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Learning with technology: theoretical foundations underpinning simulations in higher education

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Embracing learning for the future through learning technologies requires a clearer understanding of the pedagogies that inform the simulated teaching and learning strategies used to facilitate student learning. Higher Education e-learning literature often groups educational games with simulation. However, educational simulation attributes are different from games or simulated games with very different aims and objectives within the learning context, which have implications for technology-based learning designs. In order to optimize the use of technology-based simulation this paper presents the theoretical foundations of educational simulation in a disciplinary context. Understanding the simulation pedagogy will assist academics to create technology-based simulated learning environments that highlight the inherent simulation attributes to enable and facilitate learning.

Keywords: Educational Simulations; theoretical underpinnings, e-learning, technology-based

Introduction

A wide variety of educational teaching and learning strategies are available to the teacher in a learning environment. Almost all the possibilities of face to face teaching can be replicated by technology, although some of these strategies can only be represented in a limited manner. Alternatively, some teaching and learning strategies can be enhanced through technology either by presenting alternative approaches to learning (Aldrich, 2004; Gibson, 2004; Milton & Lyons, 2003; Lyons et al., 1998); by extending learning through added dimensions that maybe impossible to conduct in face-to-face interactions (Garrison & Anderson, 2003; Gardner, 2007); or through the use of technology aids, in developing or creating a new understanding of the concepts and knowledge (Lasater, 2007; Lyons & Milton 1999).

Learning by simulation and games enhances the acquisition of new knowledge, and skills, According to Whelan (2005), games if they have the mechanism that promote learning and the development of knowledge and skills will ensure that:

> Games translates into acquisition of new knowledge, transfer of learning, the development of intellectual skills (abstraction, anticipation, strategy-building, problem solving, lateralization, spatial representation function-movement relationship), and the development of behaviour and attitudes (p. 250).

The skills are developed through games and simulation if they provide immediate feedback, interaction, active engagement and participation, control of learning, repeated practice challenge, motivation, dialogue and teamwork (Barnett et al. 2005, and Lyons & Milton, 2002). Sauve et al. (2007), citing others suggests using socio-constructivist pedagogy inherent in games to meet the needs of the new generation learners.

The difference between games and simulation are that games attributes include player, conflict, rules, predetermined goals, its' artificial nature and pedagogical nature, whereas, simulations are based on reality, are dynamic in nature, are simplified representation of reality and has fidelity, accuracy and validity (Sauve et al, 2007). These attributes in simulation promotes basic and complex competency development; promotes interaction, and enables repeated practice in safe learning environment. Simulations offer learning environments which: promotes development of mental models in learners; allows efficiency testing to explain or predict events and outcomes; optimalises discovery of the relationship between variables and divergent approaches; decreases cognitive load using enabling and facilitating functions for learning to take place (Milrad, 2002; Goldenburg et al., 2005).

In order to optimize the use of educational simulation in disciplinary context this paper presents the use of simulations in midwifery education commencing with an emphasis on the use of experiential learning and simulation in the broader educational context. This is followed by a discussion on theoretical foundations of simulations in educational context. The pedagogy of simulations as an educational approach is also described in detail to enhance the learning designs of the future.

Theoretical foundations of simulations as pedagogy

Simulations as learning environments have a long history of use in education and training. Simulation derives its foundation as a pedagogical approach from as far back as the "writings of Aristotle and the practices of Socrates", (Ruben, 1999, p.500). These predate the evolution of learning theories such as experiential learning based on John Dewey's work and later Rogers (1969) experiential learning theories. According to Walter and Marks (1981, p178) simulations may be defined as "models or representations of some facet of the human experience". Jonassen (2000) argues that a computer-based simulation can be a powerful vehicle for learning by applying the critical characteristics of the traditional apprenticeship. It involves placing learners in realistic situations to experience a variety of realistic situations and to learn from them in a safe learning environment without jeopardizing other people. Simulations can present authentic tasks by focusing on the learning knowledge and skills in contexts that reflect the way that the knowledge is used in real life (Brown, Collins & Duguid, 1989). Most effective learning experiences are meaningful, motivating and can be created by goal-driven simulations and scenarios where learners apply the knowledge to solve problems similar to what they would encounter outside the learning experience as highlighted by works of Reeves, Herrington & Oliver (2005).

Simulations can precipitate deep reflection, understanding and behavioural change that results from deep learning. Dewey's central idea of reflective learning and reflective thought as "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (Dewey, 1910 p6) underpins any basic tenant of simulations. More recent interest in simulation stems from the belief that effective learning results from sustained interaction between the learner and the environment and where there are opportunities through social interaction to reflect on experiences in that environment (Gredler, 2004; Gibson et al, 2007).

Simulations are commonly used in nursing and midwifery education. Simulations do not necessarily need to involve high end and expensive computer platforms as seen in full model simulation such as flight simulators. Research has demonstrated that even low end; low fidelity simulations can be used to provide effective teaching and learning approaches and experiences, (Underberg, 2003; Medley and Horne, 2005). Simulations can involve a broad spectrum of tools that are used in nursing and midwifery education including case reports, scenario discussions, and computer-based simulations. Simulated learning is also used in nursing and midwifery laboratories with standardised patients in simulated clinical situations, virtual reality trainers, mannequins, pelvic models and high fidelity human patient simulators.

Computer simulations are programs that model aspects of real world situations and require decision making or some active input from students. Simulations differ from computer tutorials in that the student learning experience and engagement is by performing tasks in situations that reflects real world situations, (Alessi and Trollip, 2001). These authors further add that the simulated environments are generally a simplification of reality in which the learners can learn procedures, develop an understanding of a phenomenon and experiment with alternative approaches to learning. They encourage students to be more active participants in their learning because they are not controlled by a predetermined sequence of events and can experiment with the situation (Alessi and Trollip, 2001). Computer-based simulations provide a less structured environment in which there is no linearity imposed on the student by the program itself (Gibson et al, 2007) and can powerfully present a wide variety of relevant situations within a compressed timeframe.

In the simulated learning environment student centered goal setting and introduction of the learning activity commences the simulation. Case scenarios or situations can be used to provide the simulation context that requires students to make decisions and solve problems. Questioning may also be used to form the basis of a computer simulation of a real life event, during which the students must decide on the appropriate course of action and respond to the situation (e.g. an emergency procedure or situation). Once the student provides a response appropriate or otherwise, the student action is then used to update the initial simulation which reflects the consequences of students' decision and response. The system updates by providing further details on the incremental case scenarios or situations or it may provide feedback for students to consider and which again may require further student action, reflection and input. The feedback provided also closes the loop of the learning sequence where the system generates a response to student action that represents what may happen in real life.

A simulation can be realistic in terms of its physical and functional components, with the latter component related to the types of situations, tasks or settings included in the simulation. Gredler (2004) offers two major classifications of simulations: the social process simulations and the tactical-decision simulations. Social process simulations, emphasises the interpersonal communication skills and the study of human interactions and emotions in pursuing social, political or ethical goals in realistic situations. In tactical-decision making

simulations the emphasis is on problem solving and decision making based on collection and interpretation of information to analyse situations and consequences and to develop strategies to achieve specific goals. These types of simulations create an immersive environment in which learners are encouraged to make difficult decisions and explore the consequences of their decisions.

Alternatively, Alessi and Trollip (2001) identified four distinct types of simulation, namely:

a) Physical simulations

Physical simulations demonstrate how a system works and facilitates the manipulation of system components to alter the output. This type of simulation technology is conceptually linked to what is referred to as system dynamics approach which provides a way to describe and study our complex biological, physical and social world around us in terms of inputs, throughputs and outputs. It enables learners to describe and understand the cause and effect relationships, as well as the consequences 'ripple effect' which may be both intended and unintended effects of an event or decision activity.

Simulations are student-centered approaches to learning that incorporates the cognitive, psychomotor and affective domains of learning, (Nehring et al, 2002; Peteane, 2004). This type of learning is particularly true when sophisticated high fidelity simulators are used to simulate complex functionality and combine the different types of simulation. One such simulation is the 'SimMan' developed by the American Medical Plastics Laboratories. It is a realistic life-sized human model on which students can practice simple procedures such as male urinary catheterization or naso-gastric intubations. Additionally, this computerized simulation is more technically advanced than the "Resuscitation Annie" model used by all health professionals for cardiopulmonary resuscitation and advanced life support training. The SimMan as realistic, complex simulation mimics the human cardiovascular system, i.e. heart sounds and murmurs, central and peripheral pulses an electrocardiograph output including the entire advance cardiac life support arrhythmias. The respiratory system simulates respiratory process including breath sounds, chest movements with air entry and output, carbon dioxide production and oxygen consumption by the body. The simulation also simulates the pharmacological reactive system recognizing and responding appropriately to the action of more than 50 medications on the body. The peripheral pulse oximeter signal represents all the changes in the cardiopulmonary and respiratory system and all inhaled gas mixtures with a focus on oxygen saturation of the body. The simulation also shows blinking eyelids, papillary dilation and reaction to light while 'voice grunts' simulate neurological responses of the patient. These types of computerised clinical simulations provide learners with examples and scenarios of actual clinical events that enable learners to make decisions on real-life care situations. It allows the students to practice by changing the input variables as well as outlining the procedure they would use in the resuscitation process when they are placed in a situation of attending to a collapsed patient. Feedback is provided in response to their action where students can analyse what has happened as a consequence of what they have done and make further decisions to deal with the resultant situation.

In midwifery education it seems no such advanced simulation exists but a commonly used model is the 'Resuscitation Doll' which is the equivalent to the 'Resuscitation Annie' model used by all health professionals for cardiopulmonary resuscitation and advanced life support. The resuscitation doll is used in the resuscitation training for babies and small children. The simulation combines the situation of a collapsed baby with the steps in the procedures of resuscitation that enables students to apply these skills and gauge the effectiveness of ventilation and cardiac compression. Another example is the Pregnancy Simulator Learning Package (PSLP) which simulates the human reproductive system during pregnancy and the complex clinical decision making and problem solving skills used in health and pregnancy assessment by health professionals (Lyons et al, 1998; Dow, 2008).

b) Process simulation

These are simulations in which the rate of physical process is changed. This is also referred to as dynamic modelling which allows the slowing down of or the acceleration of the physical process to enable learners to easily evaluate the individual components (Conrick, 1998). This type of simulation is commonly used across many discipline areas and allows students to view an event in a reasonable timeframe for example cell division and other physiological and neurological processes used in health sciences. In midwifery, a non-computerised plastic model of the pelvic torso is frequently used to simulate labour and the birth process showing the descent and rotation of the foetus as it negotiates the birth canal. Students are able to visualise what happens during the birth process paying particular attention to the relationship of the fetus to the landmarks in the pelvis enabling them to practice what they are required to do to assist the birth of the baby.

c) Procedural simulation

Some tasks require a certain sequence of actions to be performed to achieve an outcome. The procedural simulations ensure that students follow the correct sequence of steps in order to achieve the desired outcomes. Students also learn the consequences of not performing the correct procedures. For example, in the resuscitation of a collapsed patient, the student is able to assess the situation, identify the underlying problem and initiate the appropriate patient care and management. If the collapsed patient is not breathing and does not have a pulse then the resuscitation procedure is initiated, which is to: a) Call for professional assistance as resuscitation cannot be sustained over a period of time by just one person. b) Institute the 'ABC' of resuscitation i.e. assessing and managing the airway, breathing and cardiac compression to treat the patient.

In midwifery, procedural simulations focus on how to perform midwifery practice skills hence rubber arms are used for teaching intravenous insertions and giving intravenous injections. The rubber vaginas are used to assess cervical dilatation during labour and rubber perineum together with surgical instruments are used to teach cutting and suturing of episiotomies and perineum care after the birth of a baby to mention a few. The PSLP emphasises the procedure of abdominal palpation and how to perform this procedure in terms of where and how to place the examining hands on the abdomen to obtain accurate findings from palpation. The added advantage is that the simulation provides the opportunity to demystify the age old tradition of following a certain set of steps as it allows the students to conduct and practice each palpation skill on its own and in any order with appropriate feedback to guide the students in seeing the relationships and the rationale for each palpation movement.

d) Situational simulation

Situational simulations are presentations which could be a clinical scenario, a conflict situation or an emergency situation where the student makes decisions to respond to the situation and develops strategies to rectify the situation as they would do in real life contexts. The provision of a real life situation gives learners a sense of immediacy and involvement where time and the chosen response matter to the successful outcomes. A wide range of 'what if' situations can be simulated often using complex programming and branching to allow for the variation in the situation, patient responses, student actions and decisions to solve the problems. In these types of computer simulations feedback provided makes students reflect on their responses prior to continuing or feedback provides the opportunity for students to re-assess their care management and adapt their actions appropriately to remedy the situation. The PSLP through its case studies simulates the variations in assessment findings and simulates the complicated obstetric conditions and emergency situations that a student may not have the opportunity to experience in real life.

Summary

This paper presented simulation pedagogies as educational approaches to designing teaching and e-learning activities. It has a review of current types of simulations in use with specific reference to midwifery education. Simulation pedagogy provides a framework for successful analysis, design, development, and implementation of e-learning that entails simulation attributes to facilitate technology-based learning. Similarly, teaching, assessment, and administration of e-learning can be strengthened though a process of capacity building that is able to release the full potential of embedded learning technologies if the theoretical underpinnings of simulation are understood and applied in the creation, design and development of simulated learning.

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