Enhance Learning in a Virtual Professional Environment via 3D Cases

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***Abstract*- The purpose of this research is to investigate the affordances and constraints of developing 3D teaching vignettes for effective case-based learning. It is built on the paradigm of case-based learning, which enhances higher-order thinking abilities. Sparse research explores both students' engagement and learning outcomes via three-dimensional (3D) teaching vignettes or 3D cases. In this study, a quasi-experimental study confirms the authors' earlier finding that learners overwhelmingly prefer 3D to text-based case studies. A paired samples t-test shows students demonstrate significant cognitive gains when studying a new domain subject via a 3D case study. In this paper, the authors describe a design-based research process of developing 3D case studies that capitalizes the affordances of 3D technologies. An in-depth discussion of important issues such as limitations and lessons learned is also included to explore the pragmatics of using 3D technologies to promote learning.**

Keywords: Virtual environment modeling, Educational simulations, Virtual labs , Cognition, Health Care

1. Introduction

Case-based learning is not new. A case has a narrative, a story, a set of events that unfolds over time in a particular place" (Shulman, 1992). Case-based learning is an established strategy in health professions education to promote decision-making skills. It provides opportunities for students to analyze content, apply it to clinical situations, and synthesize clinical solutions. Through case studies, students see meaningful connections between classroom and real-life settings (Thistlethwaite, et al., 2012).

However, most cases are presented in a text-based format in a traditional classroom. It's usually not practical or possible to situate students in a real life setting due to the constraints of costs, space, or risks. One limitation of using text-based case studies is that it cannot adequately represent all the modalities of a real life situation. For instance, watching how to assemble a machine is much more effective than reading a manual. Additionally, hearing a "person" describe their symptoms is different than reading about them. It includes the nuances of tone that are not necessarily gleaned from written words. Also, text-based cases often fail to demonstrate affective knowledge such as emotions, facial expressions, or gestures. Most of the time, verbal descriptions of a dynamic phenomenon couldn't effectively illustrate non-verbal representations such as accent, emotion, or imagery details. More research is needed to harness the advances of technologies in order to provide our students with a meaningful real life experiences via video-based case studies.

In recent years, researchers have started to explore the potential of 3D virtual learning environments, where instruments, surroundings, and stakeholders can be replicated as virtual artifacts with low costs and quick turn-around time (Dede, et al., 1996; Dede, 1995; Hew & Cheung, 2008). Students can observe the carryout of an event as if in a real life context, such as a hospital, a classroom, or a factory. This study investigates the pragmatics of developing 3D teaching vignettes as an alternative to text-based case studies. It discusses the 3D platforms evaluated, techniques used, costs incurred, and technical challenges occurred during the development process. It examines the engagement of video-based cases and students' preferences among the options of text-based cases, video-based cases, real life practice, and role-playing in 3D simulations. It also assesses students' learning outcomes to determine the effectiveness of 3D teaching vignettes.

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Next, the authors will review the research findings in literature, report the results of a quasi-experimental study, and discuss whether video cases are ready to be considered a pragmatic teaching instrument in case-based learning.

The following questions guide this research with Question 1 focusing on the design and usability of the 3D teaching vignette and Question 2 focusing on the cognitive learning impact of the instructional approach.

1. *What are the affordances and constraints of developing 3D teaching vignettes to promote learning?*
2. *Do 3D case studies help increase learning outcome? What is the impact of 3D teaching vignettes on students' learning processes?*

2. Literature Review

2.1 Simulations in Nursing Education

Professional education focuses on the preparation of graduates who are able to think creatively, critically, and accurately in a myriad of situations. In 2000, the Institute of Medicine released a stunning report on the status of healthcare in the United States reporting that almost 100,000 patients per year are victims of errors. Communication failures were noted to be one of the most frequent contributors to these errors. In 2004, and again in 2010, the Joint Commission issued sentinel event alerts addressing morbidity and mortality of the newborn infant and maternal mortality, respectively (Kohn et al., 2000: IOM 2004 and 2010). Both alerts call for the education of healthcare providers to include interdisciplinary team training and/or drills. There is increased competition for a declining number of actual clinical experiences. Additionally, there are some patient situations that are not appropriate for students because of potential patient risks. All of these factors led to the adoption of simulations as one alternative approach in nursing education.

Classroom and campus lab simulations have been found to be an effective instructional strategy that can enhance the graduates' transition from classroom to real-life practice, provide opportunities for students to analyze information, make clinical judgments, and respond as if working with actual patients (Stokowski, 2013). Simulation-based training is a method of education that is ideal for team training via active learning. It is uniquely able to address cognitive and technical skills as well as behavioral skills. Paige and Daley (2009) suggest that simulation learning should be viewed in a situated cognitive lens as a social activity incorporating the mind, the body, the activity, and the tools in a context that is complex and interactive. Educators believe that it is not until the student applies theory to a given problematic situation that true understanding materializes. Simulation is found to meet the broad goals within the context of any program: think critically, communicate effectively, and intervene therapeutically (Daley & Campbell, 2008). Many organizations recommend the use of simulation especially for team building (Paige et al 2009). Debriefing after simulation is reported to be extremely important in the process of developing clinical *judgment* skills (Sweigart & Hodson-Carlton, 2013).

There is also an increasing body of evidence demonstrating self-efficacy of simulation use, most notably, an improvement in self-confidence among students. Many articles in the nursing literature identify the benefits of using various types of simulation to enhance self-confidence as well as skill performance (Galloway 2009; Wotton et al 2010).

Simulation has not been restricted to nursing education. It was originally used in airplane pilot training and has been readily adopted by medical education programs, especially surgical training. Oishi et al (2011) and Malone et al (2010) reported on the benefits of using simulation in physician education training programs. Low et al (2010), Walker et al (2009) also provide support for the incorporation of simulated learning for training doctors. Kallonis & Sampson (2010) described their development of a 3D virtual classroom for teacher professional continuing education. Leung et al (2010) investigated the effects of virtual industrial training on mental workload during task performance for employees in the manufacturing and service industries.

Still, the impact of simulation on the cognitive aspects of learning is not well understood and remains an important focus for future research. We previously adopted a multidisciplinary collaborative approach to develop a prototype of a virtual learning environment through a 3D virtual platform, Second Life (Bai, et al., 2012; Lavin & Bai, 2013). Two case studies were piloted with a group of nursing, physician assistant and occupational therapy students to determine student engagement and learning attitudes. The results have led to this study, which focuses on cognitive learning outcomes using national standards of stroke patient care.

2.2 Verbal vs. Visual Representation of Knowledge

Most case studies in a traditional classroom are text-based or in verbal format. But thinking, such as reasoning or mental imagery manipulation, may involve a different set of mechanisms. For instance, an imaginary world involves visual and spatial imagery in addition to symbols and relations (Black, Turner, & Bower, 1979). Black (1992) states that mental images are a type of knowledge that exists in human cognition. If relations among objects are visually or spatially grasped, they can help to derive a mental model of a system structure more easily than a textual representation (Kosslyn, 1978; Rohr, 1986). Cooper and Shepard (1973) also show that the time people take to decide whether rotated alphanumeric characters are normal or backward increases sharply with the angular departure of the characters from the normal upright. Shepard argues that this process of mental image manipulation is necessary because normal and backward characters share the same features, so people can only tell them apart with reference to a rotated version of an internally generated image of the normal upright version. Therefore Shepard is able to demonstrate that mental images are a distinct knowledge representation from semantic knowledge represented in propositional networks. Moreover, images are more accurate and vivid ways for visual knowledge representation than verbal knowledge. As we all know “a picture is worth a thousand words.” For instance, the structure and function of a CT Scanner can be better explained through a series of video demonstrations than through a paragraph of descriptive text. Therefore, a visual learning environment is needed where users are able to construct correct mental models through observing objects and events. In other words, it would be more effective if a user’s imaginary world (Black, 1992) could be run dynamically as a simulation for him/her to observe.

2.3 Mental Models

De Kleer and Brown (1983) stated that mental models can be “run in the mind’s eye.” “Running” of a mental model occurs when autonomous objects change states, thus influencing other autonomous objects (Williams et al., 1983). Mental models are psychological representations of the real or hypothetical world. Craik (1943) described that the mind constructs "small-scale models" of reality that it uses to anticipate events, to reason, and to underlie explanation. Therefore, we need a way to simulate the "small-scale models" of reality, which will allow users to reflect upon their thinking at the meta-cognitive level. Human beings are inclined to make sense of the people, objects, and events around them. For instance, if they are fully immersed in a virtual real life environment where a stroke patient’s life is documented and an emergent situation is exposed, they can identify with the patient and better understand the problem. As Norman (Gentner & Stevens, 1983) described, in interacting with the environment, with others, and with the artifacts of technology, people form internal, mental models of themselves and of the things with which they are interacting. These models provide predictive and explanatory power for understanding the interaction. The challenge is how to expose mental models in a more explicit and concrete way. Video-based cases are the exact learning instruments we are looking for to expose mental models.

3. Design Method

This research develops a 3D teaching vignette for case study to address the research questions. The authors hypothesize that the resulting instrument can facilitate case based learning by engaging learners and enhancing cognitive performance. In addition, the authors hypothesize that the resulting virtual environment can be pragmatically deployed to other local settings to facilitate research in varied domains.

3.1 Design-based Research Methodology

The design for this investigation is a design-based research focusing on the unique learning opportunities afforded by 3D teaching vignettes. It involves the analysis of the use and performance of designed artifacts to understand, explain and very frequently to improve on the behavior of aspects of

Information Systems (Vaishnavi & Kuechler, 2004/5). Introduced by Brown (1992), design research was developed as a way to carry out formative research to test and refine educational designs based on principles derived from prior research (Collins, Joseph, & Bielaczyc, 2004). The research design included these five steps:

1) *Awareness of Problem:* identify the problem by analyzing the deficiencies of the existing systems and describe how to make improvement.
2) *Suggestion:* review the related literature and previous research. Describe how the system can be designed and implemented with feasible, optimized solutions.
3) *Development:* develop and implement the virtual environment and 3D case studies according to the suggested solutions in step 2.
4) *Evaluation:* evaluate the partially or fully successful implementations according to the functional specification in step 2.
5) *Conclusion:* discuss and draw conclusions based upon findings in the process of system design as well as the evaluations.

Steps 1, 2, 3 above are often iteratively performed in the course of the research effort. This involves reiteration from partial completion back to Awareness of the Problem. This is a necessary process that allows us to quickly identify potential problems and solve them in a timely manner to avoid disastrous system failure in the future. It allows us to develop robust designs for other application variants in other domains based upon the same framework.

3.2 Evaluate and Identify a 3D Simulation Platform

Before developing the 3D teaching vignette, the researchers defined the technical specifications and decided which 3D simulation platform to adopt as follows: 1) It should support synchronous multi-player communication; 2) It should provide authoring tools for users to develop their own artifacts and customize avatars; 3) It should have a rich virtual item library for artifact exchange and reuse; 4) It should have robot script capacity that enables pre-defined behaviors; 5) It should allow for developers to model a subject domain and the corresponding simulation environment with a quick turn-around time, thus making it a practical platform for research practitioners and instructors to embed their ideas and test out their hypotheses.

The researchers evaluated Second Life, OpenSim, SimCity, Flash, Director, and Unreal. They narrowed down to Second Life and Flash. Ninety-eight percent of the web users have the Flash plug-in in their web browsers. ActionScript that used in Flash is very similar to JavaScript, which is widely used for the web. It also has some limited fake 3D effects that can meet project needs. Flash does not have a built-in game or physics engine. Therefore, the most common features of a game engine such as conflict resolution and real time navigation rendering are implemented in ActionScript. The limitation of the language itself constrained the way the game could be designed. For instance, it needs to keep tracking of any possible conflict between any two avatars all the time. Therefore, a designated thread needs to loop through entities, checking for their locations. This could result in factorial n number of loops in just one round of checking. That meant as more avatars the "stage," the loops will increase in an exponential order. This is too expensive since performance and speed are the key factors affecting the quality of a simulation.

On the other hand, Multi-User Virtual Environments (MUVEs), such as Second Life, provide virtual reality contexts that support social interaction such as role-playing. They do not embed explicit game rules or game-based rewards like those in commercial multi-player online games. But they afford opportunities for situated learning, thus promoting problem solving, communication, and critical thinking in the process (Galarneau, 2005). They also support for constructivist learning by allowing for meaningful knowledge construction from a first-person perspective in a social setting (Bricken & Byrnes, 1993; Dede, 1995; Winn, 1997). Second Life is user-friendly 3D simulation platform. Little or no prior gaming experience is needed for users to learn how to navigate and interact with others. It is a virtual platform with user-generated contents. Users create buildings, roads, bridges as well as other artifacts such as vehicles, trees, animals, or even zombies. The basic unit of these virtual items is a primitive, or prim, which is represented by a set of parameters including shape, position, size, rotation, hollow, twist, etc. There is a built-in authoring tool that allows users to construct 3D objects made out of prims and design behaviors via scripts. Second life was therefore adopted as the researchers' platform for developing 3D teaching vignettes. We purchased virtual land and assembled buildings made out of prim objects. A basic clinic was set up that includes a front desk with a waiting area, an observation room with equipment such a heart monitor, ultrasound machine, a CT scanner, a sink to wash hands, cabinets with medical instruments, and hospital beds with curtains. Constant communication among the researchers and domain experts are established to achieve a better understanding of domain specific contents such as NIHH/Glasgow Scales or t-PA. (Figure 1)

Figure 1: A virtual hospital with equipment

3.3 Develop 3D Teaching Vignettes

This project focused on developing a National Institute of Health (NIH) standard based 3D stroke-patient case scenario. The intent was to use this scenario in basic baccalaureate nursing curriculum as well as in acute care hospital settings for Registered Nurse (RN) continuing education. The NIH stroke scale (NIHSS) measures several aspects of brain function, including consciousness, vision, sensation, movement, speech, and language. A certain number of points are given for each impairment uncovered during a focused neurological examination. For instance, in the exam the patient is asked to open/close eyes, lift a leg, open/close mouth, squeeze hand, read words/sentences or describe a picture (Figure 2).

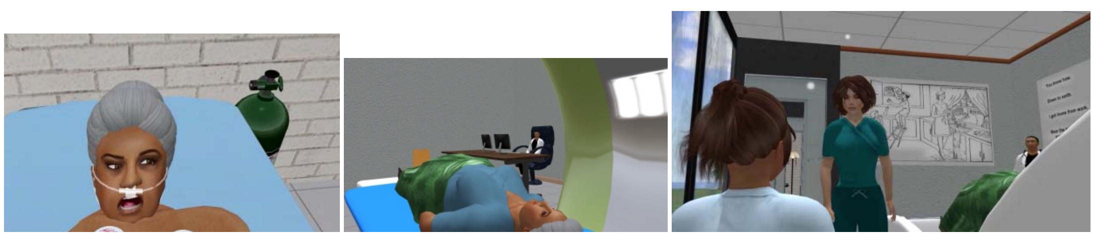

Figure 2: Avatar behaviors (from left to right: open mouth; go through CT Scanning, take NIHSS exam)

Researchers in Nursing first wrote the case study script, inserted the NIHSS exam content, and designed pre-and post-tests. Briefly, the story is about an older woman who develops a stroke and follows her emergency admission through discharge. The client has many of the risk factors for strokes: she did not consistently take her medications nor follow the recommended diet. The script was created to guide students through the assessment and acute management of a stroke.

Machinima is adopted as a technique that uses real-time 3D computer graphics rendering engines to create a movie. Instead of human actors, virtual avatars in a 3D virtual environment were used to play out a movie. Two machinima developers created avatars and control these avatars to direct a story based upon the case study scripts in Second Life. They added voice over the script, edited and transformed it to a video format. The resulting raw video clips were edited in a process similar to how a movie is made – selecting the scenes we saw fit and adding verbal scripts on the screen as well as voiceover. Screen-capture software, Camtasia, was used to record the story played out in Second Life. To edit raw video clips to a movie, the project team went through a huge amount of movie clips to select appropriate scenes and put them together to a coherent movie. They constantly adjusted such details as angle of camera, gestures and facial expressions of an avatar, or the pace of the story progress. A few animated PowerPoint slides were added to illustrate family trees or dosage calculation.

Scripts were attached to some of virtual objects that functioned as action triggers. For instance, touching a question or picture on the NIHSS poster will allow nurses to hear a patient's response to that question or picture. Some customized actions, such as facial droop or sweating, were saved to a pre-designed action library so that users can choose to execute them from a dropdown list. However, users need training to learn how to execute these actions. There is currently no intuitive way to execute these actions.

4. Study Method

4.1 Participants

Twenty-five undergraduate students participated in the study in February 2013. They were recruited from a Teacher Education course at an urban public university. They were chosen in the pilot study because 1) they had little prior knowledge on the research topic, which could provide valuable information on cognitive gains of new knowledge and identify issues regarding the flow and process of the case study; 2) they could give insights regarding pedagogy and the potential of adopting 3D case studies in their classroom as pre-service teachers.

4.2 Materials

There are four data sources: (a) pretest regarding students' prior knowledge on the topic of Stroke or CVA, which consists of 20 multiple-choice questions assessing students' knowledge retention and understanding of the subject domain; Based upon informal query, the students had not been exposed to this pretest nor the content prior to this pilot except for one student who had a relative with stroke. Each question is 1 point. Some questions have multiple answers while others have only one answer; 2) posttest, the same as pretest, which has been used with Nursing students for learning assessment in the same college; 3) survey regarding students' attitude towards 3D teaching vignettes and other alternatives: text-based cases, real clinical experiences, or role play in 3D simulations; The questions are in the format of 5-point Likert Scale, multiple-choice questions, and open-ended questions; 4) observations by two of the researchers of participants' engagement throughout the research session. The engagement evaluation also based upon the students' focus during the study. For instance, the researchers observed whether students were distracted, bored, or motivated to ask questions to clarify thoughts. Also collected are students' age, years in college, major (Teacher Education is a minor), and ethnicity. The study lasted ninety minutes.

4.3 Procedure

The participants were first informed about the purpose, learning outcomes, and format of the study before they were given written consent forms. Students were assured that all pre- and post-tests would be coded with random numbers to protect their identity and participation was voluntary and would not impact course grades. Students were then assigned random numbers and completed a pre-test. After watching a 12-minute 3D teaching vignette, the students completed a post-test and a survey.

5. Results and Analysis

5. 1 Pre- and Post-tests

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	6.4400	25	2.59936	.51987

Posttest	11.7600	25	2.74287	.54857

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-5.32000	2.60960	.52192	-6.39719	-4.24281	-10.193	24	.000

A paired-samples t-test was conducted to compare students' learning outcomes based upon pre- and post-tests. There was an extremely significant difference in the scores for Pretest (M=6.44, SD=2.6) and Posttest (M=11.76, SD=2.74); t(24)=10.1931, p = .000.

5.2 Open-ended Questions from the Survey

Four open-ended questions were analyzed based upon Bloom's taxonomy (1956). Three themes regarding cognitive knowledge were generated. They are content, comprehension, and application. In addition, two themes, format and affect were used to measure participants' learning preference and attitudes toward 3D teaching vignettes. Following are the details of the analysis results of each question.

Survey Question 1: What did you like the most about watching the 3D case study?

Student responses identified the scenario as informative, engaging, and more real than reading a text based case study (below). Out of 25 students, 14 liked the video format of the case study (e.g. they used terms like visual imagery, animation, realistic to describe what they liked); 7 thought the content was informative; 7 said it helped them understand the case better; 6 claimed it captured their interest and attention

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Themes	Content	Comprehension	Format	Application	Affect
Frequency	7	7	14	1	6

Survey Question 2: What did you dislike the most about watching the 3D case study?

Again all responses were uniform in reporting that the slides with written content moved too fast for the students to understand all of the information. Out of 25 participants, 1 mentioned he/she didn't understand the medicine letters; 2 reiterated they liked the 3D teaching vignettes although the question was framed as what they dislike the most; 1 said the case plot did not have a happing ending; 1 tried to think about a future problematic situation (e.g. what would happen if …); Again, most of them, 22, commented on the video format regarding what they don't like – almost all them of mentioned the pace was too fast and the voice could be louder. This indicates they may have experienced cognitive overhead due to the lack of prior knowledge of basic medical terms.

Themes	Content	Comprehension	Format	Application	Affect
Frequency	0	1	22	1	3

Survey Question 3: Briefly describe what you learned about Stroke based upon the 3D video case study.

Participants described specific content knowledge they learned. For instance, risk factors for stroke (e.g., obesity, race, hypertension); manifestations of stroke (e.g., facial droop); how stroke is diagnosed; what to do if someone experiences a stroke. These answers indicate clear content learning, especially when paired with the score differences between the pre- and post-tests.

Themes	Content	Comprehension	Format	Application	Affect
Frequency	20	4	0	2	0

Survey Question 4: Would you like to use 3D teaching vignettes to teach case studies in your classroom to enhance learning? Why or Why not?

As future teachers, all but two respondents (23 out of 25) said "yes" to this question and explained it captured the learners' interest and was clear and informative. The two participants who disagreed said YouTube videos would be better and they would prefer to videotape real persons. 13 considered the engagement of the video case as an important factor. 9 like the format of 3D teaching vignettes

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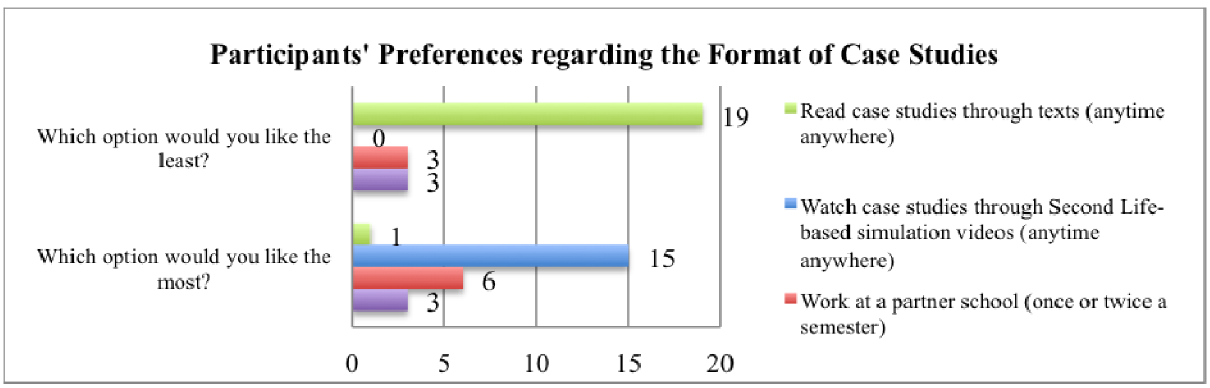
Themes	Content	Comprehension	Format	Application	Affect
Frequency	3	0	9	1	13

5.3 Questions Regarding the Format of Case Studies:

Among the following four options, which would you like the most? Which would you like the least?

To maintain data reliability, the same four options below were asked in two opposite ways. Participants need to choose which option they like the most, and then which option they like the least. They overwhelmingly prefer 3D case studies to text-based case studies (15 vs. 1), recognizing that although working in a real clinical setting is preferred, but it's not a pragmatic approach. When choosing their least favorable option, the contrast between 3D vs. text-based case studies was dramatic (19 vs. 0).



5.4 Observation Notes:

Two researchers observed the study. The participants were actively engaged throughout the study although they were not familiar with the research topic. All students closely watched the video; asked questions to clarify; completed pre- and post tests; did not engage in conversation with peers during the pilot. They were not able to control the pace of the play of the video. They seemed to be a bit bothered by the low volume of the video projected to the screen at the front of the classroom. They paid very close attention as the video progressed. Their facial expressions showed concentration, interest, and humor during the video playing. The participants were able to complete the post-test faster than the pre-test indicating some content familiarity after watching the 3D teaching vignette and possible knowledge retention.

6. Discussion and Implications

The 3D teaching vignette development involved researchers from the areas of Nursing and

Educational Technology. It inevitably invited constructive discussion and tension as researchers worked to balance design ideas. This is characteristic of design-based research, which composes a methodology that bridges theoretical research and educational practice. "Design-based research goes beyond perfecting a particular product. The intention of design-based research in education is to inquire more broadly into the nature of learning in a complex system and to refine generative or predictive theories of learning" (DBRC, 2003). During each iteration, scripts were revised and virtual artifacts were improved. A detailed analysis of design process indicates that 3D teaching vignettes, as an instructional instrument, are reusable and motivational. The following accounts for what we learned in the process of development and evaluation in regards to the questions we asked earlier.

6.1 3D Simulation Platform Promotes Interdisciplinary Collaboration

A teaching vignette was developed as a result of multi-disciplinary collaboration among three researchers from two disciplines. Using a simulation environment as a collaboration platform, we found it easy and straightforward for each researcher to identify their roles in the project and embed their domain expertise and research questions into the overall research goal. For instance, in an earlier study (Lavin & Bai, 2013), two teaching vignettes are developed based upon the belief that patent-centered care is the key in patient care. Researchers from the areas of Nursing, Occupational Therapy (OT), Physician Assistant (PA), Educational Technology (ET), and Psychology put together two cases, each of which illustrates real life situations that can be situated into their own interested contexts. For instance, Nursing could focus on assessment and nursing interventions, OT could focus on rehabilitation needs, PA could focus on emergency health management; ET could focus on simulation instrument usability and cognitive effectiveness, and Psychology could focus on cultural and gender factors in 3D simulations.

In this study on CVA, one of the researchers is a new faculty member in Nursing, who is able to easily associate our research vision with the researcher's own research ideas. The researcher first identified the problems in CVA training. The team put together a project plan to use 3D teaching vignettes to promote learning. Such interdisciplinary collaborations do not happen often because of limitations of time, cost, feasibility, and expertise. When it came to promoting authentic learning via an easy to implement virtual platform, each researcher was able to provide constructive contributions from the perspective of their expertise, which in return made the case scenarios richer and more dynamic that reflected the complex emergent real life situation.

6.2 Research Question 1: What are the affordance and constraints of developing 3D teaching vignettes to promote learning?

This study confirmed an earlier study (Bai, et al., 2012 and Bai, Lavin, & Duncan, 2012) that "students overwhelming prefer 3D teaching vignettes to text-based case studies. And developing 3D teaching vignettes can be an effective approach for multidisciplinary collaboration. This finding can be explained from following perspectives.

3D teaching vignettes take into consideration students' diverse learning styles, making available learning content in verbal, audio, visual formats. As future teachers, our participants pointed out the affective values of 3D teaching vignettes: engage and motive learning in an immersive learning environment.

Immersing students in a meaningful real life context helps create a dynamic mental model of how a system works, thus helping build confidence and strengthen self-efficacy.

3D teaching vignettes can also be accessed anywhere anytime. As mentioned by several participants in the study, 3D teaching vignettes can be posted to social media sites, such YouTube or Vimeo. Students can play, pause, or rewind, following a nonlinear learning path based upon their own learning pace. Also embedding 3D teaching vignettes in a social media platform allows students to make comments and post questions on the website. Such collaborative learning effort can be shared in different course sessions from varied majors over many semesters. Also domain experts can be invited to post their insights and feedback, creating an effective cognitive apprentice environment.

The cost of building a virtual environment is minimal in terms of equipment and there is neither concern with costly repairs nor risks that may incur in real life contexts.

Researchers from multiple disciplines can find it easier to collaborate in developing real life cases via a user-friendly virtual platform like Second Life. Virtual artifacts continue to be developed and exchanged in a very affordable price in the Second Life community. For instance, most hospital equipment or classroom furniture can be purchased in less than ten US dollars. Once the virtual environment is set up, it can be used for multiple purposes such as role-playing or 3D teaching vignettes development.

The slide pace of the video is the biggest concern. One reason is Teacher Education students encountered cognitive overhead while taking in large amount of information in 12 minutes.

6.3 Research Question 2: Do 3D case studies help increase learning outcome? What is the impact of 3D teaching vignettes on students' learning processes?

We conducted a one-group pre and posttests study. We did not have a comparison group in this pilot. In a subsequent pilot we had comparison groups of nursing students. Pre- and post- tests result shows students with little or no prior knowledge on the subject of CVA gain significantly in learning. This is also confirmed via answers to the open-ended questions. When asked what they have learned from the 3D teaching vignette, participants recalled declarative knowledge (e.g., symptoms or risk factors of stroke) and described procedure knowledge (e.g. how to treat the problem or calculate the right dosage). Some also ventured into the future and pondered about what would happen if their relatives or friends had stroke. Others recognized professionals need to be better prepared to deal with complicated issues like CVA. Participants indicated they preferred 3D case studies to text-based case studies. In conclusion, 3D teaching vignettes impacted learning in a positive way due to its informative content via visual knowledge representations and engaging format in this study.

7. Limitations

Creating a 3D virtual learning environment still faces challenges. Cost is incurred, although low, to maintain virtual lands and purchase artifacts. Some special gestures need to be concatenated together to make a new behavior, such as squeezing a hand or fainting. Those actions require no conscious effort in real life but in Second Life, users have to create their own customized behaviors. Sometimes we couldn't add complex virtual items, as there is a limit to the number of virtual items we could put to a virtual land. These constraints offset some of the affordances the virtual reality technology can offer. Also, learning curve exists for non-technical researchers, who need some basic training to learning how to navigate and interact in the virtual world. What participants disliked the most is the pace of the play of the 3D teaching vignette. Like reading a text-based case study, learners should have the option to watch, rewind, or pause a video to control their own leaning pace. This can be addressed by having the learners access the video via the Internet (e.g., YouTube, Vimeo), CDs, or a local computer.

Also, we need to more formally evaluate learner engagement. We have done so with students in a subsequent pilot using a Likert scale survey. In the future, we will ask observers to indicate students' engagement via such a formal approach as well.

8. Conclusions and Future Directions

This study focuses on a novel approach to the already established practice of case-based learning. The researchers recognize the value of 3D teaching vignettes as well as some of the constraints. The 3D teaching vignette used in this pilot study focuses on illustrating how a system works while minimizing actual risk. Overall participants reported a preference for the 3D teaching vignette in this research. Significant cognitive gains were also reported. Further research is needed to assess problem-solving skills via role-playing in such a 3D virtual learning environment. The next step is to pilot the scenario in two different generic Nursing Major classes to determine if the above results will be replicated. An additional pilot testing will be done in an acute care hospital that is designated as a certified stroke center.

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