on the sense of smell. We used to joke that "scratch and sniff" smell cues for computing (or perhaps click and sniff), but smell has been used in virtual reality for training. Work also has progressed on the technical aspects related to how to incorporate odors in educational virtual reality (i.e. usability, storage and dissemination of odors). Washburn et al. (2003) have found that employing the sense of smell in virtual reality is an effective way of supporting learning and technical training, without compromising the cognitive load of students and trainees.

Most of the advances with respect to virtual reality systems that incorporate olfactory information have evolved in military training. According to Vlahos (2006), the U.S. military, based on research and development carried out by the University of Southern California and theme-park designers, have developed virtual reality simulators to train U.S. soldiers. In the simulation environment, researchers have integrated some artificially-created odors to enhance the ambience of a simulated war scenario. The soldiers don an electronic device around the neck where the scents are generated, and each odor is activated remotely through a wireless network, according to the events generated in the virtual reality simulation and from the soldiers. When soldiers shoot simulated weapons in the virtual environment, they perceive the smell of gun powder, generated by the electronic device they wear. Preliminary research on this application claimed that the use of smells enhanced mental immersion of the soldiers in a realistic war zone simulation, and smell may be key element that favours improved training outcomes.

Spencer (2006) reviewed a number of research projects about using artificially-generated odors used along with 3D medical simulators for teaching and training, since olfactory cues are key factors in medicine to make a correct patient diagnosis in some diseases. Spencer discussed the technical feasibility of using odors in virtual reality simulations for medical training, thanks to recent technological devices for smell production in a computer interface. There are a number of efficient ways to activate such smell production, both remotely over the Internet and in local networks. Spencer demonstrated that adding simulated odors to a virtual reality medical simulator is an effective way to complement diagnosis and enhance training skills in medicine students.

Augmented Reality Interfaces to Support Training

Sanne, Botden, & Jakimowicz (2009) examine different types of simulators, focusing on augmented reality simulators for training in laparoscopic surgery. While there are a variety of augmented reality interfaces being developed and used in education, these authors contrast a set of simulators that combine elements of real-world activities set within an augmented environment. They define the augmented simulators as integrated systems that use hybrid mannequin environments with haptic feedback and capable of engaging users in more physically realistic training that utilizes real instruments that the user manipulates in order to interact with real objects. An interesting facet of the work described by these authors is their comparison of different simulation systems with the intent to understand how such augmented environments can be constructed and used in ways that provide unbiased and objective assessment of end users' performance within the system. They also extended their analysis to discuss how such performance measurements could enhance training and be used as a complementary assessment tool to knowledge-based examinations. Such approaches could allow the development of new types of combined assessment activities that would define benchmarks for certification in a particular skill area.

Sanne and colleagues (2009) point out that augmented reality interfaces or environments allow an end user to use the same instruments they would in a real-life situation. Depending on the design of the augmented reality interface, the simulator may add to the variety of virtual experiences (internal body views as seen through a laparoscope), learning resources (demonstration videos), and assessment subsystems (recording of the end users actions and choices). These types of augmented reality systems for laparoscopic surgery have been studied to evaluate construct validity, face validity, skills acquisition, and comparisons between augmented and virtual reality systems as teaching, learning, and assessment systems.

Augmented reality systems are emerging in other educational domains, such as learning a second language (Wagner & Baraconyi, 2003), and understanding 3D structural amino acids (Chen, 2006), among other learning areas. We believe strongly that a broad and diverse literature has pointed out factors shaping learning and these factors can help us understand how to build educational methods and materials to improve learning and skills development. We examined only three areas above, touch, smell, and combined facets of real-world and virtual world elements. What about the impacts of sound within a teaching-learning environment? How might sound impact development of skills and higher order reasoning (see Bishop & Cates, 2001, for a discussion of the benefits of sound with respect to learning)? What about the real-world hustle and flow of a rapidly changing situation in one place, such as care for a trauma patient just entering an emergency room? Can we imagine, build, and evaluate an environment that allows exploration of the complexity of temporal and spatial variability, such as a teaching-learning-assessment system that provides an experience of ecological research that takes the end user into the tributaries of a major river system at different times of the year. Furthermore, how do we authentically assess the construct and face validities of such a system, the reliabilities of different learning-skills assessment probes, the extension of knowledge gained to related problem areas, the retention and transfer of knowledge after exposure to the teaching-learning-assessment environment, and the costs in equipment, facilities, and instructor time to implement a system that might actually optimize learning and skills development for diverse end users.

In the next section, we turn to discussions of a general description of research and applications of serious games, the 3D social network called Second Life. We also examine simulations in healthcare education. This approach allows us to explore the use of multimodal human sensory channels through 3D graphics, sound, and haptics, supporting skills training and learning.

SERIOUS GAMES AND SIMULATIONS IN HEALTHCARE EDUCATION

Serious Games

In addition to games intended specifically for training of healthcare workers, there are a many games designed to educate healthy lifestyles and promote health-related behaviour changes. This includes promotion of healthy diet (Thompson et al., 2007, Baranowski et al., 2003), physical activity/fitness (Madsen et al., 2007, Tan et al, 2001, Unnithan et al., 2006), behavioural issues in asthma (McPherson et al., 2006), diabetes-related behaviour changes (Aoki et al., 2004, Brown et al., 1997), and educating paediatric cancer patients about cancer and its treatment (Kato and Beale, 2006). Immune Attack^{TM} is freely available educational game developed by the American Federation of Scientists that introduces basic concepts of human immunology to middle school, high school, and entry-level college/university students. Students guide a *nanobot* through a 3D environment of blood vessels and connective tissue trying to save a sick patient by retraining her non-functional immune cells. Along the way, students learn about the biological processes that enable the body to detect and fight infections (see http://fas.org/immuneattack/download).

The term "serious games" has emerged to denote games with at least some intent for learning to take place. Although no particularly clear definition of the term is currently available, serious games usually refer to games that are used for training, advertising, simulation, or education and are designed to run on personal computers, video game consoles, or Web-based portals. Serious games can be designed to provide a high fidelity simulation of particular environments and situations that focus on high level skills that are required in the field. They present situations in a complex interactive narrative context coupled with interactive elements that are designed to engage the trainees. Goals and challenges require the trainees to solve specific problems that they may have never seen prior to engaging in the game, which may increase the fun or entertainment value to the player. In addition to promoting learning via interaction, there are various other benefits to serious games. More specifically, they allow users to experience situations that are difficult (even impossible) to achieve in reality due to a number of factors including cost, time, and safety concerns. In addition, serious games support the development of various skills, including analytical and spatial interpretation, strategic decision-making, recollection, psychomotor development, and visual selective attention skills (Mitchell & Savill-Smith, 2004). Further benefits of serious games include the potential for improved self-monitoring, problem recognition and solving, improved short-and long-term memory, increased social skills, and increased self-efficacy (Michael & Chen, 2006).

In contrast to traditional teaching environments in which an instructor controls the learning (e.g., teacher centered), serious games present a learner-centered approach to education in which the student as player controls the learning through interactivity. Such engagement may allow the student-player to learn via an active, critical learning approach (Stapleton, 2004). Game-based learning provides a methodology to integrate game design concepts with instructional design techniques to enhance the educational experience for students (Kiili, 2005). Video games provide students the opportunity to learn to appreciate the inter-relationship of complex behaviors, sign systems, and the formation of social groups (Lieberman, 1997). Games inherently support engagement and, if engagement is sustained, the play in the game may facilitate experiential learning by providing students with concrete experiences and active experimentation (Kolb, 1984; Squire, 2008). By designing the scenario appropriately, a problem-based learning approach can be realized (Savery & Duffy, 1995). Similar to a good game designer, an educator should provide trainees or learners with an environment that promotes learning through interaction (Stapleton, 2004). Very interesting reviews on games and learning have been provided by Aldrich (2004, 2005). Bogost (2007), Gee (2003, 2004, 2007), Juul (2005), and Gibson, Aldrich, & Prensky (2007), Selfe (2007), and Shaffer (2006), and Squire (2008).

In addition, key conclusions by the Federation of American Scientists (2006; also see American Association for the Advancement of Science, 2004) provided important insight into building educational games. In a 2005 summit, there was interesting convergence on eight conclusions reached by expert working groups:

1. It is clear that the modern workforces of technology-oriented countries require the skills that many video games require players to master.
2. Attributes of games could be useful in applications in learning (contextual bridging, increased time on task, improved motivation and goal orientation, personalization of learning, feedback, cues and partial solutions).
3. Games for education differ from games for entertainment.
4. Rigorous research is required to help translate the art and technologies of gaming into teaching, learning, and assessment systems.
5. Video game and educational materials industries are inhibited by high development costs and uncertain markets for educational innovations developed as learning games.
6. There are a variety of barriers that inhibit markets for educational games, including market fragmentation, faculty members' and parents' negative attitudes about video games, and lack of evidence for efficacy and evidence-based learning through gaming.
7. Educational institutions are slow to transform practices and organizational systems that take advantage of new technology, including gaming and simulations.
8. There is no serious evidence-based learning framework that currently exists for implementing large-scale evaluations of the outcomes of using educational games.

Previous Work

Game playing dates back several thousands of years to the start of civilization (Bartfay & Bartfay, 1994), and the benefits of games to learning, has been used as a teaching tool for centuries (Henry, 1997). However, despite recent emergence and increased application of serious games, and game-based learning in healthcare education and training, their use is still fairly limited (Corbett & Lee, 1992). With respect to nursing education, a variety of "traditional" (non-video) games have been used in the past (Cowen & Tesh, 2002). Lewis et al. (1989) described the use of crossword puzzles and bingo-type games in nursing curricula while Stern (1989) described the use of games based on popular board games and television game shows for nursing education. The results of such studies suggested Jeopardy!-type games are effective for learning new knowledge, reviewing information, and applying concepts. Cessario (1987) developed a board game designed to motivate students to learn conceptual nursing models. This game appeared to be motivational and enjoyable while reinforcing students' learning. Such "traditional" games were not specifically tailored to the various subdiscipline areas of nursing.

Another approach was taken by Tashiro and colleagues beginning in 1996 (Tashiro, 2001a, 2001b, 2003a-d, 2009). With funding from a series of National Science Foundation grants, funding from the National Institute of Nursing Research, and contractual work with major publishers of educational materials, Tashiro and colleagues developed a diverse array of educational games. He stimulated this work by challenging educators and researchers to answer the nested questions, "What really works in the educational games, for whom when, how, and with what outcomes (Sullins, Hernandez, Fuller, & Tashiro, 1995; Tashiro & Rowland, 1997). The very first simulation model was one of the first virtual hospital systems for education and was based on the game Myst, created within Adobe Director.™ The learning environment anticipated the kind of movement and interactions now possible in Second Life. These learning environments were built from an evidence-based framework. Interestingly, although student end users enjoyed the gaming quality, faculty did not.

Tashiro rebuilt the simulations as flash-based applications that could be executed from CD-ROM and were designed to meet faculty concerns while still appealing to students. This next generation of the virtual hospital system addressed the National Research Council's seven critical issues in developing improved learning outcomes, especially in areas of higher order thinking like clinical judgment and understanding what nurses "do" as they engage in the nursing process. Over 70 major simulation suites evolved from that first virtual hospital system, including a series of different virtual hospitals, a virtual medical office, and a virtual patient encounter simulation for training emergency medical technicians and paramedics. These serious games allowed students to move around within a virtual setting and encounter patients with complex physiological and often psychosocial problems. Cases were developed by experts in a particular type of disease or injury state, reviewed by expert clinical panels, and developed into simulated scenarios of patient care. Patients had full medical and nursing records, usually with more than 50,000 data fields. These records were automatically updated within the simulations as time passed, just as they would in a real hospital. Later versions of the simulations followed students' choices and provided diagnostic feedback on students' clinical performance compared to choices that would be made by expert clinicians. As the simulations evolved, conditional logic systems were embedded into patient care so that as students' made choices their choices impacted patient outcomes, for better or worse. Together these simulations reach over 50,000 students each year (a small sample includes: Tashiro, Sullins, Long, and Kelly, 2001a; 2001b; 2003a-d; Mathers, 2006; Fulcher 2007a, 2007b, 2007c).

There are a number of virtual simulations/ serious games for healthcare training that cover community health nursing to some degree (emergency management and preparedness, and first responders in particular). More specifically, the Center for the Advancement of Distance Education (CADE) within the School of Public Health at the University of Illinois at Chicago has developed a public health simulation within Second Life that allows public health workers to test their skills in scenarios, such as bioterrorism attacks, smallpox outbreaks, and natural disasters. The focus of this simulation is not so much community health but rather first response preparedness. Players must assess the medical needs of "patients" and take appropriate action (e.g., send them to the proper station or dispense medicine if needed). The goal of the game is to maximize the number of patients handled per hour.

HumanSim^{TM} is a software simulation platform that provides enhanced initial, refresher and sustained medical education and training developed by Virtual Heroes, Inc. (Pulley, 2007). The simulation employs the latest in gaming technology and was designed for use by a wide range of healthcare students and professionals including physicians, nurses, emergency medical personnel, first responders, as well as for use by educators and researchers. HumanSim allows users to practice scenarios in a safe environment where they do not have to fear the consequences of failure. The game addresses the treatment of patients when dealing with different events.

Pulse!! is an immersive virtual learning space (i.e., a serious game) for training healthcare professionals in clinical skills. Game development was funded by the United States Office of Naval Research and developed by BreakAwayGames and Texas A & M University - Corpus Christi. Pulse!! includes cutting-edge graphics to recreate a life-like, environment where civilian and military heath care professionals practice clinical skills in order to better respond to injuries sustained during catastrophic incidents, such as combat or bioterrorism. Code Orange^{TM} is another serious game developed by BreakAwayGames geared towards the training of first responders for emergency preparedness in the event of mass casualties. This game supports a multi-player environment. Players are part of a medical team and their task is to work together to save lives. Code Orange^{TM} is based on the Hospital Emergency Incident Command System (HEICS) protocol (http://www.heics.com/).

Cowan et al. (2008) describe a serious game for critical care team training meant to foster interprofessional education. The game provides a pedagogical approach enabling healthcare practitioners to develop a clear understanding and appreciation of the roles, expertise, and unique contributions of other disciplines within teams of participating healthcare providers. In each scenario, a critically ill patient requires the immediate attention of a critical care rapid response team consisting of a number of healthcare professionals including nurses, doctors, and respiratory therapists. The goal of the trainees is to stabilize the patient through the collaboration of all response team members. The simulation supports an "online multi-player" environment allowing trainees to participate from remote locations. Heinrichs et al. (2008) developed three virtual worlds for team training and assessment in acute-care medicine: (1) emergency department (ED) teams to manage individual trauma cases; (2) pre-hospital and in-hospital disaster preparedness; and (3) ED and hospital staff to manage mass casualties after chemical, radiological, nuclear, or explosive disasters. Evaluations of these virtual worlds indicated that virtual emergency department simulations were able to provide "repeated practice opportunities in dispersed locations with uncommon, life-threatening trauma cases in a safe, reproducible, flexible setting" (Heinrichs et al., 2008, p. 161). Stytz et al. (1997) describe the Virtual Emergency Room (VER) project, a simulation system designed to enable emergency department personnel to practice emergency medical procedures and protocols. The simulation is built upon a distributed virtual environment architecture to enable real-time, multi-participant simulations allowing practitioners from a wide variety of expertise to work together remotely and ultimately to improve the readiness of emergency department staffs for a wide variety of trauma situations (Stytz, et al., 1997).

The interested reader is directed to a number of available resources including the Games For Health Project (http://www.gamesforhealth.org/) that sees the application of cutting edge games and game technologies to a range of public and private policy, leadership, and management issues. Games For Health also holds an annual conference where attendees from a variety of disciplines including medical professionals, and game developers to discuss and share information about games and game technologies and their application and impact on healthcare and policy.

A serious game utilizing behavioral simulation for acquisition of community health nursing skills safely was developed by Hogan et al. (2007), called mSTREET. It presents cost-effective experiential learning, learner-centered approach that addresses the learning needs of millennial students within a community health nursing curriculum. The serious game was built as a module upon the Modular Synthetic Research Evaluation and Extrapolation Tool (mSTREET) serious game platform. mSTREET is designed to deliver computerized virtual training and research environments in a variety of investigative and direct response settings. mSTREET provides a "base framework" for developing specific field modules that are specifically designed to emulate the functional and behavioural processes in various disciplines. Trainees and educators in the supported fields can use the software to easily construct "scenarios" that can be played out in real-time within the safe and controlled environment of a virtual 3D world. The community health nursing module consists of scenarios with specific learning objectives, feedback, and predictors of attainment of the learning outcomes related to community health nursing. A screenshot of one of those scenarios is shown in Figure 1.

Second Life

The previous subsections provide a sense of the breadth of serious games. However, we want to explore at least one serious game environment in some depth. We chose Second Life, a 3D social network that also has been used as a serious game. Second Life (SL) is as an interesting environment and one that is being increasingly used for healthcare education. We note at the start of this subsection that e-learning technologies are emerging at unprecedented rates. A number of areas have been studied thoroughly, including repositories of learning objects, ubiquitous learning environments, ranking systems based on user patterns of online bibliographic items, and automatic paper recommender systems (Ternier et al., 2009; Chang et al. 2009; Tang & McCalla, 2009). Some scholar technologies based on bibliographic indexing have been advanced to available products by Elsevier and Springer (SciVal, 2009; AuthorMapper, 2009). We believe that the right combination of emerging e-learning technologies could potentially be integrated into a unified system, for example within SL. Such consolidation could result in an interesting and powerful suite of learning modules capable of capturing and measuring learning outcomes, as

Figure 1. Sample screenshot of the mSTREET community health nursing module, showing a nurse working in a neglected area of the community

well as being able to perform competency assessments in a number of disciplines.

A number of research institutions around the world have developed and tested networked collaborative virtual reality environments (CVREs) for education and training since the early nineties. Using a local network or the Internet, CVREs allow users from multiple remote locations to interact and collaboratively to work, learn, train, and perform other activities despite being thousands of miles apart (Benford et al., 2001). However, until recently, there were insufficient computational resources and network power or adequate coding-decoding algorithms (codecs) to carry out smooth communications and immersion of participants in CVREs. Consequently, a trade-off between speed and realism was typically made. These types of constraints have limited human modality interactions, except for those focused almost exclusively on the exchange of visual and auditory information (Gutierrez et al., 2004; Chan & Lau, 2004).

Developed by Linden Labs in 2003, SL is a social network in the form of virtual world where millions of Internet users have been registered, and presently contribute to SL by developing and uploading graphical objects (Second Life, 2009). Users of SL can communicate through their graphical avatars (virtual personifications) using gestures, text messages and their voice, employing voice over IP (VoIP) technology. In general, SL graphics and a number of its features can be personalized. For instance, users can modify their avatar's clothing/appearance, as well as trade and sell goods and services using SL's own "currency", referred to as "Linden Dollars". The ability to personalize the Second Life environment is considered by many to be compelling and fun. The SL virtual world contains virtual "islands" (also called "sims") that can be purchased for a fee directly from Linden Labs or from other third-part sellers, including other SL users. Once purchased, the user can opt for using his/her island for their desired purpose. We note that there are two versions of SL, one is for adults and one is for users between 13 and 17 years of age, called Teen Second Life.

SL applications have been developed primarily for entertainment and socializing purposes, although some of its islands are increasingly being applied to education and training. Although the primary purpose of SL education and training applications is not necessarily "fun" and entertainment, this does not imply that such applications cannot be fun and entertaining and, in fact, fun and entertainment can play an integral role. For instance, in foreign language learning, fun and humor can lower the "Affective Barrier." By lowering the affective barrier to learning, student anxiety may decrease, along with other negative feelings towards a learning experience in a collaborative virtual world (Krashen, 1982, 1988). There exist a number of educational islands where courses are being taught, many owned by universities and private firms throughout the world. In addition, some educational institutions provide virtual facilities to students, such as virtual classrooms, laboratories, and libraries (Gollub, 2007). SL also boasts virtual museums that can be used in educational activities as well.

Consistent with Stephen Krashen's hypothesis (Krashen, 1982, 1988) about the affective filter and language learning, there are presently numerous educational institutions offering second language learning classes in Second Life, including the internationally recognized Instituto Cervantes of Spain. This institution also has developed a virtual library containing books in Spanish and Spanish memorabilia, and also a virtual expo hall (Cervantes Institute, 2009).

Literature reporting the use of SL for training in the IT industry has recently started appearing. For example, according to Gronstedt (2007), large IT companies such as IBM, Intel, and Dell, amongst others, are investing in the development of virtual islands, offering courses and technical training in SL to their employees. Still in its infancy, reported studies regarding SL applications and cognitive gains for general training are sparse. That being said, a number of the developers working on these SL training initiatives predict that the number of SL training applications will grow steadily, especially in countries with emerging economies such as Brazil, India, and China (Gronstedt, 2007).

Second Life and Health Training

Large government organizations have shown interest in SL for healthcare education. The United States National Library of Medicine has established a virtual hospital, a medical library, and a health and wellness center in SL's Health Info Island (Pellerin, 2007). In addition, the United States Centers for Disease Control and Prevention (CDC) developed an information center in SL (CDC, 2008). In this information center, virtual staff members explain CDC's goals and mission, providing introductory information about the CDC, and answering questions asked by its virtual visitors. The CDC virtual space currently includes displays of posters and video projections about CDC products, and includes external links to open relevant Web pages. CDC is planning to add a virtual laboratory in the near future, although its purpose has yet to be announced.

Lafsky (2009) reported a number of educational institutions that have been using SL for health training. The Imperial College in London, UK, developed a replica of an operating room (OR) in SL, where medical surgery students can learn and practice OR procedures before they are permitted to practice in a real OR. The Imperial College has also created a virtual respiratory ward, where students can interview avatar patients, guided by volunteers and professors, and make adequate diagnosis, and recommend treatments. Lafsky reports other anecdotal evidences of SL uses in health training. A heart murmur simulator with six virtual patients was created at San Jose State University in the U.S., with the objective of allowing students to listen to real cardiac sounds, perform cardiac auscultations, and identify a number of types of heart murmurs, (data are still being collected and analyzed from 2,500 users who have participated in this training). In addition, a simulator for training nurses in SL was created in Tacoma, WA (United States), called MUVErs Medical Simulation. It contains a "bot" (an avatar patient who has a set script, is semi-autonomous, and can communicate with people), and that can experience chest pain symptoms. Nursing students have to learn to make quick decisions about this "patient" and know how to use equipment (such as a virtual defibrillator).

According to John Lester of the Education and Healthcare Market Developer at Linden Labs (Lafsky, 2009), one of the primary advantages of the simulated operating rooms in SL is their collaborative aspect. They bring together students, nurses, residents, doctors, and even real patients who collaborate in training drills, no matter where those persons are physically located, and to interact in real time through their avatars present in the simulated operating room. Lester also pointed out that another advantage is reduced costs, since it can be very expensive (sometimes in the order of millions of dollars) to build and equip a real training OR facility. In contrast, simulated ORs in SL can be developed for just a fraction of that cost. Another benefit of using collaborative virtual environments such as SL for training is the reduction of travel to and from their educational institutions by both students and instructors. Reduced travel results in reduced fuels costs and reduced carbon footprints may help shape "green" models for education (Theil, 2008).

The creators of SL announced in the Virtual Worlds London Conference held on October 2008 development of a stand-alone SL version (Linden, 2009), which can run on a local server and on a local area network (LAN). One of the benefits of the stand-alone SL version is that it can be custom-configured, and cannot have access to the Internet-run SL metaverse, thus improving confidentiality and privacy issues. Some medical schools have shown interest to acquire and use their own instance of SL for their courses, running in an intranet.

Potential pedagogical benefits of using SL for healthcare training include lowering student anxiety, increasing competencies in learning a new skill, promoting student cooperation and collaboration, learning how to deal with conflict resolutions, and enhancing student self-reflection and active learning (Jackson & Fagan, 2000; Winn, 1993). Further experimental studies are needed to confirm those benefits. Such research is still in an early stage, without clear conclusions about the medium and long-term training gains of SL.

Despite the potential benefits with respect to education and training SL offers, Hansen (2008) warns that there are many issues and questions that need to be answered about educational and skill gains related to health training in SL. The applications in health training are still in a relatively nascent state. Hansen found that a main issue related to use SL for training is how relevant training in SL is for teaching medical professionals, including how fast, and to what extent SL will be embraced by healthcare trainees and educators. We note that none of the reviewed articles on SL have directly addressed students' misconceptions.

Technical Issues on Second Life

In order to run smoothly, SL requires a considerable amount of computational resources, such as an efficient video graphics card, a large RAM memory, and a reliable Internet connection with large bandwidth, (from 1.544 to 6 Mbps). According to SL´s web page (http://secondlife.com/support/system-requirements/?lang=en-US). SL needs a cable or DSL connection for accessing the Internet, and the latter Web page warns that "Second Life is not compatible with dial-up internet, satellite internet, and some wireless internet services." These requirements are strict, since we have collaboratively tested SL with very modest success in a local network connected to the Internet through fiber optics and with about 500 kbps at the time of testing. It was not possible to run SL with slower Internet connections or with computers with 1 GB video RAM and less. It may be possible to improve access to Second Life by arranging a guaranteed Service Level Agreement (SLA) with the Internet service provider, or to increase the bandwidth connection, however these can be costly solutions.

Although the network requirements of SL to run efficiently specify a cable or DSL internet connection, evidence indicates that SL may run with IEEE 802.11g wireless networks for a small group of users accessing the wireless network at the same time. However, from our own observations, we recommend the use of SL over WiMAX (Worldwide Interoperability for Microwave Access) technology, already available in some cities throughout the world. WiMAX is a recently created wireless communication medium to provide up to 72 Mbit/s symmetric broadband speed, suitable for multimedia and other types of data, based on the broadband wireless access IEEE 802.16 standard (Kumar, 2008).

A major problem with collaborative VR environments such as SL is the lag and latency inherent with such environments particularly with a "slow" network connection. This latency can negatively affect VE visualization, sound transmission, and user communication in the shared virtual environment and lead to user frustration and in some cases, motion sickness (Fraser et al., 2000). In addition, increased latency will almost certainly hinder user performance, affecting completion of training objectives in VR applications. One of the main causes of slow collaborative virtual world access is network delay that is caused by: (1) the way VR information (in the form of packets) is delivered onto a local network or over the Internet; and (2) how that information is processed at each computer connected to that network (Gutwin et al., 2004). Network delay, or the period of time to update and display the shared virtual environment for all the users, also produces latency in collaborative virtual environments such as SL. This can negatively affect user interaction, ultimately leading to a reduction in the immersive capabilities of the virtual world (Burdea & Coiffet, 2003). There may be some work-around solutions, for example trying a third-party Second Life viewer (client) called Onrez (http://viewer.onrez.com/). Onrez runs somewhat faster than the viewer developed by Linden Labs. There are other third-party companies and research groups that have developed Second Life viewers, available from: http://wiki.secondlife.com/wiki/Alternate_viewers.

Technical Causes that Potentially Hinder Training in Second Life

As summarized in Table 1, there are a number of technical issues with SL that may hinder training. This table is not an exhaustive list of problems, but is meant to provide an overview of issues we have identified. Some of these issues can lead to student misconceptions, for instance, inaccurate representations of the 3D graphical models fail to provide the necessary detail required to perform a task accurately. Student engagement and interest in the simulation may also decline when players are faced with these types of technical problems. Simply put, we need more rigorous research on what really works within SL teaching, learning, assessment environments.

EXPLORING POTENTIAL FOR DEVELOPMENT OF MISCONCEPTIONS IN CLINICAL JUDGMENT

The earlier sections of this chapter introduced some of the emerging technologies and specific examples of serious games with an emphasis on healthcare and with a deeper exploration of Second Life as a likely model for serious games now emerging. We have argued that serious games and simulations appear to have a high potential for shifting the way content and skills are taught and possibly improving higher order reasoning. However, we also point out the evidence is lacking for a generalized theory of how and why to build serious games so that they "really work" to improve learning in predictable ways and so that they do not promote development of misconceptions.

As we mentioned in the Introduction, we have tried to clarify what we do not know about "what really works" in educational simulations and serious games. Certainly, in the health sciences we should be very concerned about the possibility of health sciences students developing misconceptions that could have deadly consequences if these students became healthcare providers and engaged in patient care. We argued earlier that there are

Table 1. Technical issues that may affect training in SL

Issue	Cause
Inaccurate graphical representations or sounds of models/simulations used for training	Poor graphics and auditory design.
Distracters in the training setting	Unnecessary virtual objects placed in the virtual educational setting, or persons flying or teleporting (they are common ways of avatar navigation) around the virtual training facility, as described in Wong (2006).
Network delays	High network latency.
Inadequate computer equipment to run the SL client	Low RAM memory, slow CPUs, inadequate graphics card, etc.

eight gaps in our knowledge about effective use of educational simulations and serious games:

1. How does a simulation or serious game enhance disposition to engage in a learning process?
2. What are the relationships between the level of realism in a simulation or game and learning outcomes?
3. How do you define the threshold of experience within a game or simulation that leads to measurable learning outcomes?
4. What are the cognitive processes being developed during learning while working within a game or simulation?
5. In what knowledge domains can we measure learning as being retained and how stable is the retention?
6. What is the disposition to act on the knowledge gained during work within a simulation?
7. How well can the knowledge gained within a game or simulation be transferred?
8. What are the differences in learning that manifest as conceptual competencies and performance competencies?

An important issue is that each serious game or simulation has its own idiosyncrasies in the construction of how and why the developers mimicked elements of the real world and the interactions that occur in the real world. At the very least, then, we need to contextualize "what really works" within the situated learning experience of each different type of serious game. Even when we break out studies by serious game type, we encounter a variety of problematic issues related to developing an evidence-based approach to learning:

- Many studies purporting improved learning and skills development had methodological flaws.
- A large number of studies are based on small sample sizes with little information on the power of the test.
- Many studies pay limited attention to the multitude of variables shaping learning, especially how so many of these variables are confounded.
- While research studies on educational experience and outcomes tend to focus on a group of student-users, we do not see enough attention paid to covariates that would provide a deeper understanding of effects of computer literacy, familiarity with gaming environments, age and gender differences in preferences for design of environments and navigational schema, and differentials in access to gaming environments as well as machine power and graphics in computers being used.
- There may be new types of differentials between student users and faculty members facilitating use of the serious games for education.

Our ongoing studies of simulation and serious game environments leave us with uncertainties about what is being learned in such environments, how learning progresses, and what opportunities there are for students to engage in and follow tangents to the educational objectives, and that may lead to development of misconceptions. Again, we emphatically note that more traditional methods and materials of education are certainly not free of the potential for students to develop misconceptions. However, we actually have an opportunity to shift education to a more evidence-based framework and to be more thoughtful about and critical of educational methods and materials as faculty members and students become increasingly interested in simulation and serious game usage in education.

We will explore these ideas more deeply by examining a hypothetical virtual world and asking some hard questions about the potential for the environments of that world to potentiate development of misconceptions, especially dangerous misconceptions. Prior to writing this chapter we conducted a series of Gedanken experiments (thought experiments that serve to illuminate a hypothesis or theory). The experiments were conducted on a virtual world that we have been building over the past few years. Earlier versions of these types of Gedanken experiments were described by Tashiro & Dunlap (2007) in their analysis of the impacts of realism on engagement within serious games. For convenience, we will call this virtual world E-LAN, a pun on élan, not to be confused with the Elan programming language, and simply an acronym for Electronic Learning and Networking. We have built and evaluated components of E-LAN. All of the functional specifications have been developed and run through our Gedanken experiments, which we use to imagine a large variety of use cases within E-LAN.

Imagine E-LAN as a virtual world in which the student-player must get to a hospital at a certain time in order to start a clinical rotation. We have built virtual hospitals for nursing students, so we will imagine this version of E-LAN as a serious game for nursing students. Also, for this version of E-LAN, we will create a single-player environment in which the student-player moves through the world in a first-person perspective, that is, looking through the "game character's eyes.". Along the way to the hospital, the student-players will encounter engaging characters and events that may help or hinder them from reaching the hospital on time – sort of like a Grant Theft Auto environment on the way to clinical rotation. They encounter avatars and can talk with these avatars through a voice-recognition system. However, they have to reach the clinical rotation on time, and can earn points by arriving early, but also accrue "difficult" encounters in the hospital if they arrive late. Getting to the hospital is more of a game but some problem solving and critical thinking is possible as student-players try to get to clinical rotation on time.

Once student-players arrive at the hospital, they select a unit and begin clinical rotation. The environment of the virtual hospital and selecting a unit for rotation provide a transition that also interjects a few moments of cognitive dissonance from the possibly wild ride of the gaming environment to get to the hospital. We will return to this idea of cognitive dissonance and shifts along a gradient from entertainment to edutainment, that is from the mostly entertaining elements of a serious game to the mostly educational elements of a serious game.

Within the virtual hospital unit, a preceptor avatar assigns the student-player to one or several patients and asks the student to begin planning and implementing care. The points earned for arriving early can be used by student-players to seek help from their avatar preceptors and clinical decision support systems as they encounter problems or difficult situations. Student-players encounter a variety of difficult situations, such as not being able to find medications, patients developing emergent problems related to their disease-injury state or to a psychosocial crisis, problems with patients' significant others, being interrupted by a preceptor of Nurse Supervisor who is rude or demanding or asking them to stop what they are doing and help with another patient. Problems for student-players who arrived late are built into the rules of the game, with difficult encounters more frequent for late arrivals.

When we designed E-LAN and began Gedanken experiments, we already had developed sets of virtual patients using clinical experts to create cases and expert clinical panels to review and revise cases. This process yielded detailed cases with hundreds of thousands of data for each patient case. These cases represent some of the most comprehensive patient case studies for simulations developed to date for healthcare education at the undergraduate level. We also had figured out virtual environments in which a student-player could engage in almost every aspect of patient care. We also learned how to layer monitoring middleware into the simulations so that we could record student-players' decisions and time spent in various activities. The monitoring data and learning assessments within the simulations allowed us to map student-players' learning and competency outcomes against expectations delineated by expert clinical panels.

Essentially, E-LAN emerged from our review and analysis of the major problems we encountered from building serious games and from our critique of a diverse array of serious games. We then developed solutions to the problems we identified. These problems and solutions, presented in simplified form below, were our attempt to design the virtual world E-LAN as an "ideal" immersive virtual world for education.

Evidence-based Learning Maps and Serious Game Development. There is a gradient that we suggest ranges from games that are totally for entertainment and educational intent is incidental, to games that are designed as educational materials and entertainment is incidental. As a serious game becomes more seriously educational in intent, the entertainment portions and the educational portions need to be planned out carefully. We suggest that the combination of the fun (or at least engagement) and education can be driven by what the US National Research Council (2000, 2001, 2005) described as learning maps. We argue that learning maps should be based on evidence and so then could provide a framework in which the complex interactions within a game are mapped from planned interactions that have evidence for being both engaging and improving some type of learning. Thus, for E-LAN, let us assume that we developed learning maps based on evidence-based clinical guidelines for planning and implementing care as well as on careful attention to what is most engaging within various gaming environments. We also will assume that these maps were reviewed by expert panels and revised according to their recommendations. Finally, the development process involved expert clinical panels and game developers who worked together to study how the learning maps could be expressed as an environment in the virtual world of E-LAN.

Embedded Learning Activities, Learning Resources and Scaffolding. Not unrelated to building a serious game from evidence-based learning maps, learning activities generally, would be embedded as gaming interactions around which were nested or made available in some way a variety of learning resources for use in learning. There also would be scaffolding available to provide ongoing support for the learning process. For E-LAN, let us imagine that the gaming environment was developed through a process of using the learning maps with expert clinical panels delineating clinical scenarios and, with help of gaming experts, the possible interactions within these scenarios. This process could result in serious game development following US National Research Council guidelines (2000, 2001) as well as recommendations from the Federation of American Scientists (2006). Such games would be more likely to enhance students' disposition to learn, provide multiple paths for learning, help students overcome limitations of prior knowledge, provide practice and feedback, help students develop an ability to transfer knowledge acquired by extending knowledge and skills beyond the contexts in which they were gained, incorporate the role of social context, and address cultural norms and student beliefs? In addition, careful structuring and usability testing of virtual teaching-learning-assessment environments could provide embedded learning activities and as-needed educational resources and scaffolding that could facilitate embedding clear learning goals, broad experiences and practice opportunities, continuous monitoring of progress with detailed diagnostic feedback, contextual bridging, personalized learning experiences, and innumerable opportunities for students to repeat the serious game without increasing faculty workload.

Such a process would necessarily involve close collaboration among expert clinicians, educators, and game developers. These collaborations would focus on the gaming facets of the serious game and the educational facets of the serious game as well as the coupling of these into an interesting and engaging environment, shaped by rigorous usability studies and tested with critical end users just as big-name video games are developed and evaluated prior to release. Imagine our panels of experts working together to select and sensibly embed learning resources and scaffolding within the virtual world of E-LAN, paying attention to the game and the education of the serious game. We actually followed this very same process for some of the virtual worlds the authors have built and studied.

Authentic Assessment. In order to know if learning has taken place, learning outcome or competency assessments also can be embedded in the serious game. When and where they occur depend on what type of learning the developer is hoping student-players will engage in and achieve. The concept of "authentic assessment" is important in the sense of developing assessments of what the developer really thinks the game can teach and what the student-players can actually learn, with such assessments having reliability as well as face and construct validity. Imagine that for E-LAN we have authentic assessment methods and instruments with sound reliability and validity. Furthermore, assume that we have been able to automate the assessments tied to encounters with embedded leaning activities and learning resources within the serious game environment of E-LAN. Finally, the system will be built so that an instructor can set the assessments so they map to different types of diagnostic feedback arrays (see below).

Diagnostic Feedback. In serious games, diagnostic feedback would be tied to learning resources and scaffolding and be mapped by the developer to provide sensible feedback on student-players' performance on assessments embedded in the game. When and how feedback is provided depends on educational intent. A simple example in healthcare is learning a procedure accomplished by completing a set of tasks in a particular sequence. One type of assessment would measure the student-player's understanding of each step, with feedback for that step to help the student-player understand the rationale for and performance of a discrete task. Such an assessment-feedback strategy helps students develop a deeper understanding of each task in a sequence of tasks, but would introduce a type of Bayesian bias if you also wanted to see if the student knew the sequence as well as understanding each step. Thus, assessing a student-player's understanding of a sequence might be set up in a way to provide diagnostic feedback based on an assessment that waited until a student completed what s/he thought was the proper sequence. For our virtual world E-LAN, we will assume we have a sophisticated diagnostic feedback system that easily can be set by a faculty member to provide assessment-feedback coupling for learning activities as individual, clusters, or sequences of tasks. This coupling would assess performance and provide feedback on students' knowledge of facts, concepts, procedures, and metacognitive processing (Anderson and Krathwohl, 2001).

Instructor Time. One interesting problem is the time a faculty member must take to learn a serious game and then effectively implement the game. If faculty members decide they take on an avatar in Second Life for example, then they are spending real time engaging with students in a virtual world. It is clear that close faculty mentoring (Quality Education for Minorities Network, 1992) and also careful debriefing may be very valuable to help students consolidate what they have learned while also providing remediation for errors in judgment or underdeveloped pattern recognition while working on a clinical problem. However, how many hours does a faculty member have to work in Second Life or provide such mentoring? Is there any other solution, for example, a knowledge or expert system, or perhaps even a system analogous to clinical decision support systems that could provide ongoing support for student-players in a serious game. For E-LAN, we assume that we have a very versatile expert system, linked to an avatar who can provide as-needed mentoring. We also would have a virtual computer-based knowledge and clinical decision support system that provides on-going cognitive support for student-players (modeled after the recommendations of the U. S. National Research Council, 2009).

Adaptive Learning. We have built and are testing an adaptive learning system that tracks student-players' choices in a serious game and then maps these to learning and competency outcomes to develop a deeper understanding the pathways of how students are learning, their efficiencies, their cognitive processing, and the knowledge and skills development. Imagine that E-LAN has this adaptive learning capacity.

Levels of Realism. We also have studied and now can create modular worlds that allow us to set switches on a gaming platform that can create different combinations of realism, including visual realism of the environment and objects in the environment – including avatars, auditory elements of the environment (such as the complex sounds on a particular type of hospital floor), fine motor activity in avatars, psychosocial attributes and language exchange between student-players and avatars, use of instrumentation, amongst others. Consequently, we can adjust the levels of realism and study the impact of realism on engagement within the serious game as well as study the impact of realism and engagement on realized learning and competency outcomes. In the future, E-LAN also could have levels of realism for sensory perception related to tactile, smell, and sonification elements within the virtual world.

Network Requirements and Adequate Computer Equipment. Some of the technical issues, as described for Second Life, are harder to control, but for E-LAN, let us suppose that we manage network, computer equipment, and other technical issues by setting up a cost-efficient workstation environment that can be easily controlled and is reliable under heavy student usage.

Thus, by solving various problems with current games, we have imagineered the virtual world E-LAN as a pretty interesting and engaging serious game with a variety of student-centred capacities and grounded in the theory and practice of evidence-based learning as well as evidence-based practice in healthcare. We then engaged in Gedanken or "thought" experiments in which we ran the iterations of use cases within E-LAN in order to study how our virtual world could potentiate development of misconceptions as student-players worked and played in the virtual world of this serious game.

At the start of use case iterations, we examined how cognitive and learning sciences inform instructional design in a serious game. Patel, Yoskowitz, Arocha, & Shortliffe (2009) point out that healthcare is general collaborative (or should be collaborative) in its processes of patient care. However, within care delivery settings cognition will be shaped by the situated encounters in that workplace, which are dynamic and strongly influenced by social contexts as well as by a diverse array of other elements in the setting such as technology, temporal and spatial heterogeneity in the patient's condition, changing shifts of providers caring for the same patient, and ongoing coordination of many different tasks and decisions as well as health information management (Patel et al., 2009). Effective action requires development of pattern recognition capabilities as providers move from novice to expert. Such pattern recognition capabilities are critical to clinical judgment and decision-making during planning and implementing care. Often, the decision making unfolds in a "heuristically-guided" sequence (Patel et al., 2009, p. 177). Yet, we need to know what happens if pattern recognition development is incomplete. For example, what is the probability that working in a serious game leads the student-user to tangential analyses and making decisions that are logical to the result of such analyses but that are flawed as pattern recognition?

Pushing more deeply into use case studies, we discovered a sense of the difficulty in finding the "crouching tangents, hidden dangers" in flawed pattern recognition. Our approach focused on the gaps in our knowledge about what serious games and simulations are capable of doing, for better or worse. Earlier we described eight knowledge gaps. We used the use cases to push E-LAN to its limits of "really working" in the context of these gaps. Below, we provide our findings.

How does a simulation or serious game enhance disposition to engage in a learning process? We could figure this out. There are various methods and measures that we can use to study how engaged a student-player will be and we can develop research designs to see how engagement is related to learning outcomes. E-LAN has that capacity built into the environment, although the vast majority of serious games do not examine complex relationships between engagement and learning. Earlier, we also mentioned the transition from the Grand Theft Auto type of environment to the hospital environment and our attempt to help students make a cognitive shift from the games of a serious game to the educational elements of a serious game. Since the E-LAN design would allow us to create a variety of transitional environments, we could work across the spectrum of mostly game to mostly education. In our Gedanken experiments, we identified a large number of combinations of game-education mixes, but these have not been discussed in the literature. For example, one combination would be to have a distinct shift that occurs after the "wild ride' to the hospital and begins to increase the inclusion of more and more educational elements related to nursing, but also allows breaks for student-players in the Nurses' Lounge to re-engage in games and perhaps accrue points towards advice or use of clinical-decision support tools. You can imagine the diversity of combinations that repeated use-case analyses would reveal and the differences in individual preferences that might map out on different combinations. We felt that the research is not clear on what mix would optimize learning while preventing development of misconceptions.

What are the relationships between the level of realism in a simulation or game and learning outcomes? Again, we knew this was a problem with serious games and we built into E-LAN a way to modify realism levels and to study learning outcomes. In fact, we can even study engagement as a function of realism and the impact of engagement-realism coupling on learning outcomes. We previously had implemented a series of Gedanken experiments to study possible relationships between engagement, realism, and learning outcomes (Tashiro & Dunlap, 2007). This work led to the authors identifying key problems and building prototype learning environments designed around serious games in which realism could be easily modified. Thus, now we could build a system like E-LAN to allow shifts in level of realism at any level of the serious game. Such capacity opens the door for studying the complex relationships of student-players' preferences as well as their actual learning outcomes. However, the literature is still weak in detailed studies of how realism impacts learning and possible development of misconceptions.

How do you define the threshold of experience within a game or simulation that leads to measurable learning outcomes? Basically, you could define threshold through rigorous studies of the relationships between work within a serious game and performance on authentic assessments of learning outcomes. E-LAN was imagineered as an environment with coupled research and teaching-learning-assessment capacities. No serious games have this capacity yet, although the authors have built the prototype for such coupling. We know it can be done, and surprisingly economically. Even so, the threshold of experience that leads to stable knowledge retention as well as disposition to act on that knowledge has not been carefully studied for serious games. Furthermore, threshold is likely to be idiosyncratic to each individual and shaped by intrinsic and extrinsic motivational factors that in turn are likely to shape disposition to engage in what some call effortful cognitive endeavor (Cacioppo, Petty, Feinstein, & Jarvis, 1996). We would have to build additional subsystems into E-LAN to allow us to study these complexities in individually defining threshold for stable knowledge retention. Even if we did build such subsystems, we still would have to build additional subsystems to assess the types and frequency of misconceptions within the stable retained knowledge. Currently, data mining techniques are being applied to this approach.

What are the cognitive processes being developed during learning while working within a game or simulation? Here is where we began to stumble in our own work and to have concerns about serious games for healthcare. We realized that we had very little sound evidence for deciding what cognitive processes were being developed for the vast majority of educational materials, not just serious games and simulations. However, the great interest in serious games and their displacement of many "traditional" instructional methods and materials encouraged us to start asking in earnest, "What really works in serious games, for whom, why, how, and with what outcomes?" In fact, we started challenging all educators and educational researchers to "show us the data" that provided at least a basic foundation that a method-material combination in a teaching-learning-assessment strategy actually worked to improve learning and specifically higher order reasoning. Our abilities to follow and evaluate cognitive processes were made more difficult by the nonlinear opportunities available in serious games.

How did student-players move through the game, and what did they think and then do at each point or moment of choice in the game? Suppose there was a set of tasks that required implementation in a specific sequence. How would we follow the student-player through their exploration of these tasks and assess both their understanding of the task as well as their understanding of the procedural knowledge inherent in the correct sequence of the tasks? Well, we would "test" them in some way. But the interesting feature of serious games is that a student-player could actually engage in many more combinations of activities than they would likely engage in by reading a textbook or watching a video about the tasks and sequence of tasks. Now, we imagineered E-LAN to be able to follow the choices made by students and map these to educational outcomes. However, we still would have a very difficult time trying to get much resolution on the actual cognitive processes of any individual student-player, let alone an overall picture of a class of 20, 50, or 130 students..

In what knowledge domains is learning being retained and how stable is the retention? Not unrelated to the above discussion of developing cognitive processes during learning, we looked at a broad research literature on cognition and learning to better understand how knowledge domains are created during cognitive processing and how stable such "knowledge" might be. Certainly, many faculty members agonize and express their disappointment in students' knowledge, especially students' "inherited" from a prerequisite course who did not have the prerequisite knowledge we had hoped they would have retained. As a simple example, one of the authors (Tashiro, a PhD in Biology) returned to school late in his career to become a nurse and was stunned that the majority of his classmates could not trace blood flow through the heart after two semesters of anatomy and physiology and one semester of pathophysiology. These nursing students had all passed courses perceived as rigorous and taught by well-respected faculty using traditional methods and materials.

We did not mention in the discussion about cognitive processing and knowledge formation that there are a variety of models of cognition (Patel et al., 2009) as well as a variety of models of cognitive taxonomies that try to represent the intersection of cognitive processes and formation of knowledge domains (e.g., Bloom's revised taxonomy; see Anderson & Krathwohl, 2001). Even our imagineered E-LAN would have difficulty assessing how cognitive processes result in knowledge domains developed as cognitive schema in our student-player. We would be overwhelmed by trying to assess the probability of the relative stability of the knowledge developed. We could, of course, measure the realized stability by assessing the student-player's retention of what was learned at the end of the gaming sessions and then through time examining the stability of the retained knowledge. However, through time a student is exposed to many new educational and life experiences. So, how do we tease out factors shaping knowledge gained and knowledge retained in the context of a particular situated learning experience?

What is the disposition to act on the knowledge gained during work within a simulation? To add to the complexity, imagine that the knowledge gained during serious game sessions was stable for a couple of months. We could then examine the disposition of student-player to act on the knowledge. For example, we could ask them to act within another level of the serious game or we could ask them to act on their knowledge in a real-world situation, such as a supervised clinical rotation. In the first case, following the student-player's decisions to act in the serious game could allow evaluation of conceptual competencies and might also allow evaluation of their propensity for performance competencies. In simple terms, the conceptual competencies are the student-player's understanding of the content and skills learned in the serious game, while the performance competencies are the student-player's planning, commitment to, and then implementation of actions based on their understanding of the content and skills learned in the serious game.

The student-player's disposition to act on their knowledge would be shaped by a host of factors, some intrinsic to the student (e.g., set of intrinsic motivational factors) and some extrinsic to the student (e.g., extrinsic motivational factors). These factors tend to unfold in fairly complex patterns, even in simple situations of real-world patient care. If a patient is going through a very difficult transition (e.g., trauma, rapid deterioration, emotional crisis coupled to physiological collapse) the emerging dynamics and interactions become enormously complex. The complexity impacts the intrinsic and extrinsic factors shaping disposition to act on knowledge. Even though we imagineered E-LAN to overcome many of the problems in serious games, we could not yet imagine the systems and subsystems of serious games that allowed us to authentically probe conceptual and performance competency development, especially during situations of rapidly changing physiological and psychosocial conditions for a patient and how these impact a healthcare provider.

How well can the knowledge gained within a game or simulation be transferred? As we continued Gedanken experiments to study the complexities of assessing dispositions to act on knowledge gained, we realized that we could not easily or accurately delineate the details of a student-player's knowledge of facts, concepts, procedural knowledge, and metacognitive capacities. An enormous array of learning and competency assessment instruments and our imagineered E-LAN were not sufficient to provide us with much more than the broad strokes of what knowledge had been gained while working within a serious game, what knowledge was acted on, and so what knowledge was transferred into action. Patel and colleagues (2009) raised some additional complications. Examining medical education, Patel's group identified four common types of medical curricula. Simplified here, the four types were: (1) conventional approach; (2) problem-based learning, (3) a physiological system-organ based approach, and (4) hybrid integrations of two or more of the other three approaches (see descriptions in Patel et al., 2009, pp. 188-189).

Patel's work led us into another type of Gedanken experiment. We began asking what would happen if different skin-rules combinations for a serious game led to different types of reasoning, and if so, what might be the results of such reasoning. Here, we are using the term "skin" to mean the sense of the fictional world created by graphics and sound, while for "rules" we mean the underlying programming that provides fictional interactions within the virtual setting. We realized right away as the Gedanken experiments were implemented that a very sophisticated virtual world might be valuable to partially test components of some of the theoretical frameworks that have been proposed for cognition (e.g., cognitive load theory, cognitive flexibility theory, adaptive character of thought theory, situated learning theory). Some of these theories cluster into more individualistic structured learning, such as adaptive character of thought and cognitive load theories, while others fit within the domain of what educators call constructivist learning theories such as cognitive flexibility theory and situated learning theory (Patel et al., 2009). We also realized that serious game developers have generally not mapped the skin and rules of their games to a particular theoretical framework or a synthesis of frameworks that had some empirical foundation.

As we examined different skin-rule combinations in E-LAN, we became increasingly concerned about how and why to study knowledge transfer without mapping such transfer from educational activities and assessment of such activities that were based in a particular cognitive theoretical and praxis framework. These types of Gedanken experiments revealed that we could not very easily trace misconceptions unless we had a better understanding of how to build learning-assessment maps for each theory of cognition and then follow knowledge and skill acquisition through time within a serious games as well as post-gaming experiences for a wide range of applications in real world settings. A simple example of a Gedanken iteration was a serious game in which an 18 year-old woman presents in the Emergency Department. She speaks English, and we try to figure out what she is experiencing and what we should do. Note again, we were working with Nursing, so imagine a student-player working with a triage nurse in the Emergency Department (ED) of the virtual hospital. This iteration was based on an interesting paper by Welk (2002), which provided an example of training students to develop pattern recognition. We built a prototype in which an avatar walks into the ED. The avatar will engage with the first-person student-player through a voice recognition system that allows the student-player to ask questions in English, with English responses from the avatar. She is emitting a variety of non-verbal cues and, and the student can pose any query from a possible pool of 20 questions and respective responses by the avatar.

With some background knowledge, a student-player could figure out her condition should be considered as possibly an emerging myocardial infarction (MI). A common misconception is that this young avatar woman would be too young for an MI. We then ran other iterations in which the avatar spoke only Spanish or some English and some Spanish, trying to figure out how various student-players would react in terms of keying out the cardinal signs of an emerging MI. We discovered that slight variations in the skin-rules combinations dramatically increased our ability to trace misconception development.

What are the differences in learning that manifest as conceptual competencies and performance competencies? Building on the discussion above, as we looked more closely at different types of competencies that would be foundational for clinical judgment in Nursing, we returned to the research literature for medical education. Again, the medical education research literature is substantially more developed than that of Nursing or the allied health professions. Examining comparisons of conventional and problem-based approaches to medical curriculum development and instruction, Patel and colleagues argued that conventional curricula taught basic science as an independent suite of disciplines (usually in the first two years of medical school), but in contrast clinical contexts drive the organization and teaching of basic sciences in problem-based learning (with clinically meaningful problems introduced in the early courses of a curriculum).

The problem is that conventional curricula tend to inculcate a broadly applicable foundation of scientific knowledge, while problem-based learning creates more of a situated learning of clinical contexts in which scientific knowledge is integrated. This means that conventional curricula may teach science principles early but not within in meaningful clinical contexts while problem-based learning may inhibit knowledge transfer into practice across clinical applications if the knowledge gained in clinical contexts is too narrowly confined to a particular context (see more detailed arguments, Patel et al., 2009, p. 189).

Although the research literature provides a complex picture, there is some evidence that medical residents from conventionally trained programs were more likely to use heuristically-driven reasoning while residents from problem-based learning programs were more likely to use hypothesis-driven reasoning. Patel and colleagues (2009) argued that conventional curricula could lead to overconfidence in use of data-driven reasoning and these patterns of reasoning may become difficult to alter when errors or misconceptions are generated (e.g., when under-sampling of patient data occurs). Problem-based learning instruction, on the other hand, may not sufficiently help medical students develop the types of data-driven reasoning that are particularly efficient and accurate for routine problems and for problems in which the practitioner's knowledge is adequate (Patel et al., 2009, p. 189).

In terms of healthcare competencies within our E-LAN for Nursing, what conceptual and performance competencies could be assessed. Here, we are using conceptual competencies as a thorough understanding of a knowledge and/or skills domain. Often conceptual competencies are further elaborated as: (1) competencies in which a person can describe how and why to use the knowledge or skill in different but appropriate contexts (generativity; Patel et al., 2009); and (2) competencies in which a person can describe how to use the knowledge or skill in situations that are unfamiliar (robustness; Patel et al., 2009). However, performance competencies are those competencies in which knowledge is acted on as an expression of a variety of behaviors and decisions or skills that are implemented in the real world or some very close simulation of the real world.

Serious games can be built so that opportunities to demonstrate competencies can be embedded and student-player's knowledge is demonstrated and their activities monitored to see if competencies were achieved. For serious games without haptic interfaces or augmented reality simulations, we could not embed and measure performance competencies involving psychomotor activities. We might be able to assess conceptual competencies and through longitudinal studies see how measures of conceptual competencies and disposition to act on knowledge and skills acquired might predict performance competencies. However, through many Gedanken iterations, we did not believe we could trace development of misconceptions without first starting with a stronger theoretical framework for cognition and building serious games like E-LAN around such frameworks.

Even though we simplified the review of Patel and colleagues (2009), the important point is that serious gaming is currently not being developed with these sorts of complexities in mind. Just as there is ongoing debate and controversy about the rationale for educational approaches in medicine, there should be an active and ongoing debate about how experiences within serious games are likely to shape knowledge and skill acquisition as well as transfer to clinical applications with real human beings. Importantly, even as there is still an underdeveloped evidence-base framework for medical education, there is an underdeveloped evidence-based framework for how knowledge is developed and transferred in serious games.

And, sadly, the educational practices of Nursing and allied health professionals have been less well studied than for medicine.

EVIDENCE-BASED LEARNING AND FUTURE TRENDS

Certainly, there is a very large and diverse literature that converges on the idea that there are educational benefits to electronic educational materials that use simulations and gaming technology. These benefits include: involving students in complex practice skills without risk, improved psychomotor skills, enhanced retention of knowledge as well as enhanced decision-making skills, interactive learning, opportunities for replay at a particular step in a sequela as well as repeated practice of a sequela, options for immediate feedback, and retention of knowledge related to procedures. Some of this literature was reviewed in the report on the recent Summit on Educational Games sponsored by the Federation of American Scientists Federation (2006). Additional literature reviews and syntheses have also been provided by Bogost (2007) and Gee (2007, 2004, 2003). Work in healthcare has been reviewed by Feingold, Calaluce, and Kallen (2004), while the United States National Research Council (2000, 2001, 2005) presented summaries of research covering topics in the areas of how people learn and the science and design of educational assessment.

These works extend a very large and diverse research literature from artificial intelligence, simulation, education, and psychology. Recent work on cognitive taxonomies (Anderson & Krathwohl, 2001) also holds promise for informing how and why to build electronic educational materials. While the evidence for the benefits of electronic educational materials is accumulating, the development and usage of such materials still lacks a sensible evidence-based approach to improving learning. Publishers and faculty members share responsibility in the lack of evidence-based approaches to building and using electronic educational materials (Tashiro, 2009). Our analysis suggests there are important ethical issues that must be explored in the development and usage of electronic instructional materials. In particular, we argue it would be worthwhile to examine more closely the processes by which publishers decide to build educational materials for undergraduate healthcare students and how faculty members decide to use such materials. We hope this chapter provokes some deeper thinking and further ethical analyses of publishers' and faculty members' roles in developing and using electronic educational materials for undergraduate healthcare students. Indeed, we would like to see a broader approach that goes beyond undergraduate healthcare education into other disciplines and also reaches into other academic levels. We feel that an ethical analysis coupled to an evidence-based learning framework may lead to educational frameworks that define educational materials development frameworks and evidence-base learning praxis frameworks for developing, choosing, and using instructional materials.

The Federation of American Scientists (FAS) recommended a rigorous research program and also delineated ten specific game attributes for application in learning. These were derived from advances in cognitive and learning science (Federation of American Scientists, 2006; see pages 18-20) and FAS argued games should provide:

1. Clear learning goals.
2. Broad experiences and practice opportunities that continue to challenge the learner and reinforce expertise.
3. Continuous monitoring of progress and use of this information to diagnose performance and adjust instruction to a learner's level of mastery (see also research on adaptive learning and teaching).
4. Encouragement of inquiry and questions, and response with answers that is appropriate to learner and context.

5. Contextual bridging, which is closing the gap between what is to be learned and its usefulness to the learner.
6. Engagement leading to an increased time on task within a learning game environment.
7. Motivation and strong goal orientation.
8. Scaffolding in the form of cues, prompts, hints, and partial solutions to keep learners progressing through the activities in a learning game.
9. Personalization that allows tailoring of learning to the individual learner.
10. Infinite patience inherent in a game environment that literally does not tire of repetitive actions and so provides learners with innumerable opportunities to try an activity over and over.

We used these recommendations to conceptualize our partially built and completely imagineered E-LAN and also as pathways for Gedanken experiments to iteratively study a large number of use cases for working within E-LAN as a serious game. We came to the conclusion that four major problems in electronic educational materials, simulation, and serious design for undergraduate healthcare impede widespread development of educational games and simulations. Importantly, these problems point out the difficulty of developing electronic educational materials that can be used to develop evidence-based frameworks for learning in academic healthcare programs as well as in clinical settings. The four problems described below appear to inhibit development of electronic educational materials that meet the FAS and National Research Council recommendations (Tashiro & Dunlap, 2007):

1. Instructional designers seldom conduct the research necessary to demonstrate their products actually improve learning or skills. In healthcare, an empirically-driven approach becomes especially critical in the context of the Institute of Medicine's call for broadly based core competencies (AACN, 2003; Institute of Medicine, 2003). Similar deficiencies in research foundations for effectiveness exist throughout the educational games and simulations available at the K-12 and undergraduate levels.
2. With few exceptions, commercially available electronic educational materials have not been shown to improve what some call critical thinking (including the important higher levels of declarative, procedural, and metacognitive knowledge) of users while also improving disposition to engage in higher order thinking (Anderson & Krathwohl, 2001; Alessi & Trollip, 2001; Sadowski & Gülöz, 1996; see also papers by Cacioppo and colleagues, 1996). Such materials have remained elusive, despite many different types of simulations that are being evaluated, and principally because designers have not used empirical approaches to build disposition to improve critical thinking into educational materials.
3. Few commercially available electronic educational materials have been developed to mesh sensibly with the strategic needs of K-12 and undergraduate curricula or with professional development, continuing education, and training programs.
4. There are few commercially available products related to improving learning outcomes or skills competencies that are designed to become part of an evidence-based education framework as well as an evidence-based practice framework that improves students' and practitioners' learning-training outcomes.

These four basic problems are exacerbated by the complexity of studying the impact of realism and engagement on educational game and simulation design as well as the ultimate impact on student learning (Tashiro & Dunlap, 2007). However, the role of faculty members adds another layer of complexity to these four problems. The faculty members and other experts providing input to a publishers' business decision may not reflect the normative values of the majority of faculty in a discipline area. This is because most faculty members are not well grounded in the research related to what really works to improve education. On the other hand, while perhaps reflecting a larger percentage of faculty members in a content domain, advances in educational materials and methods are not likely to evolve from input of educators who are not well versed in educational research on methods and materials that really work. A publisher's strategic planners, subject matter experts and business algorithms may be based on success of sales and market exploitation rather than on whether or not a product actually improves educational outcomes. Why? Simply put, there are so few studies of product-outcomes coupling.

Another layer of complexity, and one of the oddities of undergraduate educational materials, is that faculty members are generally the purchasers of most instructional materials but students are the end users of the materials. That is, faculty members are the purchasers because they select materials, order them, and set the required usage in a course. Even though students actually pay for the materials, faculty members dictate the conditions of purchase. In discussions with both faculty and students, there was considerable dissonance in what each group felt they needed faculty to teach and students to learn. One of the most striking features of this dissonance was noted by the author during his case study of his classmates in a nursing program (Tashiro, 2009). Most students in his courses purchased large textbooks but very few actually read the textbook assignments the faculty member required for a course.

We are not discouraged by our findings that there may be innumerable crouching tangents-hidden dangers in serious games. The opportunity to build evidence-based frameworks for learning is very exciting and challenging. Even the failure of our virtual world E-LAN to allow detailed tracking and prediction of misconceptions provided us with the chance to better understand the complexities of building serious games and understanding their likelihood of inculcating misconceptions. Certainly, we look forward to rebuilding E-LAN and taking another step towards shaping serious games within a framework of evidence-based learning.

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KEY TERMS AND DEFINITIONS

Collaborative Virtual Reality: A shared virtual world using a local network or the Internet as a communication medium, where its users interact to work, learn, train, and carry out other activities together.

Competency: The sum of knowledge, skills, and characteristics that allow a person to perform an action successfully and productively.

Computer Simulation: A computer program that attempts to simulate an abstract model of a particular system, which generally uses input variables.

Misconception: In the area of education, erroneous student's understanding or mistaken notion of a scientific or technological concept or phenomenon.

Network Latency: Network delay, consisting of how much time it takes for a data packet to get from one designated point to another in a computer network.

Second Life: A social network in the form of 3D virtual world shared by millions of registered users, using the Internet as a communication medium.

Serious Games: Video games that are used for training, advertising, simulation, or education, and are designed to run on personal computers or video game consoles.

Virtual Environment: A computer-generated 3D space, also called virtual world, where 3D graphical objects and sounds reside. Its user is represented in the virtual environment by an avatar (a graphical personification) and can interact with the virtual objects and its environment.

Virtual Reality: Computer technology capable of generating a three-dimensional space called virtual environment, which is highly user interactive, multimodal, and immersive.