État de la situation

La simulation dans l’éducation

Rapport final

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État de la situation sur la simulation dans l’éducation

Sommaire

Ce rapport est le fruit d’une recension de la littérature sur l’état actuel de la simulation dans l’éducation des adultes. L’utilisation de la simulation et des jeux dans l’éducation des adultes ne date pas d’hier. Ces procédés jouent un rôle auxiliaire dans les approches plus objectivistes de la connaissance qui sont généralisées depuis deux siècles dans l’éducation des adultes. La simulation et les jeux représentent une illustration systématique d’une vérité universelle au sein d’une discipline. Une simulation ou un jeu construit communique l’image « correcte » directement aux apprenants. Cette approche de l’apprentissage a donné de bons résultats dans les paradigmes de formation où le but de l’expérience éducative est la création d’une population active homogène possédant un niveau uniforme et prévisible de compétences. Depuis plusieurs années, la majorité des changements intervenus dans l’utilisation de la simulation et des jeux dans ces milieux mettent en jeu une augmentation de la fidélité et du réalisme rendue possible par les progrès de l’informatique.

Cette approche traditionnelle continue de procurer les résultats voulus dans beaucoup de contextes de l’apprentissage chez les adultes, mais il existe de plus en plus d’information laissant à croire que de nouvelles approches de l’éducation devront se développer parallèlement. Une pédagogie qui débouche sur une approche objectiviste de la connaissance suppose une structure d’information inchangée. Or, ce procédé ne convient pas dans un monde en rapide évolution. L’économie du savoir qui émerge actuellement exige des travailleurs non seulement qu’ils comprennent comment produire l’information,

mais encore qu’ils comprennent comment la filtrer, comment en tirer un sens et enfin comment l’appliquer dans un environnement ambigu et en évolution constante. L’une des conséquences des approches éducatives classiques a été que le développement des compétences de jugement, de réflexion critique et de créativité a été négligé chez de nombreux apprenants adultes. Or, toutes ces compétences seront indispensables pour réussir dans l’économie du savoir.

Afin d’examiner le genre d’approches pédagogiques qui seront nécessaires pour transmettre ce genre de compétences, l’on s’intéresse beaucoup aux simulations éducatives. Des travaux importants sont en cours en vue d’explorer leur potentiel dans le cadre d’un nouvel ensemble d’outils pour les concepteurs en enseignement. Le but de ces derniers est de créer des expériences éducatives qui aideront à faire évoluer les apprenants adultes vers un ensemble de compétences plus utiles, mieux adaptées aux réalités d’une économie nouvelle où l’information joue un plus grand rôle.

Deux grandes influences affecteront l’avenir de la simulation en éducation. D’abord, la conception de l’instruction évolue vers des approches plus constructivistes qui tablent sur la création du sens au niveau personnel, comme approches d’apprentissage valables. Il faudra donc modifier la manière dont la plupart des simulations éducatives sont actuellement conçues et mises en œuvre. Les simulations éducatives devront devenir beaucoup plus ouvertes, ambiguës et chaotiques afin de soutenir ces approches constructivistes. Cette démarche exigera également des paradigmes d’évaluation très différents, souvent fondés sur les compétences et le rendement. L’autre influence qui s’exercera découle des innovations en matière de conception et de technologie issues de l’industrie des jeux informatiques d’abord conçus comme divertissements. Bon nombre des types d’apprentissage que les chercheurs éducatifs estiment plus naturels et efficaces ont été observés dans le contexte des jeux informatiques. Il reste à voir si la technologie et la conception de ces jeux peuvent être adaptées à un contexte éducatif fondé sur des objectifs spécifiques, et si oui, comment.

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Introduction

Educational simulations do not represent a new phenomenon as they have been a part of adult education for decades. In that course of time, they have proven effective in supporting traditional educational technology approaches to instructional design, delivery and facilitation. Throughout this time period education has continued to evolve as it addresses new perspectives on pedagogy and the demands of society. As researchers examine the practical implications of these new perspectives on educational technology, they have identified simulations as having the potential to assist in those changes. The technology that is currently being developed in the computer game and simulation domain has sparked much of the interest about that potential. This new technology represents a powerful set of tools for educational technology that can change the way instructional designers create experiences as well as the way instructors facilitate those experiences. Understanding how this will happen presents a number of challenges. Like any paradigm shift there will be considerable resistance to games and simulations being used in a novel way. The impact of previous experience in instructional design, teaching and learning will all lead to a collection of biased understandings about how knowledge is created and how simulations are used to facilitate that process. This is going to affect how simulation is utilized and will likely result in a degree of subversion of simulation technology so it will provide support for traditional methods of teaching rather than exploiting their new potential.

Traditional methods of learning emphasize an objective and knowable perspective on reality. This has resulted in models of learning and instruction that focus on successfully internalizing information within a specific content domain. For many adult learning contexts the main goal is to build the capacity to recall that internalized knowledge. There is no real thinking or problem solving required. Each situation encountered in the workplace would require the recall of specific information, procedures or algorithmic knowledge that would help the learner navigate any issue. This was an effective approach to adult learning in a static, structured and unchanging work environment. The information they recalled would always match the challenge that faced them. The emerging knowledge economy has resulted in a significant re-thinking of this approach. It has resulted in such a large volume of information available that memorizing it all is impossible. It would not even be a lucrative approach as the information is changing so rapidly that it would quickly be obsolete and meaningless. There is increasing criticism from the professional realm that students who are entering the workplace aren't dealing well with this environment. They don't possess the critical thinking skills they need to analyze, judge and act upon information as it changes.

Educational simulations are one of the technological approaches available to education to facilitate the building of skills such as critical thinking. Traditionally, simulations are something that bridges the gap between the typical classroom setting and the real world where actual practice occurs. They have been used to assist in the capacity for students to understand and use information to solve problems that are actually relevant to a real context. They do so by representing the world that the adult learner will encounter when they enter the workplace. In the past this has meant a replication of a mechanistic and unchanging work environment. In such a setting, the experience inside an educational simulation can have a positive impact on actions in the real world.

Despite this restrictive use, simulations have the capacity to mimic the chaotic and ambiguous environment of the real world. Simulations are more than just an interactive model or a collection of facts with which the learner interacts. It provides the framework for learners to build on their existing knowledge and augment existing cases they already have in their memory. They are an experience where learning is both interactive and dynamic. No one in the field of simulation or AI research is naïve enough anymore to believe that they can ever completely model the real world in enough detail to replicate reality. What they do believe is that the technology is becoming good enough that in a specific context they can make learners believe that they have encountered an accurate representation of reality. This belief is enough to begin thinking about how we can use simulations to learn in an authentic way. Allowing us to act virtually in a way that is similar to how we would act in the real world (Shank, 1995, p. 93).

By examining the trends in research and implementation of educational simulation, this review will provide the framework for the identification of gaps in current research, directions of simulation-based education and suggestions for the intelligent focus of resources for further development. This general framework is challenging as many specialities have developed in the gaming and simulation market. The resulting specialties of military, medical, business and educational gaming have all developed their own models for creating learning experiences using games and simulations. All of these disciplines come with their own philosophical perspectives on the nature of knowledge, learning and instructional design.

There is considerable evidence that educational simulation based on traditional instructional design models work well in many current adult education settings. The newest interest is in the potential of the next generation of simulations and what they are going to do for adult education. Despite the belief that these new educational simulations have a lot of potential for adult learning there is still surprising little known about them. There seems to be an intuitive belief that they can represent more authentic learning environments and allow the construction of more meaningful knowledge. Much of the recent interest has developed due to growing evidence of learning during entertainment based computer game play (Gee, 2003). Despite the large number of adults who have encountered these in an informal setting, they have had little experience in using these types of games in an educational setting. Their history of pedagogical experiences has been focused on conventional classroom settings. In these kinds of environments there is no engagement or excitement, only non-interactive and static content. A lifetime of education in this traditional environment has resulted in a considerable amount of momentum so that by the time these learners reach adulthood they have come to expect it. Both the adult learners and their instructors view the engaging and exciting environments of the computer-based simulation with suspicion. They have built up an extensive belief system that tells them that engagement and enjoyment do not have a place in educational settings.

Without an understanding of the strengths and weakness of educational simulations in evolving instructional design paradigms it is unlikely they will have a significant impact. It will take a strong, focused research community to provide the support and kind of research necessary to allow educational simulation to have its strongest impact on learners. Failure to do so will lead to a familiar scenario where new technology is subverted to an older, established approach to education. The seemingly innovative approach will merely be a new skin on an older system. It will temporarily excite, but ultimately disappoint, the learners and instructors within the system.

Background

The idea of abstract representations of reality as a learning forum is not new. Simulations and games have long been a part of human history. Their presence in the archaeological record goes back thousands of years. Their role in the past is a matter of debate but they are usually allocated to the realm of recreational activities. As a result of this classification they are often not considered in terms of the potential impact they may have had on society. There is evidence early on in the historical record that games changed from being considered just entertainment to an activity that can actually change the players who interact with them. This history has lead to much of the current perspective on games and simulations and still has an impact on how they are perceived in the educational world (Appendix I).

Ontology

What are games and simulations?

Determining commonly held understandings about the nature of a game or simulation is one of the initial challenges in discussing their current role in adult education. In discussions about their nature and purpose the terminology within the discipline is often used interchangeably, depending on the context. This has resulted in a considerable amount of confusion about what definitions are most appropriate. The terms educational games and simulations seem to be used to describe a large variety of the software that is available on the marketplace. Marketing, politics and honest misunderstanding about the technology create much of the confusion. One example is how it is common for a game to be associated with entertainment while a simulation is considered to be a more serious approach to a subject. This distinction tends to be more arbitrary than definitive and without a discrete ontology it makes it difficult to build any kind of framework for discussion, assessment or evaluation. This confusion has led to a number of attempts in the gaming industry to develop a common ontology in the hopes of developing a semiotic domain where intelligible conversations can occur about design and development (Lindley, 2003; Rollings & Adams, 2003). The academic community involved in the active research of simulation and games has encountered the same problem (Feinstein & Cannon, 2003; Sauvé, Renaud, & Kaufman, 2005).

Although there are many perspectives, a common element for computer-based simulations and games is rules. Rules, and their exceptions, are what defines and delineates all aspects of interaction with simulations and games. There are essentially three components that have been derived from a variety of sources. This includes Shirt's definition of simulation (Shirts, 1975, p. 76) , Greenblatt's definition of game (Greenblat, 1975, p. 14) and Rollings and Ernest's definition of challenge (Rollings & Adams, 2003, p. 200).

A pure simulation represents a set of rules that define a specific model that reflects reality (Shirts, 1975, pp. 76). One example would be the laws of physics that define how objects move and interact with one another. A pure game is a set of rules that define the conditions a player must agree to follow in order to create a desired state (Greenblat, 1975, p. 14). A game is not automatically about competition, as it does not define a win state. A pure game may focus on cooperation, fun or coordination. Challenges are the rules that define the successfully resolution of a conflict or competition (Rollings & Adams, 2003, p. 200). In its purest form, it provides a definition of a win. Despite this, there are no rules that define how that win state is achieved. Human survival is often the purest challenge, as it doesn't matter how an individual survives adversity as long as they are alive at the end of it. All of these elements combine to create a wide continuum of possible constructs. Their placement in that continuum defines their purpose and ultimately their relevance to a pedagogical situation.

Simulation

A simulation is a model of events, items or processes that do or could exist (Feldman., 1995, pp. 347). There are many different examples of models that are used to convey information. Verbal models present statements about the world while visual models can present graphic representations of abstract concepts. A simulation is another kind of model that is differentiated from the others by its dynamic nature. It represents an operating model of a system. It allows an observer to view not only a single point in time in the model but also how it changes under different parameters (Greenblat, 1975, pp. 13). It is not meant to be a complete representation of an event but rather an abstraction that focuses on a specific aspect of that event. The interrelationships represent the focus for either an issue that a researcher is investigating or a concept that an educator is teaching to their students. Simulation models are explicitly defined, as it is important to define the biases this particular view of reality introduces to both research and education. Once they are set up they provide a venue where new ideas can be explored and complex interrelationships examined (Greenblat, 1975, p. 10). It is through experimenting with the numerous variables that control the underlying models that a simulation can provide a variety of outcomes. A pure simulation does not provide an evaluation of the outcomes of that experimentation. These kinds of assessments of the behaviours of the participant are often external to the actual simulation.

Simulation challenge, non-game

A simulation challenge, that does not have a game element, has a form of assessment built into its design in the form of a win or an end state. The lack of a game element means it is only designed to simulate real life conditions without any artificial constraints. The challenge creates some form of explicit problem that needs to be solved before an end state can be achieved (Walker, 1995, p. 2). The end state may be defined by a single state where success is gauged or there may be multiple end states, none of which represent a specific win state. These can be examined and debated upon in order to decide which is the best or represents the most efficient behaviour within the simulation. An example would be crisis simulation that presents a specific emergency scenario and then allows the participant to solve the problem with the skills and equipment they would have available to them in a real situation. In the commercial software market many of the flight simulators that are available for desktop computers are extremely accurate representations of flight physics and aircraft. The military versions of these types of flight simulators are another example of a simulation challenge as their main focus is to eliminate any artificial constraints on behaviour and present an accurate depiction of aerial warfare where the win state is survival and defeat of an opponent.

Simulation challenge game
In a simulation challenge game the participants are experiencing a contest, either against themselves, others or resources. The simulation aspect models a number of systems that often define the environment or context in which the participants interact. This may or may not be an accurate representation of reality. The game aspect defines a set of restrictions in terms of possible participant behaviour in the environment. The challenge aspect defines how to achieve a win state within the environment. This category is where the vast majority of commercial games exist. The restriction imposed upon participant behaviour often defines the genre of the game itself. For example, many games that involve conflict often only offer violent options for the resolution of that conflict. Many of the first person shooters offer an option of different weapons but not the option to pursue non-violent resolution to the conflict.

Simulation game, non-challenge
In a simulation game that does not have a challenge aspect the participant is focused mainly on the rules that are imposed by the game elements and reacting to the environment created by the simulation. This kind of approach is most commonly seen in role-play where the game rules define the behaviours that the participant must use to play that role. An aspect of role-play is also the ability of the participant to react believably within the simulated environment. Success is often measured by the authenticity of their role and their reactions to the environment (Dixon, 2002, p. 361). There are many role-playing computer games on the market that focus on creating a believable role and using that role to temper social interaction with other players. The popularity of some massive multiplayer online role-playing games, such as Everquest and World of Warcraft, is in part due to the appeal of taking on fantasy roles within the artificial world represented in the online environment.

Challenges

Challenges are designed to test the abilities of the participant. They are competitive in nature and may represent archetypal conflicts such as man versus man, man versus himself or man versus nature. These challenges may be natural and represent real threats or a designer may abstract them with a specific goal in mind. A designer of the challenge creates a problem and information that feeds back to the participant about the nature of that problem (Rollings & Adams, 2003, p. 206). In computer games, the majority of challenges are mental; they do not commonly have a physical component.

Game challenge, Non-simulation
This is almost the definition of a pure game, as it is not based on any kind of model or simulated environment. It is composed entirely of a win state and a set of rules that define how to achieve that state. These include many sports games and logic games. In computer games these types of games are seen in puzzle and logic game genres and are represented by games such as Tetris and Bejewelled.

Games

A game is a goal-directed activity that often has a competitive nature and works within a framework of accepted rules (Lindley 2003). These rules often take the shape of limitations to their behaviour that make the game more challenging. Games are interactive and therefore only work with explicit player decisions and action (Greenblatt 1975, p.14). The rules that constrain the player define the fair play of the game as playing outside of these rules to achieve victory is considered cheating. In computer games, the programmers who created the game explicitly define these rules. The players implicitly accept them. It is one of the goals of the player to learn the rules that constrain them during the course of game play. It is interesting that exploiting poorly defined rules and discovering these inherent weaknesses in the game is often a major activity of game players.

Significance

Most of the research to date has been on how to define games and simulations. It has been very objective in trying to define very discrete ontologies. Although this has been very important to begin a dialogue, it will need to continue to develop. It is important that some form of ontology can be used to describe games and simulations from an educational perspective. This needs to be explicit to the decision maker, the educators and the students. Terminology will often lead to expectations about the nature and type of learning experience a piece of software will provide. If this is not dealt with there will likely be incompatibilities between what the user expects and what is delivered. If the educators and learners are not in the proper mind-set then their approaches to the learning event will be incompatible with the kind of learning that will be expected of them (Jones, 1988, p.33).

Ontology Research Directions

What Generalizations can be drawn?

There are many different perspectives and terms used to describe games and simulations. It is unlikely that any form of universal language will be created that will allow all participants to communicate flawlessly. It is also not consistent with post-modern perspectives on knowledge that are becoming more prevalent in educational research. Instead of definitions, it is more common for research into ontology to facilitate dialogue that can help develop general understanding.

What are the major gaps in Research?

Much of the current research involves the debate over a common ontology amongst a small group of specialists. The two largest groups are the game industry and the academic world. This conversation needs to continue but it also needs to widen in scope.

It is unknown how compatible the current ontology and terminology of gaming and simulation is to the existing framework of adult learning. This includes curriculum, policy and instructional design. It is likely that this confusion will lead to a delay in the adoption of any simulation-based educational material. It will be important to examine how this will affect the use of simulations and games in adult education in Canada.

It will also be important to examine how ontology is going to change within evolving post-modern perspectives on knowledge and the world. Most of the current research into ontology involves an attempt to build a comprehensive set of definitions in order to describe games and simulations. The approach is a reflection of the belief in an objective reality that is prevalent in the domain of computing science and adult training. Post-modern perspectives do not necessarily have the same perception of the nature of reality and it is unlikely that older perspectives on ontology will work in these new discussions. For example, most of the interesting research into the cognitive effects of ambiguous and chaotic virtual environments does not fit well into any existing discussion framework on how learning occurs in simulations. A similar incompatibility is occurring with the field of instructional design. These include the constructivist instructional design approaches that are being created to facilitate the building of ill-structured problem solving domains for learning. As the complexity of human behaviour within these virtual environments increases, it will only become more difficult to describe them in a universally relevant manner. Despite this problem it will be important to continue to examine how these environments evolve. That can only occur through a continued discussion about the nature of games and simulations in education from the perspective of educators, learners and institutions. This dialogue will assist in fostering a dynamic and growing discussion about the nature of games and simulations. This will allow perspectives on ontology to move beyond just a simple common understanding to more meaningful questions about why they impact learners who encounter them and what that can tell us about our perspectives on knowledge and understanding.

What are the most profitable lines of inquiry?

Until educational simulations and games have a more significant adoption rate in the adult education community they are unlikely to have a significant impact. A detailed analysis of where existing curriculum and instructional design terminology intersects with simulation and game ontology would be helpful in creating a dialogue between the two. There needs to be a chance for all parties involved to quickly move to a common understanding instead of beginning with such a massive gap in perspective that a common dialogue is impossible. Establishing a rapport would be the first step to assisting in the kind of understanding that will be necessary before successful adoption can begin.

It will also be important to continue to facilitate an active dialogue amongst Canadian researchers in the field. Although it is important that the dialogue be inclusive and continuous, it will be necessary to determine the best ways to facilitate that process. Having a conduit in place will allow an ongoing discussion among academics. This will give them the experience they need to continually modify their existing perspectives so they can develop their understanding of the impact of games and simulations on the educational market.

General Adult Educational Simulations and Games

Simulations and games in adult education have a long history. They began in the form of abstract representations that were based in physical components such as board games and paper and pencil exercises. They have moved from there to computer-based virtual environments that are continuing to grow in sophistication as computer technology offers new options to the educational world. The underlying design behind educational simulations has also continued to evolve as policy and perspectives on adult education have changed. As they have continued to gain popularity they have also increased in variety and scope. This is not just because of the increased availability of simulations and games to the adult education market. Many adult education institutions are looking for alternatives to a typical classroom setting. They are attempting to diversify from this single pedagogical approach. Much of the need for diversification is coming from criticism that the traditional system is not producing workers that are able to think and thrive in a changing knowledge economy (Lainema & Makkonen, 2003, p. 132).

The first documented evidence for the explicit use of educational simulations and games for the adult market comes from the social/ political arena (Cecchini, 1988, p. 216). This form of simulation looked at the use of role-play and strategy as a device for developing successful communication and heuristic skills in the political arena. Simulation was used to explore the options available as well as to examine new options before they were tested in the political arena. Not surprisingly much of the documentation of the use of these strategies comes out of the politically challenging period of the Italian Renaissance (Cecchini, 1988, p. 216). This use of games has spread beyond the political arena to include such areas as medicine, military, business, science and engineering. The military is by far the strongest proponent of this educational approach (Appendix II). They have the longest history of formal usage and are currently the largest consumer of game and simulation based products. Their influence in the field cannot be underestimated and they continue to push much of the development in the area. Medicine is close behind in research and development (Appendix III). They are keen to develop new approaches to medical education and assessment. Business has also had a long history of usage of games and simulations (Appendix IV). Business continues to have an impact on current education. Many of the simulation and game products being developed for the civilian adult education market are focused on the corporate domain. Although there is a considerable adult market within the post-secondary educational sector there is not an active amount of product being developed for it (Summers, 2004, p. 234). Given the financial situation of most post-secondary environments they are unlikely to attract much attention from commercial developers.

Many types of games and simulations, including role-play and strategy games, have continued their task from earlier, informal settings to become an important part of educational simulation and gaming today (Frisenna, 1988, p. 235). The social, political and cultural focus of some general adult educational simulations differentiates them from some of the more competency-based approaches. They are not always focused on the development of discrete skills and task competencies within a defined context. Many of these simulations have a much more ambiguous approach (Crookall, 1988, p. 3). These types of approaches are about exploring social/ political/ contextual information. These kinds of educational games are also focused on generalized knowledge, communication, creativity, and thinking skills. It is important to note that these types of games have been traditionally unpopular due to their lack of easily accessible quantitative measures for assessment. This has been often perceived as an indication of a lack of accountability. Despite this bias there has been development of evaluation methodologies for simulation that has encompassed both quantitative and qualitative measures.

Current Arguments for Games and Simulations in Adult Education

One aspect of deciding on the use of games and simulations in adult education has been understanding where they excel as teaching tools. Paper and pencil simulation and gaming have been a part of education for hundreds of years. It has been the advent of the personal computer that has taken simulation and gaming to a whole new level. Advances in computers, networks and bandwidth increases have opened up a range of new possibilities for the use of simulation and games for teaching. The current tools make it much more feasible to build complex models into gaming simulations. The online, multi-player ability in many of the current game engines allow students and teachers to be distributed while working together online. The high level of fidelity and realism available in game environments are allowing much more believable interactions for the students.

Despite there being a variety of contexts for the development and implementation of games and simulations in adult learning there are several common elements that have been identified to justify their use.

Risk free environment

A risk-free environment allows the learner to fail and then provides them with the chances to go back and modify their strategy until they have achieved a successful result. Failure is seen as a necessary experience for learning in a simulated environment (Aldrich, 2005, p. 136). There are two advantages to removing risk during teaching. One is the ability to improve the skills of learners in a way that does not affect actual outcomes (Walker, 1995, p. 6). In situations where the student is learning skills that may affect human health and welfare the cost of failure in real life is often extremely high. Allowing them to fail occasionally in the course of their education will not affect the real world. The other positive effect is that learners do not come to fear failure. Failure becomes part of the learning process that will lead to their improvement in that area of knowledge, not the end of their involvement in it (Carstens & Beck, 2005, p. 25).

Experimentation
Simulations can allow a learner to modify both their own behaviour and the model parameters in order to observe how the simulated system changes. Most simulations are designed with a flexible architecture that allows their variables to be altered. By directly modifying a model, students can experiment with the behaviour of the models in a number of different scenarios. They can then experiment with how their own behaviour might change given the modified variables. The learner centric nature of the simulation makes the outcomes completely dependent on the player's actions (Aldrich, 2005, p. 136).

The goal of allowing this level of interactivity is to provide a deeper understanding of the model for the student. This is seen as providing an added advantage in solving problems related to that model (Jones 1989, p.13). Another aspect is looking at how human models of behaviour can be affected by non-learner manipulation of different environmental variables. This kind of approach would examine how things like decision-making and problem solving would be affected under a variety of conditions. This kind of work often requires an ethics review for use in any academic study (Walker, 1995, p. 6).

Problem solving skills
The ultimate test of an individual's knowledge isn't simply being able to repeat that knowledge but rather the capacity to convert that knowledge into an appropriate pattern of behaviour (Ruben, 1999, p. 502). In conventional simulation, the goal is to focus the learner onto a specific set of problems that test their understanding about previously learned concepts (Greenblat, 1975, p. 10). These are often scenario-based problems that reflect a situation the learner would encounter in the real world. The simulation presents the environment, authentic information sources and the tools to let the student solve the problem and test their knowledge. The simulation then provides them with the feedback to modify their existing ideas and patterns of behaviour they will need to navigate that environment. This process engages the student and gives them insight into the subject matter as well as the nature of their own skills for dealing with the problems presented in the simulation scenarios. It is not learning in a conventional classroom setting as the student is virtually placed in an authentic decision making locale. Many simulations are designed with randomness in their variables. In this way they aren't predictable and require students to examine their strategies and constantly modify them between simulation scenarios.

Assessment
Perhaps one of the strongest aspects of simulation is their ability to evaluate if the theoretical knowledge of students can actually be enacted in a practical application. Often a passing grade in a theoretical subject is assumed to be the basis for correct decisions and problem solving in real-world situations (Jones, 1988, p. 22). If an educator is interested in examining the type of knowledge reflected in the marks they could present a simulation to evaluate the competence of the student. Often they find that the student has become adept at passing standardized exams rather than gaining the ability to solve problems with the knowledge they possess.

Social Interaction
Traditionally knowledge is transferred from an expert to an individual. This is even the case in a classroom of 400 students who are all being instructed by the same professor. Simulations can allow learning to occur outside of that classroom setting by interacting with other students in an online environment. It is possible to gain social and collaborative skills by solving problems together within the simulation environment (Ruben, 1999, p. 502).

Gamer Culture
One of the reasons games and simulations may have a much more significant impact on adult learners is that many of them are part of a new generation that has grown up on computer games. Learning experiences that use a familiar form of media provide this group with a recognizable paradigm (Ruben, 1999, p. 503). It is the same paradigm where they have already developed many of their problem solving skills through years of interaction.

The business world has always seen the value of experiential learning and they are watching the up and coming generation of gamers very closely. They are seeing a new generation that is much more competitive and driven to winning. They are also more optimistic and determined to solve problems because they've learned that eventually some combination of behaviour will result in success. This drive makes them very creative. Failure and risk don't frighten them as they've come to learn that both are survivable. The social aspects of multi-player gaming also make them very good at team efforts and coordinated approaches to problems (Carstens & Beck, 2005, p. 25). Research also indicates that the work ethic of twenty something gamers is better than non-gamers. They care more about the company if they are presented with challenges and properly motivated (Beck & Wade, 2004, p. 61). These are not skills they are learning in school but rather in spite of it. Business is becoming aware that this will be a very different generation to manage and they will be able to make them into great employees if they know how to manage them properly (Silverstone, 2004).

Current Simulation Types

Games and simulations have evolved into some practical applications that are currently in use in adult learning contexts. Clark Aldrich (Aldrich, 2005) undertook one of the most extensive evaluations of current products and companies. His work resulted in the observation of four distinct genres of simulations that are currently being used in adult education contexts today. These include branching stories, interactive spreadsheets, game-based models and virtual labs/ products (Aldrich, 2005, p. 4). They represent the stable products that are used by organizations who have decided to use simulation and games in their training programs.

Branching stories are essentially a series of events that are linked by decision points (Aldrich, 2005, p. 4). They are easy to deploy and can be created with a number of off-the-shelf tools available today. They are commonly used to demonstrate conversations between characters and to identify strategy decisions when presented with a specific condition. The learner would then choose the appropriate response and receive positive or negative feedback with appropriate commentary. These kinds of designs can deploy well inside of a standards-based LMS (Learning Management System). The instructional design behind these sorts of exercises can be traced back to the 50s with the programmed instruction techniques of Crowder (Saettler, 2004, p. 295). These techniques were originally designed for the United States Air Force to train trouble-shooters to find problems in malfunctioning electronic equipment. If incorrect information were given, then the learner would be directed towards information that would help them understand why they had made a bad decision. It was essentially designed to replace a professional tutor and was a continuation of earlier programmed instruction techniques that the military had pioneered during the Second World War when they needed to train a large number of adult learners in a short period of time

Interactive spreadsheets present a systems approach to the world. They are designed expose a learner to a particular system and provide them with the opportunity to observe and learn the parameters of the system (Aldrich, 2005, p.. 26). As a model with quantitative variables, they can be set up to represent a number of different scenarios within a system. They are often used in a business or military logistics context. These kinds of approaches gained popularity with the development of game theory. Work on game theory began early in the 20th century. It was an attempt to abstract strategic situations into a mathematical theory (Dresher, 1961, p. 2). The initial work was extremely theoretical and it wasn't until the publication of *The Theory of Games and Economic Behaviour* in 1944 that the idea of quantifying conflict and competition in a mathematical model was put forth (Rasmusen, 1989, p. 13). It answered one of the most common criticisms of learning games and simulations. This was the lack of any kind of valid, quantitative model that could determine the outcome of decisions made during challenges presented by the activity. Game theory provided a way to quantify the values that determined the outcomes of decision-making. In this way, decisions made within a certain system could be successful, partially successful or a complete failure. It was not restricted to simple success or failure. Game theory is not about actual gaming, but rather refers to the mathematical theory that allows the definition of state of information, choice, strategy, consequences and payoff (Shubik, 1975, p. 14). This became a major source of validation for simulation and gaming. Military and business gaming could begin to think of games as valid mechanisms for heuristic learning within the systems of tactical and strategy based games and simulations. The ideas have continued to evolve into computer-based simulation systems that can be deployed in standards-based LMS systems today.

Game-based models are based upon a belief that you can create an entertainment-based game with embedded educational content (Aldrich, 2005, p. 37). Essentially the learner is rewarded with continued game play if they provide the correct answer to a question. These kinds of educational experiences are based on the idea that people learn best when they don't know that they are learning (Aldrich, 2005, p. 37). In most cases the types of games presented have nothing to do with the educational subject matter. Most of these kinds of products are designed to deploy inside of a standards-based LMS.

Virtual labs and virtual products are a virtual representation of physical objects. They are designed so that learners can interact with them in the same way they would with a real world physical model (Aldrich, 2005, p. 42). They are attractive in the adult education world because they are a more cost effective way of deploying new product to potential customers, trainees and developers. They can also offer embedded commentary and annotations that can help the learner as they explore the object. They offer unique views and perspectives, such as cutaways, that would not be possible with a real, physical object (Aldrich, 2005, p. 43). However, they are not presented to the learner simply as a working model, rather they work best when they are used with scenario-oriented tasks. Using defined scenarios makes them generally quite restrictive in terms of the actions and behaviours that are available to learners. The belief is that the learner will gain knowledge in the process of accomplishing these tasks. The more straightforward and mechanistic the real life situation, the more likely these kinds of simulations will be successful. They are often developed to be deployed in a commercial, standards-based LMS.

Benefits and Limitations

In research done on the benefits of these types of simulations there were a number of observed results. In virtual lab simulations students seem to be assisted in the development of abstract thinking skills (Ramasundaram, Grunwald, Mangeot, Comerford, & Bliss, 2004, p. 30). This included understanding of complex processes that they would be unable to observe in real life. An example would be the complexities of an ecosystem that would be unobservable even from a trip to an actual environment. By being able to view an entire system and play with the variables they were able to come to a more comprehensive understanding of how the elements of the system work together (Ramasundaram, Grunwald, Mangeot, Comerford, & Bliss, 2004, p. 31 Hansmann, 2005 p. 370). Understanding a single system also seems to facilitate the understanding of more abstract, generalized concepts as well (Mills, 2004, p. 25).

Initial study indicates that the active learning that occurs during a simulation-based educational experience has a much longer-term effect on attitude than traditional classroom models (DeKanter, 2005, p. 30). This follows the advocacy model of simulation delivery where a substantially more effective change in beliefs occurs through action rather than just a passive classroom setting. The attitudinal change also carried over to behaviour in real world situations (Hansmann, Scholz, Francke, & Weymann, 2005, p. 372) .

Although currently not a common type of simulation in computer-based adult simulation education, role-playing has a positive effect on the communication abilities of students to interact with foreign cultures for the purposes of fieldwork (Hirsch & Lloyd, 2005, p. 335). They achieved their goals of gaining empathy for another cultural position and facilitating the smooth running of a project within another country. In these kinds of approaches the learner not only came to an understanding of a natural system but also the importance of that system within multiple cultural paradigms.

The problem with most of the studies conducted is a universal concern about the validity of the models behind the simulation (Hansmann, Scholz, Francke, & Weymann, 2005, p. 366; Couture, 2004, p. 41). Adult learners were affected by their experience within the simulation. It is of great concern that an educator show that the new knowledge the learner has created is actually legitimate and can be transferred to the real world. Creating false knowledge has the potential to do a lot of damage as students try to use it to make critical decisions in a situation with real consequences. Beyond model validity, it is difficult to generalize the limitations of simulations and games. There is a more detailed analysis of the limitations and benefits within the more specialized realms of military, medical and business simulations contained in Appendices II-IV. Many of the difficulties with the use of simulations and games in education have to do with the instructional design aspects more than they do the simulation design.

Simulation Research Directions

What Generalizations can be drawn?

The transition of established design paradigms with new simulation technology continues to happen as simulations become more common in the adult education marketplace. As new technology develops it will continue to facilitate and support older paradigms. Where instructional designers deem them relevant, these kinds of simulation technologies will be appropriate to support specific educational objectives. It will be necessary to continue to evaluate new simulation technology and its ability to continue to support and facilitate these approaches.

Although the use of simulations in education has been well established, there is still a considerable amount of work that must occur to help instructors understand if the simulation models underlying them are valid (Ramasundaram, Grunwald, Mangeot, Comerford, & Bliss, 2004, p. 32). This will allow for feedback to the simulation designers about refinements that are necessary to the model. As simulations become more common in the teaching environment, it will be necessary to continually update and refine the models. Eventually this lifecycle will need to be shortened and simulations will need to have the flexibility that will allow the instructor to modify it to fit a number of educational contexts (DeKanter, 2005, p. 31). The openness of the simulation to modification will require a degree of transparency of the underlying models. Many educators feel a need to understand the strengths and limitations of a simulation model before they introduce it to their students (DeKanter, 2005, p. 30). It is important that educators understand where the model most closely reflects reality and where license has been taken to meet the instructional design and playability requirements of the simulation.

It is likely that simulation and games in the commercial marketplace will continue to expand. Their use in the academic, post-secondary settings is still limited. Allowing the academic world to modify and develop their own educational simulations from an original piece of software may be the best way for them to gain widespread adoption in post-secondary settings. Resources within these institutions are often limited and technology choices are usually linked to budgetary constraints. This means that there will be relatively few resources available for academia and a limited number of commercial vendors who are interested in providing them with solutions. They will likely need to look towards internal resources to modify existing simulations in order for any institutional success to occur.

There is also a challenge of integrating the new technology into existing educational paradigms and infrastructure (Ramasundaram, Grunwald, Mangeot, Comerford, & Bliss, 2004, p. 33). Although effective, many simulations do not fit into the current teaching practices or uses of technology at educational institutions. It will be necessary to understand how simulations can fit into existing approaches as well as how current educational programs will need to change in order to accommodate them. Understanding effectiveness is one of the predominant problems facing any organization that is considering educational simulations. In many cases, the reason for the effectiveness of the simulations is complete conjecture. They can show an effect but the actual reason for the change cannot be linked to a specific design element or delivery approach (Hansmann, Scholz, Francke, & Weymann, 2005, p. 366). The amount of time it takes for the knowledge to be formed during a simulation-based activity is also unknown. In some cases there is speculation that a much longer time period is needed before the effects of simulation-based learning are seen (Mills, 2004, p. 26). Most organizations or institutions require a better understanding of these issues before they are willing to commit to the time and expense of changing their current educational practices.

What are the major gaps in Research?

Most of the research that discusses simulation design for educational purposes tends to focus on effectiveness and validity. What is often missing is the underlying theory of design and philosophy of knowledge about the models used to develop the educational simulations. Unfortunately, these have come to be regarded as academic, rather than pragmatic pursuits. This negative perspective towards academic issues has a lot to do with values that exist in adult learning in general. Earlier accountability movements, which were championed by military and industrial advocates, heavily influenced much of the current attitude towards academic perspectives on design. This approach affected both instructional design and educational simulation design. It had the impact of focusing creative efforts only on a product that was effective in producing an efficient learning experience.

This began when adult education looked to industry to develop standards of efficiency, which would assist in the development of accountable, competency-based education. The end result was that educators were destined to be "mechanics, not philosophers" that were responsible for turning learners into effective product using proven, standardized methods (Saettler, 2004, p. 292). Although this idea of performance contracting failed in the K-12 market it still maintains considerable control over the adult education market. The perpetuation of this type of objective, programmed instruction is evident in the kinds of educational simulation that are currently available on the market today. In many ways the technology has improved but the underlying design has not changed in decades. The dogmatic reliance on these proven models has stunted research into the theory and philosophy of simulation in adult education. The ability of academic researchers to provide meaningful research into the issue continues to be marginalized by some of the major influences in adult education. One obvious example is the perspective that universal truths can be represented within a simulation. It is an important consideration for simulation designers who need to make critical decisions about what kinds of truths they are expressing in their models and the interpretations that have occurred to arrive at those truths. Aldrich (2005, p. 91), representing a research head at the Gartner Group, dismisses this debate over universal truths as pointless. This kind of continued implicit value judgement on the role of theory and philosophy on the evolution of simulation will only continue to stifle advancement in the field. There needs to be a considerable amount of research into the nature of simulation design and how it reflects our own perspectives and biases. There also needs to be an attempt to translate the value of such work to many of the practitioners in the adult education market. Most of the educational simulation designs that are found in the literature can tie their origins back to theoretical perspectives that, in some cases, go back to the 1940s. Many of these perspectives borrow heavily from objective, scientific methodology, which has an implicit belief that systematically gathered data can be used to create inductive generalizations about the world (Ackroyd & Hughes, 1981, p. 13). This has placed a heavy positivistic perspective on most of the simulations available today. Given the rapidly shifting nature of the world and the increased awareness of more ambiguous and chaotic models for reality, there are obviously other areas that need to be researched. It would be wise to examine the basis for current simulation theories and whether or not they serve as a valid platform for all educational simulation design today.

What are the most profitable lines of inquiry?

Obviously a more detailed discourse on the underlying theory and philosophy of simulation design is required. It has been neglected for decades and it will need to examine itself in light of changing perspectives in educational and learning. Most of the current discussion is about what kinds of technology are going to be incorporated into the next generation of simulations. One of the common areas of focus in discussion of this next generation is the computer games of the entertainment industry. They are consistently being used as examples of the kinds of technology that can provide engaging, natural learning experiences (Aldrich, 2005, p. 134, Gee, 2003 p. 5). There seems to be an assumption that the technology can somehow be transferred to an educational simulation. Most of these discussions are vague and largely the result of limited understanding of how the game design in commercial games affects the people who play them. It is unlikely that the straight transfer of the technology will somehow create a similar engaging experience for learning. It will instead require a careful consideration of the instructional design paradigms that are being used as the basis of these educational simulations. It will also take a careful examination of how, and if, simulation design and technology can facilitate those paradigms. It is a much richer area of research than simply the technology alone. There will need to be a number of research approaches from both a quantitative and qualitative perspective before we start to get a more balanced perspective on how design is affecting the game players in entertainment-based games. It will be need to be a focus of research to understand how and if that design knowledge can be transferred to explicit educational experiences.

Another area that requires focus is one directed at academics themselves. It will be necessary to create a discourse with many of the consultants and experts within the adult education world. It is obvious that they do not understand most of the language used in the domain of academics. In a review of Gee's "What Video Games have to teach us about Learning and Literacy", Marc Prensky takes a negative stance towards Gee's use of "jargon" throughout the book. His position is that it makes the book inaccessible to most and was only written with the goal of impressing other academics for the purpose of professional advancement (Prensky, 2003, p. 4). Marc Prensky is a major consultant for industry and influential in the world of adult education. It is obvious that the current output from the academic world is being labelled with a less than complimentary judgement from the practical side of simulation in adult education. It will be necessary to investigate the kinds of liaison resources that will be necessary to create a more meaningful dialogue between academics and practitioners. Without such a discourse in place, much of the theoretical research that occurs will continue to be largely ignored by simulation designers.

Education in Simulation

Understanding the potential role of simulation and games in adult education involves far more than just technology. One of the most significant issues with their use is the current instructional design paradigms used in education (Kaufman, 2006, pers. comm.). As already identified in the simulation design section, many of the instructional design approaches follow perspectives that are decades old. Obviously they are still effective in certain contexts of education as they are still in use. Most of these traditional perspectives on education were designed to address an industrial age and not an information one. Traditional models emphasize mastering of content from a specific domain. Based on this perspective a single, objective version of that content was commonly presented to the learner. Storing knowledge and being able to recall it in a relevant context was a focus of these approaches (Duffy, 1992 p. 3). Educational simulations and games proved to be useful tools to facilitate this approach. Most of the commercial products on the market today are designed to help with this goal. The information age is changing the requirements for adult learners though. It has resulted in far too much information to be realistically mastered and a degree of change that would make any mastery obsolete very quickly. At the centre of this approach is a need to understand and use information to solve problems, not to simply be able to recall the information. It is one of the central skills that will be necessary for adult learners to thrive in the growing knowledge economy.

At the centre of the knowledge economy is information technology. It is seen as a transformative force that is no less impactful than the steam engine of the industrial revolution. It is very different from those older machines though as it can also change the way society works. It is already affecting the way people "research, communicate knowledge, learn, publish and manage intellectual property" (Thorp & DMR, 1998, p. xviii). Understanding the types of workers that will thrive in an environment that constantly changes is challenging. Understanding how to create educational experiences that will help them thrive is yet another issue. It will be important to examine the explicit and implicit issues with current instructional design methodologies as well as newly developing ones. They are all based on conceptions of knowledge that facilitate different types of learning (B. G. Wilson, 1996, p. 3).

In many commercially available educational simulations these views and perspectives are only obvious upon the analysis of their design, they are rarely discussed in terms of the actual use of the product. In the area of instructional design there are several regions that will affect the use of simulation. These include the learning environment design, delivery and facilitation, evaluation and e-learning standards.

Instructional Design

In order to understand how games and simulations have been utilized in the past it is important to have a brief background on where they fit into various instructional design approaches. Often these design approaches come with a number of beliefs and theories that are not necessarily made explicit. There are innumerable perspectives on the terminology used to describe these approaches but for the purposes of this review they are being organized into objectivist and constructivist approaches.

Objectivist Approaches

The objectivist perspective is based on a belief that the world can be described and structured in terms of objects and the properties and relations of those objects (Duffy & Jonassen, 1992, p. 2). It follows a strong western scientific perspective that all natural phenomena can be described in terms of the components and the systems that logically define how those components work together.

In this approach the goal of education is to provide an experience that can allow learners to understand the objects, properties and relations that exist in the world. The world can then be viewed as a set of propositional models. Education is then comprised of the acquisition of the entities, relations and attributes of each model (Duffy & Jonassen, 1992, p. 3). It is an internalization of an external, objective knowledge (Davis, Sumara, & Luce-Kapler, 2000, p. 61). The approach does not discount previous experience or the understanding of those models. It just makes an assumption that previous experience will only lead to partial understanding. The goal of education is to provide a complete and correct understanding of those models. The validity of this perspective is based on an underlying belief in a complicated or mechanistic interpretation of human cognition (Davis, Sumara, & Luce-Kapler, 2000, p. 56). The underlying cognitive structure of the human brain is understood as being readily able to understand and process information that is presented in an objective manner, much like a computer.

It is not surprising that the logical, mathematically based models of educational simulation became a popular tool for instructional designers. These simulations were lucrative because they were perceived as concrete, effective and consistent. They could present a dynamic version of a real-world model to the learner. Simulation became one of the many types of media that tended to dominate instructional design. The job of this media became the transmission of the objective content that had been outlined by the instructional designer. It could be formalized in an overall instructional design process

(Figure 1). In this model a message was chosen for transmission to the learner. The technical design component is then created and is comprised of the messages or information that has been selected for transmission. The media instruments are the types of media that have been chosen to deliver that message. Simulation models presented an option for that transmission. The people involved are those that are required to control or facilitate the simulation. The methods are focused on issues of presentation. The environment delineates the requirements for the delivery of the simulation. This is generally a computer-based approach for the purposes of modern simulations.

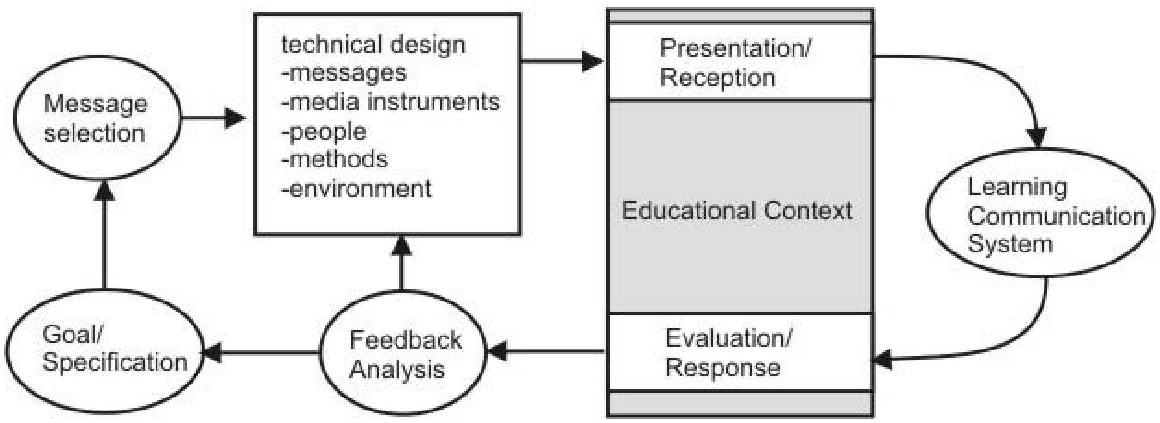

Figure 1. Instructional Design Development Cycle (modified from Saettler, 2004 p. 9)

This design has led to a systematic approach for much of the instructional design in adult learning. The logical models of many computer-based simulations seemed to be a natural fit for this mode of delivery. Many of the heavily positivistic disciplines, such as military and business education, found the idea of transmitting a consistent, objectivist message as extremely appealing. The learners who went through such an educational experience could be perceived as being consistent with all other learners who had gone through the same education. This consistency would assist in creating a universally competent workforce that could be dependably slotted into prescribed positions in any organization. It followed with the industrial age thinking that pervades most organizations in terms of how equipment and personnel are organized. Every piece of the machinery follows a specific function and will contribute to an overall function of the system.

This approach to instructional design continues to have a purpose in adult education. For those situations where training requires a consistency in workers and a predictable response to stimuli in the workplace they work well. Simulation will continue to play a role in this type of training. This instructional design approach is not necessarily reflective of the best way for people to learn and does not represent the realities of a new information age. It also provides a very simplistic perspective on simulations, as they are often very complex entities. Using an instructional design approach that doesn't acknowledge or facilitate ambiguity and chaos within the design is going to limit the utility of simulations. Objectivist approaches attempt to limit the complexity of most simulation and therefore have a tendency to delineate the learner experiences and curb their creativity within them (Lobuts, 2004, p. 4). The resulting structure is more suited for a licensing process that is focused on producing quantity rather than quality for the workforce. This limited range of options within the simulation results in a very limited tool, such as the branching stories being used in workplace education now. These kinds of products are often marketed as a simulation but in truth they are so limited that it has become a simulation in name only.

Constructivist Approaches

The epistemology of constructivism is an alternate perspective on how learners perceive and interpret the world. Unlike objectivism, constructivism believes that the learner imposes his or her own reality onto the world. The world does not and cannot exist independently as a consistent objective component (Duffy & Jonassen, 1992, p. 3). Constructivism accepts many different perspectives and maintains that learning is a very personal interpretation of the world. Every person has a number of prior experiences, mental structures, and beliefs that are used to interpret objects and events (Jonassen, 1991, p. 7). Each new experience is compared to and indexed by, our existing experience (Duffy & Jonassen, 1992, p. 4). In this way it is impossible to have a common, consistent shared reality among all learners.

This approach presents a challenge to instructional design. It dispenses with the naïve notion that you can create a well-structured educational experience that will result in your learners all acquiring an identical perspective on knowledge. In terms of instructional design this is a problem as much of the current research has been heavily based on earlier objectivist perspectives (Willis, 2000, p. 5). In recent years there has been a growing body of knowledge on how constructivist perspectives can be put into practice in instructional design. The central issue with this is that constructivist philosophy views truth as something specific to a context and a social construct. There can therefore be no single design approach in constructivism that can be viewed as the single, correct way of viewing design (Willis, 2000, p. 5). A number of different perspectives have arisen but perhaps the best way to approach it is that the design must work towards the creation of a constructivist environment in which a number of instructional designs can be implemented. These sorts of environments are places where learners can work alone or together with others. They allow the use of a variety of tools and information sources to follow a guided and facilitated problem solving activity (B. G. Wilson, 1996, p. 5). The focus of these activities is defined within the learning goals of the environment but they don't restrict the path that the learner needs to follow to achieve these goals.

The role of simulation design in constructivist perspectives is changing as new opportunities are being offered from the technology world. It is unlikely that there will ever be a single technical design that can match all constructivist instructional design perspectives. Given the variety of developing constructivist instructional designs that are becoming available any new technology will need to be evaluated independently for each. One consistent aspect to the use of technology is in its rationale for usage. It must be there to facilitate the construction of knowledge (Jonassen, Myers, & McKillop, 1996, p. 94). It cannot be simply used as a transmission mechanism for information.

The role of simulation in these kinds of design approaches is also an evolving issue. One of the environments that have been suggested as facilitating constructivist instructional design is a computer micro world. These are self-contained environments where learners can be presented with specific phenomena and allowed to subsequently manipulate their environment (Wilson, 1996, p. 7). This type of use of simulation is seen as providing more of an opportunity for natural learning that is closer to the way learners actually experiences the real world (Shank & Cleary, 1995, p. 77). The technology and design paradigms behind computer based simulation and games would seem to be a good fit for these kinds of approaches.

Facilitation

An often-neglected issue is the facilitation that is necessary for simulations to work in an educational context. Facilitation can be defined as the skills and capabilities for managing simulations and games for learning (McGarry, Eberle, & Kato, 2004, p. 5). They have a significant impact on the achievement of intended outcomes. Regardless of the philosophical perspective behind the instructional design, it is necessary that the facilitator understand the intent of the simulation design. In situations where there is an incompatibility between the teaching styles and the instructional design of the simulation the learning potential will be weakened.

Obviously, educational games and simulations that are based on constructivist approaches will likely have a number of issues when deployed in a traditional adult learning environment. It has a very different perspective on knowledge and how learners interact with the world when compared to educational simulations based on objectivist ideals. In many cases the existing management is still in a very different mind-set about the purpose of education. They are not totally aware of the implications of the knowledge economy and the types of adult workforce they will need to succeed in it. They see the technology of the knowledge economy as a tool to facilitate existing process. They don’t understand that the most valuable skills needed when dealing with the flood of information is the ability to critically think, evaluate and make judgements based on that information. Any single process that was developed to solve an issue with that information could easily be obsolete in a week. Subjecting adult learners to educational simulations that focus on the memorization of information and process is an obsolete concept in a technology environment. This idea of internalizing a single body of correct knowledge takes a very mechanistic perspective on the business and the adult learners who are working there. Instead of looking at their potential to increase productivity and capability in a knowledge economy environment they are looking at adult learner as a competent components within a system. In many ways the simulation technology and instructional design has developed but the mind-set of management has not. They have the same industrial-age perspective on work automation. This is clear, mechanistic, predictable and easy to measure in terms of benefit and ROI (return on investment) (Thorp & DMR, 1998, p. xx). This is reflected in the types of professional development offered to employees and the goals that are identified for that education.

Evaluation Issues

Evaluation of simulation-based learning is problematic. There are several industry specific examples of how the issues are being resolved contained in Appendices II-IV. Central to all of these is the issue that traditional assessment approaches simply don't show the beneficial impact of a simulation-based experience. In Gosenpud's (1990) review of several research studies on the effectiveness of experiential learning all of the assessments and evaluations occurred outside of the actual learning experience. These were often in the form of exams and essays that were used to compare simulation taught students with a more conventionally taught group of students. This approach did not show any differential impact of the simulation-based approach. It will be important that instructional designers have access to different kinds of evaluation for simulation-based learning. This will most likely be a form of evaluation that occurs inside of the simulation environment itself.

E-Learning Standards

E-learning standards might not seem immediately relevant to a discussion about educational simulations. Their importance lies in the fact that they can have a substantial impact on the types of instructional design that are available to organizations. They often come with a set of philosophical assumptions that will affect the kinds of design, development and deployment tools that are available to an instructional designer.

Current e-learning standards have been designed to create a structured paradigm to deliver identical content that uses essentially the same design in a standardized way. Although there is far from a universal adoption of many of these new standards, Sharable Content Object Reference Model (SCORM) is the current standard in use in most adult learning contexts (SCORM). It began as an initiative of the U.S. Department of Defense.

The approach works well with static content that is delivered within a learning management system (LMS) environment but is not well suited to true simulations. Much of the simulation-like content, such as games and branching stories, can be delivered within a standardized LMS framework where the AICC API can track progress and gather scores as the user moves through a series of defined challenges. Most of the true simulations only have an LMS usable output that creates a summary file of the activity of the learner within the system. This is then stored as an assessment component within the LMS. The AICC API is also designed for web-based content and most true simulations and certainly the next generation simulations will not be using this approach for their delivery. The limited use and incompatibility of the SCORM standard will require a new discussion of how simulations in adult learning will be tracked and scored within standards based approaches. The only active group that is in discussion on this issue is SISO (Simulation Interoperability Standards Organization). This group is an offshoot of ADLNet, the parent organization of SCORM. SISO is currently developing standards to facilitate the interoperability of simulations with many different systems, including SCORM compliant systems (SISO, 2006). Although this kind of activity can open up the amount of interaction that is happening between the various developers of educational simulations it is important to understand the underlying philosophy behind this organization. It is mostly composed of DOD (Department of Defense) and military contract suppliers for the American military. Most of the standards developed will be designed to facilitate those kinds of organizations.

SISO will continue to research and develop standards. It is likely that many people will misunderstand the nature and relevance of these standards to their own approaches to simulation in adult learning. Many government and business organizations learned an expensive lesson by having educational content that was not interoperable between systems. They are often quick to move towards a standard that promises that the same mistake will not be repeated. They will be hoping to ensure that new systems, components and design methodologies allow as much interoperability between systems in order to maximize their investment. Much like the current standard SCORM, which is used for many commercial LMS products today, the standards will influence the authoring tools, the delivery tools and instructional design methodologies. In order to maximize the range of options that will be available to educators it will be important to ensure that those standards are not restricted to a certain pedagogical perspective. These standards will shape the tools that will be available to the adult workplace, be it business, government or post-secondary. For example, it is unlikely that any post-secondary that has invested in a campus-wide LMS license would be encouraging faculty members to build educational simulations that aren't standards-based and fit into their system.

These developing standards have the potential to perpetuate older, objectivist models of instructional design. Some of these approaches date back decades and were an appropriate response to the adult education environment at that time. They are still relevant but it will be necessary to ensure that these standards do not restrict the ability of simulations to be developed to address current and future situations as well.

Education in Simulation Research Directions

What Generalizations can be drawn?

Instruction design will continue to be an issue with educational simulations and games in the adult education marketplace. There is both a strong objectivist tradition in place and a lack of any explicit understanding of the theoretical implications of perpetuating those approaches to pedagogy. Simply using newer and more sophisticated simulation technology does not mean the restrictions of the instructional design are going to disappear. It is a rather dogmatic assumption that these older approaches are going to address the issues facing adult learners in a knowledge economy. This complex and chaotic world will require a much different approach for those learners to succeed. It may be possible that the constructivist approach can provide the kinds of environments that will help adult learners address these issues. Currently this is unknown, as are the places where educational simulations will assist in facilitating that type of learning.

It is also apparent that the current corporate environment has an antiquated perspective towards technology, let alone the kinds of skills their employees are going to need to use it. The industrial perspective towards organizations is outdated and in many cases this misunderstanding will lead to the failure of technology. Any attempt to introduce educational simulations will likely be subjected to the same kinds of value judgement. Those simulations that define a very distinct and proscriptive approach that will develop specific skills that will result in increased productivity will be reviewed favourably. It is a simple matter to look at the kinds of commercial simulations available for the adult education market to realize that this is currently the case. Attempting to integrate educational simulations that break this mould by helping adult learners to understand the ambiguous and chaotic world of modern business are likely to produce a disconnect with existing corporate thinking. In the unlikely event that these types of simulations were to ever make it into an organization they would likely fail as a result of improper management and facilitation.

E-learning standards also represent an issue for the next generation. E-learning in general has been impacted by the previous encounters with e-learning standards. Despite being based on military and industrial instructional design and theory from the 40s and 50s these standards have taken a strong hold on the education marketplace for K-12 and post-secondary. They have heavily influenced the kinds of content creation tools and delivery mechanisms to almost any organization that wishes to become involved in E-learning. It is unlikely that any large organization would deliver online courses in anything other than a standards-based LMS. The same kinds of restrictions could soon be imposed on educational simulations. Unless the standards are built to accommodate a variety of perspectives on learning and knowledge, the tools that are based upon those standards will restrict the potential range of any simulations created. If the previous trend continues this would mean an exclusively objectivist approach to learning would dominate.

What are the major gaps in Research?

The concepts around constructivist learning are not new. On the other hand, the actual instructional design that defines how to implement this approach is constantly evolving. It is realistic to accept that no single correct way will be created for constructivist instructional design. It has allowed a degree of flexibility that can accommodate specific educational contexts. How this will impact the role of simulations and games in adult education is a relatively unexplored area of research. There is a considerable amount of speculation that the open, chaotic environments that are seen in commercial games may represent some of the environments necessary for constructivist learning. Most of this is just speculation as is the design and technology that will be needed to facilitate any learning.

This is not to say that research in objectivist approaches to education is exhausted. As new technology appears in the simulation marketplace it will be necessary to continually assess it. It may be able to facilitate the discrete goals of objectivist approaches in a better way than previous technology.

One area that seems to be lacking is a theoretical perspective on knowledge creation inside of simulations. There is very little that deals specifically with the instructional design of simulations for the adult market. In many ways it is treated like any other form of media that is used to deliver a message from the instructional designer. Understanding the implicit theories that underlie a design would be extremely helpful when trying to determine why it is succeeding or failing. Given the general lack of philosophical or theoretical perspectives into the pedagogical models of simulation in adult learning this presents a weakness.

The potential impact that developing E-learning standards are going to have on the next generation of simulation design is relatively unknown. Historically these standards have had a substantial impact on the kinds of pedagogical designs that are available to instructional designers. The same fate may await educational simulations if E-learning standards impose themselves on simulation design, creation and deployment tools. This will need to be investigated in more detail as the standards evolve.

What are the most profitable lines of inquiry?

Much of the existing educational simulation product available for the adult learning marketplace provides support for industrial models of business. There is evidence that they can perform effectively as media instruments for facilitating that approach. Understanding how simulations can support learning that will assist learners in the evolving knowledge economy holds much more promise. Canada is moving away from an industrial and resource based economy and will need to become more competitive in the emerging knowledge economy. Constructivist approaches, that encourage learners to thrive inside of ambiguous, chaotic environments, seem to provide a good analogy for the new world. The technology behind many existing simulations and games may be able to facilitate such a design but there are many unknowns. It would be necessary to begin investigating both constructivist instructional design approaches and the kinds of simulation technology that can facilitate them.

Analysis of Literature

The literature that was gathered for the review was subjected to an analysis to identify dominant themes in research and implementation. It is important to realize that some issues that were identified as gaps in the literature in the previous section do not show up in the analysis. The exclusion of issues such as underlying philosophies of knowledge and instructional design were not intentional. Most of those published papers recovered instead dealt more with practical issues of implementation. Within that range, there were several trends that were identified and documented. In many cases some of the more extensive pieces of literature scored in several of the categories as they discussed a wide range of topics.

Major issues in Implementation and design

There are a number of issues in the implementation of educational simulations. These showed up throughout the literature (Table 1). These issues were all important to the success of the implementation of the simulation in a variety of subject areas and not restricted to one specific type. Many of the issues occurred repeatedly through the review and rose to become dominant themes.

Element	Occurrence in literature reviewed
Providing feedback	2%
Repetitive practice	12%
Curriculum integration	5%
Range of difficulty	2%
Multiple learning strategies	2%
Capturing variation	2%
Individualized learning	5%
Defined outcomes	7%
Simulator validity	21%
Realistic simulation context	12%
Low cost of failure	27%

Table 1. Simulation Elements in Implementation

Providing feedback: Appropriate feedback to the user involves the simulation providing some form of assessment as to the performance of the user. It is considered important for the learner to be able to understand where they succeeded and failed and adjust their behaviour accordingly.

Repetitive practice: The simulation must allow for the learning activity to be performed over and over again. This was seen as the key to mastering the fundamental skills within the simulator so that the learner could perform those same skills in a real life context. It was recognized that each learner would need to repeat the simulated skills at very different levels of repetition. By allowing him or her to do so, the simulation would provide a very learner-centric experience that could be customized to each learner.

Curriculum integration: This is related to the ability of a simulation to take several different curriculum subject areas and demonstrate how they are all integrated together. This type of simulation was designed to break the traditional constraints of linear curriculum by showing how it integrates into a dynamic model. It is considered important because too many students did not understand the knowledge they were building in a holistic or systematic perspective.

Range of difficulty: The simulation must have an ability to facilitate learners of different levels of competence. It is important that learners must not be bored if the simulation proves too easy or frustrated when they cannot perform the tasks in the simulation. A simulation that can slowly scaffold in additional tasks is seen as the ideal design as it allows learners to build up complex behaviours over time and at their own pace.

Multiple Learning Strategies: Some learning objectives required very open simulation models that would allow learners to experiment with many different options. The ability to achieve similar results through a variety of strategies would allow several different approaches to learning to be integrated into a single simulation.

Capturing Variation: For some simulations it is important that the natural variation that occurs within the real world is captured. This is certainly the case in biological systems. A simulation was not considered to have enough authenticity unless it had a degree of randomness and uncertainty that the learner would also experience in the real world. Without this element the learner would only build mastery of a single procedure within the simulation and neglect to build up skills for dealing with unexpected elements.

Individualized learning: This is the ability of a simulation to allow entry of different variables in order to customize each experience to the individual learner. This could involve changing the quantitative parameters that go into the simulation models or modifying the rules that define the win state of the simulation or game. This could be easily changed to address the learning needs and skill level of individual learners.

Defined outcomes: No matter how valid the underlying model is, it was important that the simulation make the learning outcomes of the experience very explicit. Learners needed to have a complete understanding of the purpose of the simulation experience as well as the parameters they would need to achieve to finish it.

Simulator validity: This is a very important aspect of a successful educational simulation. As every virtual environment is constructed it is critical that it be based on valid models that closely represent reality. In most adult learning contexts, the skills that are built up within the simulation must translate to a real world context. In many cases, the cost of failing in the real world can have consequences to both health and safety.

Realistic simulation context: The realism of the simulation context is related to the placement of the simulation into a real life context. It is considered important that even though the learning is occurring in a simulation that both the learner and the simulation be physically located in the place where the skills will be performed in real life.

Low cost of failure: One of the most important elements identified within a simulation was the ability to fail during the learner's attempts to successfully navigate them. The concept relies on the belief that it is better to fail in a simulated environment, as it is a low-cost environment. This was considered important for dealing with learners who needed to not only fail but also be able to see the consequences of that failure within the simulation. The goal of having this kind of element is to provide the learner with an understanding of a system so that they can successful deal with a situation in the real world that may affect health or safety.

Major trends in Research

There were several trends that appeared in the research elements of the literature (Table 2). These included the elements where current research was occurring and additional research was being recommended.

Element	Occurrence in literature reviewed
Design	24%
Haptics	15%
Graphics	2%
COTS	15%

Table 2. Research Elements in Simulation.

Simulation Design: There are a number of aspects of educational simulation design that have been the focus of research. The design elements necessary for a simulation to be effective as a perceived valid model of reality, the type of technology that will best suit those goals and the kinds scaffolding that will be required for them to be effective are all being questioned. There is also a desire to build a common ontology so that simulations could be compared with one another and their different approaches evaluated for their effectiveness.

Haptics: One of the common elements that came up was the use of haptic devices to provide realistic visceral feedback to the user about their interaction with the virtual environment. This was most common in discussions about virtual surgery systems where there are many who believe that better visceral feedback to the user will be critical to learners gaining skills that can be transferred to real contexts.

Graphics: The visual realism of simulation is increasingly becoming an issue for educators. Most high-end simulations, such as flight simulators, already have a high level of fidelity and this is desired in the other types of simulators being developed. This is most important in virtual environments where recognition and manipulation of objects must translate to structures in the real world.

COTS (commercial-off-the-shelf): One of the biggest obstacles to the widespread adoption of simulation has been high cost. Many groups are now looking at COTS based products that are being developed in industries such as the commercial computer game industry. The size of the market has driven the price of these technologies down considerably. As well, all of these technologies run on consumer grade desktop machines rather than expensive proprietary equipment. Organizations are examining the kinds of challenges they will face in modifying that existing technology to meet their needs.

Major Educational Issues in Simulation

Obviously, in order for educational simulations to be effective they need to address a number of pedagogical issues. Although the instructional design challenges of making an effective educational simulation affect all simulation projects there are some other major elements that are becoming obvious. These include new uses for simulation, simulation as an evaluation tool and dealing with existing belief structures within educational settings (Table 3).

Element	Occurrence in literature reviewed
Teacher Belief Systems	17%
Student Belief Systems	49%
Assessing Professional Competence	15%
New Technology Skill Requirements	7%

Table 3. Educational Issues in Simulation

Teacher Belief Systems: A significant element that will impede the adoption and successful implementation of simulations is current teaching beliefs within adult education. Many studies identified teacher attitudes and confusion about simulation as an issue. In most cases the current curriculum structure and classroom structure were incompatible with educational simulation approaches. If a solution was offered it was the creation of professional development opportunities for teachers to understand this new teaching paradigm and to adjust their beliefs about effective teaching to accommodate simulation.

Learner Belief Systems: There were two major learner attitudinal themes that pervaded the literatures. One was the ability of simulation to change student attitudes about a subject or topic. The other was the attitude needed by students in order for simulation to be taken seriously and therefore act as an effective agent of change. The changing of personal belief systems about a subject has been a goal of the instructional design behind educational games and simulations for at least a century.

In terms of student attitudes towards the simulations themselves there is a significant issue with the way the upcoming gamer generation is going deal with simulations in an educational setting. They will need to view them differently than the entertainment-based games they have traditionally encountered.

Assessing Professional Competence: Simulation is not only being viewed as an educational tool but an important tool for assessment. Many disciplines are questioning the validity of using classroom hours as an indication of competence in a particular field. They see the dynamic systems of simulations as a way to bring together a number of curriculum elements into a single environment. The students ability to successfully navigate that environment and accomplish tasks is being viewed as a much more valid measure of their professional competence before they are allowed to work in a real environment. The assessment paradigm also applies to professional development, as it will serve as an ongoing test of the skills of the practitioner. Skills are often forgotten over time and a simulation-based assessment is viewed as an excellent way to determine when they have dropped below an acceptable level and require some professional development to bring them back up to operational levels.

New Technology Skill Requirements: Simulation is no longer just being created to address existing workflows. As new equipment and procedures are being developed there are educational simulations being created to educate adult learners about workflows that have never even occurred. It will become increasingly common for companies to send out simulations of their products that will train learners how to use their product long before they even see it. Gaining expertise to a point where they can move directly onto the new equipment in a real context is going to take a considerable amount of confidence and it will be important that these new approaches to simulation are proven effective.

Conclusions

We have entered into a new millennium that is characterized as an era of constant, and in some cases, radical change. Much of the change will be related to technology advances and the kinds of diversity people will encounter in a global knowledge economy. These periods of shift often result in change of economic systems, cultural practices, and social institutions (Hagood, 2000, p. 311). As this shifts occur there will need to be a change in the types of education that is available to adult learners. There is growing dissatisfaction from the workplace environment with the types of adult learners who are currently entering the job market. The education they have received does not seem to facilitate their easy integration into the current global market. This is being blamed on existing pedagogical methods that use linear information transfer and static, mentalist models of knowledge. This approach creates adults with a considerable amount of information in their heads and the belief that it is a correct and unchanging image of the real world. This is considered to be an inappropriate perspective for dealing with the rapidly changing conditions of the real world. Many governmental organizations are beginning to recognize the limitations of formal education to meet the needs of the new global economy as well. They are shifting policy towards recognizing that fact and are trying out a number of new approaches to facilitate those policies. As part of the search for a more relevant approach to adult education, computer-based simulation has been repeatedly identified as one of the most effective methods for learners to encounter potential situations that they might face in real-life practice. They have demonstrated that they can encourage the development of critical thinking skills, create attitudinal change, improve performance, increase safety and decrease costs. These strengths are currently being examined in a number of adult learning contexts and there are a several areas that will require additional research before definitive statements about their effectiveness can be made. These include issues surrounding the technology, pedagogy and assessment paradigms that are used with educational simulations.

The weaknesses of educational simulations and games are also the subject of a considerable amount of research. A lack of realistic models inside the simulation, unprofessional behaviour by players, unrealistic levels of complexity in the environment and questionable transfer of skills from the virtual world to the real one are all issues. Another problem is the long history of games and simulations in our culture that has led to a deeply entrenched perspective on these resources as being an entertainment vehicle. This perspective is one of the challenges in existing belief systems that will need to be addressed. The problem is not entirely unique to simulations. Many of the criticisms about simulations and educational games are common complaints for many poorly presented and poorly designed educational resources. It is not the concept of educational games and simulation that needs to be evaluated as much as their appropriate design and use.

It will not just be new design and technology that will be needed to make educational simulation successful. If they are to be delivered within current adult learning frameworks such as professional development, training departments and post-secondary institutions there will also need to be changes in the way curriculum is organized and education is delivered. This will involve organizational and policy changes within those institutions. Most significantly, the current belief systems about the structure of formal education, for both educators and learners, will need to be changed before simulation can be used effectively in any adult learning context.

There will also need to be a considerable coordination of multi-disciplinarian teams in order for research to progress in educational simulation. The US military has already created a number of successful models that integrate academia, computer science, engineering and workplace learning together. Similar models of collaboration will need to be facilitated at post-secondary research institutions so that the adult education marketplace can take advantage of the work that will result. Interdisciplinary cooperation and coordinated funding are just a few of the benefits to the creation of such research groups.

The role that Canada will take in research and development of educational simulations for the adult marketplace is currently quite open. The amount of published Canadian research in this area seems quite limited but most of the current research from around the world has only been published in the past 5 years. The area is still very new and there are a considerable number of questions that need to be answered.

Appendix I: History

It is important to understand how the current state of simulation and games in education evolved. Those influences and biases continue to affect the discipline today. This requires the inclusion of a discussion on the history of games and simulation in human society and how they have increasingly been considered as a powerful tool for learning. The central premise of the review is that games and simulations have constantly had a place in human society. Their learning ability has always been understood implicitly and some cases this poorly-defined, abstract benefit has been part of their allure. The historical review will look at the turning points when society began to explicitly look at games as more than entertainment and as something that could have an actual impact on the player. The types of learning and the models used to validate that learning have continued to develop over the past two centuries. This evolution has had a number of branches through history up until the modern situation.

Ancient History

Evidence for games has existed in the archival and archaeological records for thousands of years (Wilson, 1968, p. 2) (Table 4). Although there is physical evidence that they existed in many cases there is little evidence available to determine their role yet alone the rules used to play them. It isn't until much later in recorded history that the importance attached to being able to play these games becomes apparent. Early games

Time	Game	Location	Type	Comment
3000 BC	Royal Game of Ur	Mesopotamia	Abstract Strategy Board Game	Oldest complete set of gaming equipment
	Senet	Egypt	Abstract Strategy Board Game	Egyptian game
2000 BC	Wei-qi	China	Abstract Strategy Board Game	early version of Go
	Go	Japan	Abstract Strategy Board Game	
1400 BC	Morris	Egypt	Abstract Strategy Board Game	found at the Temple of Kurna
	Mancala		Abstract Strategy Board Game	
700 BC	Dice		Dice game	Cubical dice
0	Tabula	Rome	Abstract Strategy Board Game	Early Backgammon
300 AD	Nard	Babylonia	Abstract Strategy Board Game	Early Backgammon
400 AD	Hnefatafl	Scandinavia	Abstract Strategy Board Game	brought to Britain by the Vikings
550 AD	Chaturanga	India	Abstract Strategy Board Game	moved across Asia to Persia to become chess
700 AD	Chess	Persia	Abstract Strategy Board Game	
900 AD	Fidchell		Abstract Strategy Board Game	
1300 AD	Cards	Spain	Card Game	Earliest mention of card games
1430 AD	Tarot	Italy	Card Game	
1600 AD	Backgammon	England	Abstract Strategy Board Game	Earliest mention of Backgammon
1700 AD	Solitaire		Card Game	
1800 AD	Bridge		Card Game	
	Poker		Card Game	

Table 4. Timeline of games (historicgames.com, Masters 2005, Wilson 1968)

such as Wei-qi and Go have been used as examples of games that were designed to demonstrate tactical concepts to students. This game provided a turn-based board game where players made moves that were designed to encircle and defeat their opponent. Chess is probably the most commonly known western example. The game was considered to be an equivalent to the kinds of decisions required during war (Wilson, 1968, p. 2). In Persia it served as a training tool for princes and the elite that had no local enemies on which to practice warfare. There is more recent evidence that skill in chess was seen as important to development of thinking skills. Often the elite played these games in order to provide the kind of education necessary for those in positions where strategic thinking were critical to success. It is interesting that later on, social activists such as Benjamin Franklin advocated that everybody should play chess so that anyone, no mater their social status, could benefit from the skills they would create by gaining mastery of chess. The skills that he believed chess could teach included foresight, circumspection and caution (Franklin 1779). From this perspective, chess could teach the ability to think and strategize. It was not just a game for the elite but one that everyone should play it in order to increase they intellectual abilities.

Although these games were promoted for their ability to increase strategic thinking skills there is little research to provide evidence of how the learning occurred or how it would transfer to the real world. At the very least a player could become very skilled at playing strategic board games but there is no scheme in place on how to transfer that to other contexts. There was only an implicit belief that the experience would somehow generalize to other meaningful contexts.

It is important to realize that not all games were seen as encouraging intellectual activity. Even those that were designed to teach strategic skills could be played for entertainment rather than with an explicit goal of increasing mental capacity. Many other games were created purely for entertainment and then added an element of chance that would limit the success based on skill alone. This dichotomy between serious games and those that were purely designed for entertainment is a division that has continued until today.

Appendix II: Military Simulation

One of the first groups to look at simulations and games, outside of their abstract learning potential, was the military. Their use has evolved to a point where they are currently viewed as pivotal to their success as an organization. Their rise in popularity came with an increase in a scientific, positivistic view of warfare. This resulted in a belief that war could be defined by a set of scientific laws (Wilson, 1968, p. 2). This quantifiable approach to the chaotic event of warfare drove forward the idea that simulation-based education could provide learners with a consistent tool that would be able to assist them in understanding warfare. This work has continued up until the modern day. The military now provides the most research and development funding for adult learning in simulation.

Background

Educational simulations are not considered to be a replacement for real world training but they continue to be developed because they are considered effective and economical. Actual manoeuvres and warfare are considered a much more costly context in which to learn military skills. As simulations and games continued to evolve they were recognized as having two roles in military education. One was in the actual training of tactics and strategy but the other was the evaluation of those skills (Wilson, 1968, p. 12). It is both a teaching and an evaluation tool for students to prepare them for the real and costly exercise of warfare.

The military has many more years of active experimentation in the use of games and simulation in learning environments. As a result they have branched out into a variety of formats (Table 5). Most of these activities are focused on the deployment and use of a variety of weapons systems (Shubik, 1979, p. 13). These games are mainly focused on developing competencies in weapons systems within a simulation of a real environment. In recent years there has been a development of role-playing games that focus more on communication and empathy.

	Type	**Goal**	**Evaluation methodology**	**Validity**
Operational Games	Tactics and Strategy	Heuristic skills	In-simulation and real-world evaluation	Game theory
	Planning	Logistic skills	In-simulation and real-world evaluation	Simulation/ model of real-world process
	Advocacy	Indoctrination	Change in opinion	Simulation/ model of perceived-world process
Teaching and Training	Skill Acquisition	Specific Skill	In-simulation and real-world evaluation	Simulation/ model of perceived-world skill
Role-play	Narrative	Empathy/ End game	Verbal/ Written De-brief	Qualitative assessment

Table 5. Military Games and Simulations

Tactical and strategic games are used to build skills in appropriate decision-making. Although this is often about learning to recognize the most profitable decision given a set of criteria it has also been used as a creative tool in the military. In these kinds of scenarios the player is given a situation where they can explore a number of strategic options within a safe environment. These kinds of tools have gained increasing interest as the military tries to encourage heuristic skills (Wennergren, 2003).

Planning simulations focus specifically on creating logistical skills. They are an example of the interactive spreadsheets that are commonly used in civilian adult education. The goal of the logistical simulation is to provide an understanding of the process in place that allows an organization to function. Although decision-making skill is important it needs to be based upon an understanding of a dynamic process that controls the flow of resources.

Advocacy is an interesting type of simulation. It is often created to skew opinion towards the message of the simulation. These are used to demonstrate the validity of a plan or operation by portraying it as a successful event. One of the most famous examples of this was the Schlieffen Plan created in Germany between 1894 and 1905. This was a detailed operational war game that outlined how Germany could defeat both France and Russia in a single, short campaign(Wilson, 1968, p. 22). The game became the justification for Germany initiating the First World War as the government had been convinced by the military that the operation would be successful based on the outcomes of the game. The game was inherently biased, as it had not factored in several political and logistical implications of an invasion of France and Russia. The resulting four years of war devastated Europe and it was not until later, when more objective eyes looked at the game, that the weaknesses were discovered.

Military teaching and training games are often more focused on building specific competencies in their participants. The skills built within a simulation are carefully designed so they can transfer to a real-world scenario. Often the types of training are focused on equipment that is too expensive or dangerous to allow students to make mistakes with in real life. Many of the military flight simulators fall into this category.

The American military continues to develop simulations to address all of these areas. It has an annual budget of $4 billion for simulation training with $50 million going towards developing new wargame training scenarios and technologies (Blank, 2004). This smaller budget has been targeted at a new, low-cost approach to producing wargames. This is a direct result of a new willingness in the military to build strategic alliances with the entertainment industry and academia. This trend began with the release of the commercial entertainment game, Battlezone. This game was released in 1980 and was unique due to its vector-based graphics. It was a tank combat game that provided a simulation of a 3D, first person perspective for the player. The most important aspect of Battlezone was a request by the military for Atari, the game's maker, to build a military version of the game for use in training their own tank crews (Parish, 2005). This marked the beginning of the relationship between the military and the entertainment industry.

The American military realized that is was no longer the technology driver in the simulation business by 1995 (Wilson, 1995, p. 44). In 1999 they signed a $45 million contract with the University of Southern California to establish the Institute for Creative Technologies (ICT). The new organization has a mandate to develop new modelling and simulation technologies for military and educational purposes (Blank, 2004). The ICT has joined forces with US Army Research, Development and Engineering Command, US Army Training and Doctrine Command (TRADOC) and several commercial game companies (Blank, 2004). The first product of this partnership was Full Spectrum Warrior and Full Spectrum Command, released in 2003 (Burger, 2003). Full Spectrum Command was a logistical training simulation at a captain rank level while Full Spectrum Warrior taught squad-based tactics. Both simulations were for Military Operations in Urban Terrain (MOUT). Full Spectrum Warrior was developed to run on a Microsoft xBox so it could be run on a console and a basic television, allowing multiple players to interact together at the same time using simple technology.

The British military has created similar organizations to address their own training issues. The Directorate of Analysis, Experimentation and Simulation (DAES) was created with a mandate to integrate the numerous simulation-based training technologies into a joint, collective training system (Oliver, 2005). They are also investigating the use of commercial-off-the-shelf (COTS) games technologies for both experimentation and training.

Benefits and limitations

Like most organizations, the military must constantly look at the best tools for transforming their students. One of their core vehicles for the past two centuries has been simulation and gaming. The level of accountability required for any training has encouraged them to constantly update their methodology and assessment procedures. Although the core goal of the military may be distasteful to some, the knowledge they have gathered during the use of simulation in a learning context provides many useful lessons. They continue to adapt and build new methodologies to address a rapidly changing military environment. This has facilitated a number of innovative approaches to building up multi-disciplinarian teams, integrating new technology and creating training for new and novel situations. The military has already built a successful liaison with the commercial gaming industry and actively works with them to assess newly developed technologies for military use. One aspect of the military simulation community is their limited publication of research results. This makes an assessment of the effectiveness of all these new technologies difficult.

Next Directions

The high cost and causality levels associated with live exercises have driven an increased reliance on simulation-based exercises in wargaming (Brown, Hoyle, Lake, McGhie, & Burger, 2001). The military is looking to simulation as a key part of its future training efforts. One large component of that is the integration of simulation into the design and eventual deployment of new equipment (Strachan, 1999, p. 63). In some cases, the simulation will be integrated directly into the hardware itself, allowing learners to directly interface with the equipment that they will eventually use in real life (Aldrich, 2005, p. 129). This includes optical and audio systems that are built into the equipment, allowing it to act as a simulator. The advent of embedded training meets the goal of narrowing the distance between the learning context and the actual real world where the training will need to be put into effect. In many cases these simulation features are being linked into a larger digital battle ground so that large scale war games can be conducted with a hybrid reality approach of real and simulated equipment (Brown, Hoyle, Lake, McGhie, & Burger, 2001).

The military is faced with an ever-changing military climate as deployments occur around the world into a variety of settings. Multinational deployments and constantly changing tactics are forcing new training to be developed quickly while meeting the goals of being cost-effective and shared among many different services and nationalities (Oliver, 2005). Simulation-based training is increasingly taking on a role in filling training needs as they arise. A recent example was the Virtual Combat Convoy Trainer (VCCT) designed to address post-conflict attacks on convoys in Afghanistan and Iraq. Using existing technology it was possible to develop a completely mobile virtual reality training facility in just 21 days (Oliver, 2005). The training resulted in a significant drop in deaths within those operations theatres. This emphasis on rapid turn around on the design and development of educational simulations will continue to affect future efforts.

An area that has continued to grow in the past few years is a close examination of commercial-off-the-shelf (COTS) hardware and software from the civilian sector that can be adapted for military use (Strachan, 1999, p. 63). They are seen as having a number of advantages over military simulators. They are much less expensive than their military counterparts and they can run on consumer grade technology (Oliver, 2005). The gaming industry is also driven by substantial market forces so it is capable of responding to new trends and technology very quickly (Blank, 2004). The military is realizing that the commercial industry, free of policy and regulations, are able to create a new commercial game in much less time and at a fraction of the cost of a military simulator. Many of these commercial games can run on consumer grade computer platforms as well, eliminating the need for expensive hardware. Many of the commercial games available on the marketplace have as much realism, physics engineering and artificial intelligence as military grade simulations. The biggest drawback is that many in the military still consider them toys (Blank, 2004). The relationship that has been built between the military and the commercial game industry will continue to drive a relationship of cooperation and collaboration. In many ways it serves as a model for the kinds of relationships that will need to develop in other disciplines as well.

Appendix III: Medical Education Simulations

The medical profession has realized that there is a growing need for effective education. They have continued to expand their use of educational simulations into a range of areas (Table 6). They are motivated by the number of lethal medical errors that happen every year, projected shortages in medical professionals, and the need to quickly train workers to deal with newly evolving threats such as pandemic and bio-terrorism (Eder-Van Hook, 2004, p. 2). There is also a growing awareness that medical graduates do not have the

	Type	**Goal**	**Evaluation methodology**	**Validity**
Operational Games	Planning	Logistic skills	In-simulation and real-world evaluation	Simulation/ model of real-world process
	Advocacy	Indoctrination	Change in opinion	Simulation/ model of perceived-world process
Teaching and Training	Skill Acquisition	Specific Skill	In-simulation and real-world evaluation	Simulation/ model of perceived-world skill

Group	Communication/ Cooperative strategies	Communication/ Language/ Teambuilding	Playability	Qualitative assessment
Role-play	Narrative	Empathy/ End game	Verbal/ Written De-brief	Qualitative assessment

Table 6. Medical Simulations

critical thinking skills necessary to work in an increasingly complex clinical environment (Jeffries, 2005, p. 97). The increasing amount of new techniques in medical imaging and surgery are also making student understanding of three-dimensional medical information much more important (Hariri, Rawn, Srivastava, Youngblood, & Ladd, 2004, p. 896). It is questionable that the knowledge and procedures taught in a traditional classroom setting can be effectively transferred to practice in order to address all of these issues (Hamilton, 2005, p. 295). For many in the medical education system this period of uncertainty about the most effective way to teach has lead to a common understanding that new educational paradigms need to be examined. Those beliefs come back to a common principle that medical education needs to define a set of desired outcomes and develop the tools that are required to determine if those outcomes are being met (Shaffer, Gordon, & Bennett, 2004, p. 168).

In order to teach these skills many medical schools in the United States are currently using an experiential model for medical, nursing and health workers. This apprenticeship model has required that students work under realistic conditions in order to gain the skills they will need to work on real patients. Until recently this has mainly focused on the use of cadavers, laboratory animals or real patients where the practitioner had a chance to pick up new skills (Eder-Van Hook, 2004, p. 2). This is based on a belief that working on analogous animal structures, preserved tissue and real cases will translate into increased competency in the real practice of the physician (Liu, Tendick, Cleary, & Kaufmann, 2003, p. 599). Although cadavers and laboratory animals are helpful, real patients provide the majority of the learning opportunities for students. This model is beginning to suffer under changing delivery methodologies for healthcare. The financial drivers that are reducing the amount of inpatient time and quickly moving them through the medical system, are limiting the exposure many students have to a variety of disease and physical findings (Issenberg, McGaghie, Petrusa, Gordon, & Scalese, 2005, p. 12). This is beginning to have an impact on the amount of time students are able to devote to maintaining and improving their skills. In addition to these constraints the pace of innovation in medicine has increased considerably. This has left medical students with a requirement to know even more while having less time to actually learn (Shaffer, Gordon, & Bennett, 2004, p. 169).

As existing experiential models are becoming less accessible to students, medical simulation is being viewed as an innovation that will change the current approach to training students. They are being viewed as not only a new training tool but also a way of evaluating skills years after students have graduated and left school as part of an ongoing test of their competency (Knapp, 2004, p. 286). This use of medical simulations will continue to be a major goal of future medical education (Eder-Van Hook, 2004, p.

3). It is seen as a realistic way to train and learn from mistakes without putting patients at risk.

The types of simulators include screen-based computer based simulators, completely immersive virtual reality simulators and physical patient simulators that are computer driven. They are all designed to provide skills in a variety of areas from management and problem-based situations to actual motor skill development. As in all other fields the parameters of the simulation will need to be understood in terms of their strengths and limitations. In most cases medical simulators are very explicit about what they are capable of doing as understanding fidelity and transfer is critical to clinical practice (Fanti, Marzeddu, Massazza, & Randaccio, 2005, p. 559).

Benefits and limitations

Health care workers have a learning approach that involves observation and repetition. In a real clinical setting this means they are only allowed to learn from the cases that present themselves during the short period the learner is in school. Simulation-based approaches allow the learner to engage in realistic training in communication, leadership and team interaction as well as observation and repetition as many times as is necessary to achieve mastery. The overall benefit of allowing students to use training simulations, with appropriate pedagogical scaffolding, is considerable. They are believed to provide better-trained health care workers, reduce medical errors, save money due to lower malpractice and improve the quality of patient care overall (Eder-Van Hook, 2004, p. 6; Hamilton, 2005, p. 294; Issenberg, McGaghie, Petrusa, Gordon, & Scalese, 2005, p. 24). Several studies have already proven that learners trained using computer-based and physical simulations make fewer mistakes (Gallagher & Cates, 2004, p. 3025). Simulations have a number of advantages over traditional approaches with bench or cadaver models. They can offer a variety of situations that can mimic a real clinical situation such as bleeding. They can also gather quantitative data about student performance that can be stored for later evaluation (Knoll, Trojan, Haecker, Alken, & Michel, 2005, p. 1278).

There is also a higher level of student satisfaction in those groups who were able to use simulations rather than traditional, lecture-based material (Docherty, Hoy, Topp, & Trinder, 2005, p. 530). The higher level of satisfaction is likely due to the findings that simulation-based approaches are more motivating and interesting than traditional work assignments (Spinello & Fischbach, 2004, p. 365).

In some medical sectors simulation has reached a point of validity where it is accepted and included in the training recommendations for not only existing procedures but also new ones as they are developed. This means that as new procedures and equipment are developed, they come with simulations already built to provide instruction. Simulation also offers a controlled environment where complexity can be scaffolded gradually for such practices as surgery. This allows the student to learn at their own pace, building their skills without the real-life constraints of physiology and surgery (Liu, Tendick, Cleary, & Kaufmann, 2003, p. 600). This has become the basis of an advocacy for performance-based curricula, where learners can use a simulation to practice a procedure until they have reached an acceptable proficiency level (Brunner et al., 2004, p. 155).

In many cases, the simulation technologies are becoming mobile enough that they can be used for training in the actual clinical environment, removing learning from the classroom altogether (Kneebone et al., 2005, p. 583). Although this represents a large logistical challenge for medical institutions, the ability to integrate learning simulations into a clinical context has been viewed as extremely important by those educators who want to see a bridge between learning and practice (Silverman & Wood, 2004, p. 38). It also provides a pathway for practicing medical professionals to continue assessing their competency and work on their professional development. In some cases it has been viewed as the key to the creation of continued competency ((Knapp, 2004, p. 286), (Gordon et al., 2005, p. 120). By creating virtual scenario-based situations within a simulation the practicing professional is able to engage the content with the same experiential approach to everyday learning that they are already using daily (Docherty, Hoy, Topp, & Trinder, 2005, p. 531; Knapp, 2004, p. 286). It is a combination of all these factors, knowledge and skill transfer, assessment of competencies and retention of skills over the long term that been used to encourage the use of simulations in medical education (Hamilton, 2005, p. 295).

Next Directions

In the United States there has already been a detailed analysis of the medical simulation industry. It showed a number of beneficial effects from educational simulations on student performance and professional development. Some examples include the fact that simulation-based education has been shown to have an improved score in traditional assessments (Gordon et al., 2005, p. 119). Despite their ability to integrate into existing assessment paradigms of written exams, this is not where they are best suited. In order for them to be used to their full potential as an assessment tool, medicine will need to undergo a shift towards a competency-based training model (Shaffer, Gordon, & Bennett, 2004, p. 167; Brunner et al., 2004, p. 155). In this approach, medical professionals aim at building and verifying skills rather than attending a required number of hours in classroom based instruction. In order for this to occur a number of key studies will need to be initiated. These include such areas as haptic feedback systems for surgical simulations to actually provide opportunities for visceral feedback as well as procedural knowledge (Liu, Tendick, Cleary, & Kaufmann, 2003, p. 601; Knoll, Trojan, Haecker, Alken, & Michel, 2005, p. 1278). The technology is being developed but determining its strengths in medical education will require more work (Maassa, Cakmaka, Kuehnapfela, Trantakisb, & Strauss, 2005, p. 729). Another study would be required to examine the impact of simulation-based education on performance and knowledge transfer. It is a new paradigm so educators and medical students will need to come up with some innovative thinking about the nature of performance and expertise (Shaffer, Gordon, & Bennett, 2004, p. 175). This will require answering a lot of questions about how best to use simulations and other pedagogical components throughout the learning experience. There may be any number of different combinations that will depend on various factors related to the learning outcomes desired (Ziv, Ben-David, & Ziv, 2005, p. 197). There will be some areas where simulation will not be effective. It is still questionable if a completely simulation-based approach to medical education will address all needs, such as communication skills (Silverman & Wood, 2004, p. 38).

There will also need to be a careful examination done on the effects that graphic fidelity can have on learner understanding and knowledge creation (Hariri, Rawn, Srivastava, Youngblood, & Ladd, 2004, p. 901). The visual quality of these simulations, as with all other aspects of fidelity, are always being improved as technology advances become available. In some cases the lack of realistic visual cues has been identified as a weakness of simulation-based approaches (Weller, Dowell, Kljakovic, & Robinson, 2005, p. 1154). Current research indicates that this will be an important component of any microsurgical simulations (Wang, 2004, p. 315).

As the number of simulation implementations begins to increase there will need to be a degree of coordination going on between participants. There have been a number of successes in the use of simulation in medical training but there is currently no approach in place to compare those successes. This would need to be based on a framework that identifies relevant variables and allows study to occur in a systematic way (Jeffries, 2005, p. 97). Building a framework for the design, use and evaluation of simulations is going to be essential. The eventual creation of a valid framework for the use of simulation in medical education is hoped to have the outcomes of increased knowledge, increased skill performance, greater learner satisfaction, critical thinking skills and self-confidence on the part of the practitioner (Jeffries, 2005, p. 102). These outcomes, on part, focus on the recognized strengths of simulation within an educational framework.

One significant task will be developing the relationships within the simulation community. Given the multidisciplinary aspects of simulation design and delivery it would be necessary to have strong communication skills to leverage and build relationships between engineers, computer scientists, educators and learners (Haluck, 2005, p. 235). This kind of coordination to organize the community will assist in groups pooling resources and working collaboratively towards solutions (Eder-Van Hook, 2004, p. 11).

Appendix IV: Business Simulations and Games

The business world saw the potential of simulation and games for many of the same reasons as the military world. They wanted intelligent decision-making and they wanted their failures to be cheap, fast and educational. Yet failure was not an option that could be frequently explored by a company. Bad decision-making could end the existence of a company long before it was able to learn from a mistake. They began to introduce business games in the 1950s and started to explore the range of issues that games could address (Meier, 1969, p. 69). They continue to make them a part of their overall training strategy. In 2003 the training budget for US organizations was $51.3 billion and between $276 and $503 million were spent on business simulation (Summers, 2004, p. 213).

This interest in games and simulations was not an experiment by the business world. As a profit driven enterprise they would only invest in an approach they believed would have results. The sudden increase in the popularity of games followed the publication of “The Theory of Games and Economic Behaviour” in 1944. This book provided an examination of game theory that broke down decision-making to a model. Previous mathematical theory was examined and used to solve the problem of the zero-sum game and non-zero sum game. These mathematical models served as the quantitative basis for the development of models to help business understand how to effectively make strategic decisions (Rasmusen, 1989, p. 13).

The development of business games fell mainly into the area of operational games (Table 7). Much like the military, the games that the business world focuses upon are in the two areas of strategic and planning games. All of these tools were being developed so that companies could understand how their own decisions could control how the economy behaved (Ghemawat, 2002). Understanding the risks, short term and long term impact of decisions were important skills. Business started looking a games and simulations that could teach their staff about how those models worked and the skills they would need to navigate them. They could fail quickly, cheaply and learn from their mistakes.

	Type	**Goal**	**Evaluation methodology**	**Validity**
Operational Games	Tactics and Strategy	Heuristic skills	in-game and real-world evaluation	Game theory
	Planning	Logistic skills	in-game and real-world evaluation	Simulation/ model of real-world process

Table 7. Business Games and Simulations

At the simplest level business games were viewed as a “sequential decision-making exercise structured around a model of a business operation” (Carson, 1969, p. 39). The goal of the game is to expose the student to the consequences of their decisions by providing immediate and long-term feedback. This approach uses identified quantitative measures that can be used to evaluate the effectiveness of the student’s decisions. This looks at not only the consequences of a single decision but several decisions combined over a period of time (Meier, 1969, p. 72). The criticism of traditional educational approaches using case studies was the subjective and qualitative evaluation framework within which the student was judged (Carson, 1969, p. 40). The quantifiable aspects of simulations helped to encourage their use for many in the business world.

Business games were not without their critics. For some, the games are not realistic enough to help in solving real management problems. Players would quickly realize that the cost of failure is nonexistent and end up playing rather than learning during the business game (Roberts, 1969, p. 48). There was also concern about whether or not it would be possible to get any real validation of business game skills in the real world. Some considered the games too simple or too complex to be useful in a training context. The heavy quantitative emphasis of these games was also a point of criticism. Although this emphasis had validated the approach for many, the fact that the games didn't take qualitative factors into consideration was considered a weakness (Nanus, 1969, p. 55).

The traditional role of business games and simulations is expanding. There is a considerable amount of criticism from the business community that current business curriculum is not linked to business realities (Lainema & Makkonen, 2003, p. 132). Business schools are beginning to believe that their programs should move away from the simple transmission of content, knowledge and skills. The graduates of these programs should be able to exhibit critical thinking skills that can be used to challenge existing assumptions and beliefs within an organization. As they integrate simulations into their curriculum it is resulting in a move away from traditional lecture-discussion pedagogies (Maxwell, Mergendoller, & Bellisimo, 2004, p. 496). Another issue in current curriculum is its inflexible, conservative nature (Lainema & Makkonen, 2003, p. 132). It is not preparing students for the levels of ambiguity and uncertainty they will be facing within the workforce. Business schools are also not integrating the various subject areas into a curriculum that reflects how those subject areas will all to work together in real business settings. Many simulations combine several subject areas into one holistic perspective. The role of simulation is also moving beyond simple problem solving as it is starting to be used as a tool to help students understand how to make ethical business decisions (Teach, Christensen, & Schwartz, 2005, p. 386). These simulations are designed to help students to understand the long-term and system wide implications of unethical choices within an organization in a simulated environment where experimentation with ethical choices is possible.

Future Directions

The initial use of business games and simulations proved to be effective in the past but it is becoming obvious that they will need to change and take a larger role in business school curriculum. The business world is facing change at an incredible rate and the linear, content-based approach taken by most schools is inappropriate (Lainema & Makkonen, 2003, p. 132). This is going to result in a shift in the current pedagogical structure of business schools. Teachers are going to be moving towards a role as a facilitator in a more learner centric model where they guide students towards through the complexity of a simulation, towards more in-depth learning (Maxwell, Mergendoller, & Bellisimo, 2004, p. 496).

Business simulations will also have a larger role in the overall increase in training going on in the business sector. Changing business practices, demographics, new simulation technologies and lowering costs are all going to facilitate the increase in simulation as an educational tool (Summers, 2004, p. 217). Business practices are becoming much more dynamic under the pressure of globalization and new business processes. In many cases this more competitive market has changed the organization, reducing the amount of training time available (Summers, 2004, p. 217). As the demands on the business community increase they are going to need to explore the effective and flexible educational options offered by simulation.

Appendix V: Literature Review Methodology

Aim

The aim of the literature review is a comprehensive examination of the current state of simulation in adult education. This is to be achieved by the systematic collection, analysis and interpretation of existing literature in the field of simulation. The review includes a background to how the current state was formed and the influences and biases that continue to affect it today. By examining the current trends in research and implementation, the review will provide the framework for the identification of gaps in current research and directions of simulation-based education. The goal is to communicate those gaps to the CCL in order to inform that group and allow them to make intelligent choices on areas of further research.

Scope

The literature review is narrowed in scope to adult education. This is the current mandate of the CCL and provides a guideline for the work. Although there has been work in games and simulations that occur in the K-12 area, this research has been predominantly focused on a critique of the current school system rather than providing research results or case studies on the successful use of games in education. Where this critique can be generalized to the case of simulation and games in adult education it has been integrated into the literature review.

Search Methods

The literature used in this review was identified during an exhaustive search of a number of online databases. The search was conducted using a range of key words to ensure a complete range of literature was examined.

Inclusion and exclusion criteria

The range of a state of field literature review is considerable. Much of the information necessary to build a cogent perspective of the field includes historical perspectives, theory as well as current practice within a number of semiotic domains. The initial pool of 150 references were narrowed down to 105 based on: 1) the applicability to adult learning 2) the applicability to the identified areas of adult learning 3) empirical studies 4) the use of the simulation as an education tool or assessment paradigm.

Limitations

The literature review is restricted to articles in the English language. Given the global focus of simulation and gaming it is likely that there are appropriate resources in non-English that may have had valuable input. The unpublished theses used in the literature review were also restricted to those that were electronically available.

Search Keywords

Theory

E-Learning
Education
Games
Hermeneutics
Learning
Phenomenology
Semiotics
Simulation
Virtual Reality

Assessment

Curriculum
Skills-based competency
Standards-based assessment

Learning

Active Learning
Behaviourism
Creative thinking
Critical thinking
Cognition
Constructivism
Experiential Learning
Far transfer
Instructional Design
Learner centric
Learning environments
Meta-cognition
Near transfer
Situated Learning
Training

Results

105 references were identified that were relevant to the use of simulation in adult education settings. Although they varied in absolute relevance they all provided useful information within the defined search parameters into this domain. Medicine, business, military, pedagogy and theory were the broad categories used to classify the literature.

Databases

The search was undertaken in a variety of online databases of academic resources. The interdisciplinary nature of research area required a wide ranging search strategy. These included collections of academically as well as privately published resources.

Academic Search Premier
Provides coverage of some 4300 periodicals with full-text of some 2600 peer-reviewed scholarly publications covering many academic areas of study, including social sciences, humanities, education, computer sciences, engineering, language and linguistics, arts & literature, medical sciences, and ethnic studies. This database includes Business Source Premier, Canadian Reference Centre, Communication and Mass Media Complete, ERIC, Health Source & Medline.

ACM Digital Library (Association for Computing Machinery)
Journals, transactions, conference proceedings and other materials in the field of computing and related disciplines.

ACP medicine : a publication of the American College of Physicians
An electronic medical textbook covering a wide range of general clinical and internal medicine topics. The textual information is supplemented by numerous illustrations, tables and other graphics, as well as sound and video. The database is updated regularly and extensive references to the journal literature are included so that the user may examine the evidence on which recommendations regarding patient care are made, as well as to facilitate further reading for a more in-depth understanding of a topic.

Applied Science Index
More than 350 international, English-language periodicals, covering engineering, mathematics, physics, and computer technology, including articles, interviews, meetings, conferences, exhibitions, new product reviews/announcements, and more.

Books 24x7 IT Pro
Books24x7, is a leading provider of web-based digital technical and business reference content, containing thousands of digitized "best-in-class" reference books, research reports, documentation and articles.

CINAHL
The Nursing & Allied Health (CINAHL) database provides comprehensive coverage of the English language journal literature related to nursing and the allied health disciplines.

CISTI Source
The CISTI Source database indexes about 14,000 journals worldwide in all subject areas. Over 60% of the journals covered are in the areas of science, technology and medicine.

Compendex
Comprehensive interdisciplinary engineering database covering journal articles, technical reports, and conference papers and proceedings over the entire spectrum of engineering.

Defence Magazine Library (Jane's)
Defence magazines published by Jane's Information Group including Jane's Defence Industry, Jane's Defence Upgrades, Jane's Defence Weekly, Foreign Report, Jane's Intelligence Digest, Jane's Intelligence Review, Jane's International Defence Review, Islamic Affairs Analyst, Jane's Missiles and Rockets, Jane's Navy International, and Jane's Terrorism and Security Monitor.

Health Source: Nursing Academic Edition
Provides full text of nearly 600 scholarly journals focusing on nursing and many other medical disciplines, plus abstracts and indexing for an additional 850 journals.

PubMed
Database from US National Library of Medicine covering medicine, nursing, dentistry, veterinary medicine, molecular biology, the health care system, and the preclinical sciences.

Safari Tech Books Online
A library of books on information technology, digitized and made available by Safari Tech Books Online in conjunction with the original publishers. This is a great collection of computer manuals on almost any topic and at any level. Publishers include Cisco, O'Reilly, Microsoft Press, Sun, etc.

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