Educ Inf Technol (2017) 22:383–398
DOI 10.1007/s10639-015-9453-x

Nursing students' experiential learning processes using an online 3D simulation game

Jaana-Maija Koivisto[1] · **Hannele Niemi**[1] · **Jari Multisilta**[2] · **Elina Eriksson**[3]

Published online: 28 November 2015

Abstract The growing use of game-based simulation in healthcare education reflects the opportunities afforded to learners by serious games, which simulate real-world situations and enable students to emulate the roles of healthcare professionals in a safe and engaging learning environment. As part of a design-based research project to design, test, and evaluate an online 3D simulation game for use in game-based simulation in healthcare education, the present study applied Kolb's experiential learning theory to investigate nursing students' experiential learning processes during a 3D simulation game. The data, collected from eight nursing students, comprised audio and video recordings from gaming sessions and focus group interviews. The results indicate that in 3D simulation game, patient-related experiences were supported by audiovisual authenticity, the authenticity of scenarios, and interactivity. Feedback triggered students to reflect on their own learning processes. Students conceptualised knowledge by applying nursing theory, and they internalised procedures that can be used in real life. They also had an opportunity to experiment by exploring and making decisions in the gaming environment. One of the main issues arising from these findings is that 3D simulation games used in game-based simulation should share familiar characteristics of leisure games to ensure an engaging learning experience.

Keywords Game-based simulation · 3D simulation game · Experiential learning process · Nursing students · Healthcare education

✉ Jaana-Maija Koivisto
jaana-maija.koivisto@helsinki.fi

[1] Faculty of Behavioural Sciences, University of Helsinki, P.O. Box 9, FI-00014 Helsinki, Finland

[2] Tampere University of Technology, Pohjoisranta 11A, FI-28100 Pori, Finland

[3] Department of Nursing Science, University of Turku, 20014 Turku, Finland

1 Introduction

The use of serious games in healthcare is growing. Serious games lie at the intersection between leisure games and educational simulations (de Freitas 2006), integrating gaming elements with learning objectives. Such games commonly focus on problem solving (Susi et al. 2007), and the ability to solve clinical problems is among the core competencies of healthcare professionals. The term "serious games" also refers to a movement of researchers, designers and educationalists working to develop games and simulations specifically to ensure fun, motivation and educational value in games developed for formal education (de Freitas 2007). Because they are compelling and present realistic simulations of real-life situations, serious games represent an important opportunity to improve education (Bellotti et al. 2011).

De Freitas (2006) has defined games used in learning contexts as a voluntary activity played out within a specific time and place; using PCs, games consoles and other handheld devices; separate from real life and creating an imaginary or immersive world. According to Gaba (2004), "simulation is a technique, not a technology, to replace or amplify real experiences with guided experiences, often immersive in nature, that evoke or replicate substantial aspects of the real world in a fully interactive fashion". A computer simulation is a way of modelling a real-world situation on a computer (de Freitas 2007). In the nursing literature, there is some confusion in the terminology used in different studies, reflecting the varying models of delivery of computer-based simulation (Cant and Cooper 2014). In their integrative review, Cant and Cooper (2014) found that web-based simulation programs used in nursing education range in fidelity from narrative, text-only case stories to animated characters situated in virtual communities in cyberspace to filmed patient-actors simulating medical situations.

Adopting the definition of game-based simulation as a learning method that combines games, simulations, nursing knowledge and learning objectives, the present study focuses on games and simulations delivered in web-based, mobile, or virtual reality learning environments. Games provide motivating learning environments, and simulations enable immersive online "real-life" experiences. According to Petit Dit Dariel et al. (2013), the benefit of combining games and simulation is that games can provide much more complex scenarios than are possible in a laboratory simulation. In a game-based simulation, the learner can make different decisions, leading to a limitless number of paths as determined by the game engine. Game-based simulation offers an ideal teaching method before students are entrusted with the care of real patients in supervised clinical practice (Graafland et al. 2012). For present purposes, simulation games are defined as virtual simulations that integrate gaming elements with learning objectives, in which learners simulate real-world situations and emulate the roles of healthcare professionals (Forsberg et al. 2011; Graafland et al. 2012; Roh et al. 2013; Vottero 2014). One advantage of simulation games is that students can use them for self-directed distance learning (Alinier 2007).

2 Theoretical background

New graduate nurses should enter the profession with valuable experiences on which to build as they strive for clinical experience (Bauman 2012). Serious game

design should integrate entertainment and educational features to build games that are realistic simulations of the physical world that provide effective learning experiences (Bellotti et al. 2011). Game-based simulation is often experience-based. The key challenge for effective learning with games is for the learner to be engaged, motivated, supported and interested, but for learning to be effective in game worlds, a connection must be made between what is learnt and how it is applied in practice (de Freitas 2007).

In healthcare education and in professional development, learning is often experiential in nature. Learning with game-based simulation places greater emphasis on learning as a process rather than on specified learning objectives and outcomes (de Freitas 2007). Game-based simulation in virtual environments can be seen as an ideal space for experiential learning to occur and as a step towards actual practice. The common core of simulations and games is a situation designed to create personal experiences for learners in support of their own process of inquiry and understanding (Kolb 1984). Games are virtual fields of practice that provide players with opportunities for problem-solving and skill performance in a controlled setting (Bauman 2012).

In earlier studies of web-based e-simulation programs used in nursing, the interest has been in learning outcomes (mostly procedural skills) rather than in the learning process (Cant and Cooper 2014). Games and simulations have been seen more as an application of experiential learning than as an experiential process of learning. In the present study, experiential learning theory (Kolb 1984) is used to investigate nursing students' experiential learning processes during a 3D simulation game. In Kolb's theory, the term "experiential" emphasises the central role that experience plays in the learning process. Learning is seen as a constantly evolving and deepening process, in which knowledge is created through the transformation of experiences in a cyclical process of concrete experience, reflective observation, abstract conceptualisation and active experimentation. Knowledge is continuously derived from and tested in the experience of the learners. For experiential learning to be effective, learners need four different kinds of ability: concrete experience, reflective observation, abstract conceptualization and active experimentation (Kolb 1984).

Learners must involve themselves fully and open-minded in new experiences (Kolb 1984). Interactive 3D virtual simulations and games are immersive worlds and they can be seen as facilitators of virtual experiences (de Freitas 2007). An environment is said to be immersive when visitors have the feeling or perception of being part of it. The level of immersion is influenced by the fidelity of the environment as a whole, in terms of graphics, audio effects and interaction with objects (Bauman 2012). When patients are brought to life, learners can engage more fully in learning; if learners cannot interact with the patients, they are likely to become frustrated and bored (Carlson-Sabelli et al. 2011). The veracity, authenticity and reliability of patient scenarios provide students with more complete experiences of real clinical situations (Cook et al. 2010; Forsberg et al. 2011; LeFlore et al. 2012). The experience of feeling safe enhances students' preparedness for real-life situations (Heinrich et al. 2012; Ulrich et al. 2014).

Learners must be able to reflect on and observe their experiences from multiple perspectives (Kolb 1984). Game-based simulation provides opportunities for reflection on learning through feedback, enabling learners to construct new mental models and to

discover new and better solutions to the problems encountered (Kiili 2005). Feedback on performance inspires students to seek reinforcement of learning in assessing their level of clinical skills (LeFlore et al. 2012). Correction of errors during gameplay is associated with good learning outcomes (Ketamo and Suominen 2010). Feedback on performance reinforces learning, and self-reflection is connected to professional development (Bulman et al. 2012).

Learners should be able to create concepts that integrate their observations into logically sound theories (Kolb 1984). By experiencing concrete realities in virtual worlds, learners can engage with complex concepts without losing sight of the real problems they solve (Shaffer et al. 2005); simulation games can help students to acquire knowledge or skills through this kind of abstraction from real situations (Blakely et al. 2009; Cook et al. 2011; Heinrich et al. 2012; Hogan et al. 2011; LeFlore et al. 2012) by having clear goals and challenges that are matched to the learner's skill level (Kiili 2005). Carlson-Sabelli et al. (2011) found that the use of multi-user virtual environments helped nursing students to achieve a deeper understanding of nursing concepts. They argued that learning in a virtual community requires higher-order thinking and the use of critical thinking to interpret, analyse and synthesize knowledge. In short, simulation games can contribute a level of realism that links theory and practice, helping students to think and work creatively for the benefit of patients (Blakely et al. 2010).

Learners should also be able to use theories to make decisions and solve problems (Kolb 1984). Through active experimentation, students become actively involved with the patient and the situation (Guise et al. 2012; Heinrich et al. 2012). Simulation games provide opportunities for testing, experimenting and repetition, so improving performance (Foronda et al. 2014; Heinrich et al. 2008). Roh et al. (2013) found that computer-based simulation increased satisfaction among nurses in setting priorities and implementing nursing skills as a protocol.

3 Purpose of this study

To ensure effective use of game-based simulation in nursing education, more knowledge is needed about how students learn while gaming. In general, students have more experience than nurse educators of gaming and virtual worlds. Taking account of generational factors in using games for learning, the aim of the present study was to investigate nursing students' perspectives on how they learn while playing a 3D simulation game. Here, experiential learning processes are considered to be an important component of professional learning in nursing education. The purpose of the study was to investigate nursing students' experiential learning processes during a 3D simulation game and to determine which game characteristics support experiential learning. The research addresses the following questions:

1. Which characteristics of 3D simulation game support students' concrete experiences of nursing?
2. How do students reflect on their experiences in 3D simulation game?
3. How do students conceptualise in playing 3D simulation game?
4. How do students experiment in playing 3D simulation game?

4 Method

4.1 Research design

This study is the first cycle in a design-based research (DBR) project that uses iterative cycles to design, test and evaluate a 3D simulation game for learning in healthcare education. DBR is an appropriate approach in that it is well suited to game design to improve teaching practices by analysing practical problems, developing and testing solutions and introducing newly-found design principles from the research process to advance theory and practice, in a collaboration between researchers, designers, and practitioners (Amiel and Reeves 2008; Wang and Hannafin 2005). DBR uses multiple research methods to maximize the credibility of the research (Wang and Hannafin 2005); in the present case, qualitative methods were used to produce new theoretical knowledge about nursing students' experiential learning processes during gaming. This knowledge can be used to develop serious games from the perspective of experiential learning theory. The results of this study directly impact on practice because students' experiences of their own learning processes can be used in game development (see Barab and Squire 2004).

The online 3D simulation game CareMe® used in this study was a first playable prototype. The game has been developed specifically to meet the challenge of providing an engaging, motivating and safe learning environment for clinical nursing education. The software was purposefully developed at the University of Applied Sciences in Helsinki as part of a healthcare learning environment development project (Teho Pro 2011–2013), for use within the university as a tool for self-directed online learning (either distance-based or on-campus) as one dimension of a blended learning approach. The game can also be used for continuing training within healthcare organisations. The research has highlighted a gap between game developers, learners and educators and curriculum designers and has encouraged the use of participatory methodologies for game development (de Freitas 2007). The game was designed in collaboration with researchers, nurse educators, students and programmers. The current trend is to place learners at the centre of the design process in order to more closely address their needs (de Freitas and Jarvis 2006). The design principles for the game prototype were created on the basis of research evidence (Table 1). The Unity development platform was used to create the game, which is modular, customizable, graphically pleasing and platform-independent. It has an integrated editor, and it runs in the cloud. The game consists of patient scenarios, which are events designed around a specific medical problem. During gameplay, learners develop their clinical decision-making skills in different clinical situations and patient scenarios. The game is designed to guide learners through the nursing process of assessment, diagnosis, planning, implementation and evaluation. In the game, students assess the patient's need for care; based on this assessment, they make decisions about interventions. At the end of the game, students receive feedback on their performance (see Table 1).

4.2 Data collection

The study participants were eight third-year student nurses, five male and three female, aged 21–32. They volunteered to participate on the basis of their interest in simulation

Table 1 Design principles for the online 3D simulation game prototype

Design principle	Reference
Nursing process	Cook et al. (2010); Forsberg et al. (2011); LeFlore et al. (2012).
Immersive 3D environment	de Freitas (2007); Ulrich et al. (2014).
Realistic and authentic patient scenarios	Cook et al. (2010); de Freitas (2007); Forsberg et al. (2011); LeFlore et al. (2012).
Real-time feedback on performance	Cook et al. (2010); de Freitas (2007); LeFlore et al. (2012).

game design, and all were commencing a thesis related to game development. Participants received an information sheet about the research, and they were asked to sign a form confirming their permission and participation. They were told that they could withdraw from the study at any time.

The study was implemented in a real classroom environment and emphasised cooperation between researcher and students. In game development, it is essential to involve users in the design process from an early stage. Students were asked to describe how they learned when they played the game prototype and what characteristics of the game supported their learning. They were also asked to describe what characteristics would influence their learning if they were missing from a game. This information can be used to redesign the game.

The data were collected in autumn 2013 during four gaming sessions organised in a computer class at the University of Applied Sciences in Helsinki. Participants were assigned to two groups and participated in two gaming sessions, in which they played one or two single-player and multiplayer patient scenarios. In the first session, there were four students in each group, and in the second session, there were three students in each group (two dropped out for personal reasons). Data consisted of audio and video recordings of gaming sessions and focus group interviews. Video is a useful method when conducting research that closely examines teaching and learning in learning environments (Derry et al. 2010). Video data was collected twice, and in the intervening period, some changes were made to the game. Gaming and the game prototype acted as thought instigators, and participants were asked to comment on the game while gaming. The timeframe for solving one scenario was 10 to 20 min. The researcher was present during all gaming sessions.

Focus groups interviews involved semi-structured discussions with students. This method was chosen because group dynamics can assist students in expressing and clarifying their perspectives (Burns and Grove 2005). Interviews were conducted in two groups, immediately after the first gaming sessions, with four participants in each group. Participants were asked to describe how they learn during the 3D simulation game and what game characteristics supported their learning. The duration of the focus group interviews ranged from 45 min to 1 h and 20 min, and they were audiotaped.

4.3 Data analysis

Thematic analysis was applied as a method of identifying, analysing and reporting themes within the data (Braun and Clarke 2006), which were saved using Atlas.ti

software. The analysis included four phases, conducted by one researcher. First, audio data from the gaming sessions and focus group interviews were reviewed, and the videos were watched to identify episodes for further detailed analysis (Derry et al. 2010). After reviewing the data, all speech was transcribed, and this material as a whole was analysed inductively. Before actual coding began, notes were made about ideas for coding. The researcher searched for meanings and patterns in how students learn during a 3D simulation game and what game characteristics support their learning. Speech was coded, codes were grouped into subthemes, and subthemes were grouped into themes (see Table 2) (Braun and Clarke 2006). After the themes were identified, they were organised by using Kolb's theory as a framework to describe the experiential learning process.

5 Results

5.1 Characteristics of the 3D simulation game supporting students' concrete experiences

Analysis of students' experiences revealed a focus on the patient. Three characteristics of the game were found to support patient-related experiences: audiovisual authenticity, authenticity of patient scenarios and interactivity (Table 3).

For students, "audiovisual" referred to game graphics, animations and sounds. Highlighting how audiovisual authenticity supports real-life experiences, students felt that the prototype lacked sufficient realism. They referred to patient appearance and medical devices in terms of "graphics", noting that the patient's clinical condition and any changes could be observed with the help of "animations", referring to patient movements, facial expressions and gestures. "Sounds" referred to both hospital sounds and noises and to patients' voices and other sounds. Students felt that sounds suggesting clinical conditions could direct them to the patient's problem. In referring to "authenticity of patient scenarios", students assessed clinical conditions as realistic and sufficiently challenging and patients as varying in age and sex, as in real life. Students stated that the patient scenarios in the prototype were authentic. By "interactivity", students referred to the player's scope to react to patients' care

Table 2 Example of phases of data analysis

Data extract	Coded for	Subthemes	Theme
"And if there was some patient with breathing difficulties and you could hear, you know, that it is difficult to breathe, so those sounds would be really good. And moving and gestures too could be there. They can be quite difficult but anyway some of them because it is pretty important in observing".	Patients' breathing difficulties	Sounds	Audiovisual authenticity
	Patient moving	Animations	
	Patients' gestures	Animations	

Table 3 Patient-related experiences in a 3D simulation game

Themes	Subthemes
Audiovisual authenticity	Graphics
	Animations
	Sounds
Authenticity of patient scenarios	Realistic scenarios
	Challenging scenarios
	Varying clinical conditions
	Patients varying in age and sex
Interactivity	Students' reactions to patients' clinical condition
	Patients' reactions to care provided

needs and how the patient reacted to the given care; in the prototype, the latter was not realised.

In the following quotes, students describe how audiovisual qualities of the game and interaction within the game can activate learning and disclose how graphics can improve authenticity and make the patient's clinical condition visible. Others noted that, for example, patient's breathing sounds would draw their attention immediately to the patient's problem, helping to prioritise nursing interventions to support breathing.

> "Somehow I'd want to have something visual in it because it is, the whole game, so much text, and there is the patient there in the background but not really connected to the game in any way. I think it would be really good (and it may of course be too difficult to make) that if you needed to measure oxygen saturation then there would be a picture of the oximeter, and you could click that or something. I think that you would connect it to something in your head, and so activate learning about it". (#OM05)

> "Well, not everything was mentioned, like pulse oximetry and blood pressure monitor, and I don't know if you could see the patient's skin colour or if the lips were blue". (#OM08)

> "For example, like rasping breath and such, and plenty of coughing all the time, so you would wonder whether that means something directly to do with the lungs, because of it". (#OM01)

> "Well, I would have a look, but I would start by giving extra oxygen straight away…" (#ON02)

And in the following quotes, one player describes how different realistic patient scenarios bring variation to the game.

> "…and then those variations could be more about how there are many patient scenarios rather than that this one case changes from worse or better—you know,

like in real life and so on, that there are as many of these familiar patient scenarios as there can be". (#OM06)

In the following comment, the player suggests that the game should be developed further so that changes can be seen in the patient's condition. The implication here is that it would be easier to engage to the game if it had more interactivity.

"…and then, when the game evolves, and if it changes so that what you do has some effect on that patient when you start or really quickly, and you can really like empathise, then you can play cases that you feel are challenging for you". (#OM01)

5.2 Students' reflections on the 3D simulation game

In the analysis, three different reflection themes were identified: patient observation, feedback during the game and feedback after the game. During the game, students observed patients by monitoring their vital signs and assessing their clinical condition. Based on these observations, they then made a nursing diagnosis, leading to nursing interventions. The data suggest that feedback triggered reflection (Table 4).

The prototype did not provide immediate feedback during the game, and participants stated that they would have preferred if it did. As well as favouring immediate feedback on their performance, they wanted the game to keep score, as an accumulating score increases satisfaction. They felt that the best feedback during gameplay would be a change in the patient's clinical condition, which did not occur in the prototype. Feedback after gameplay included the total score, reasoning and description of the correct performance, and participants felt that this was well realised. The provision of reasoning for correct choices helped students to reflect both on decisions made and on the underlying knowledge.

In student's comments recorded during the game, an issue arises about how to examine the patient's breathing when assessing clinical condition. Another student ponders on how to conduct a systematic ABCDE examination of the patient's clinical condition, which is a very important nursing skill.

Table 4 Students' reflection of knowledge and performance in a 3D simulation game

Themes	Subthemes
Patient observation	Monitoring vital signs
	Assessing clinical condition
	Nursing diagnosis
Feedback during the game	Immediate feedback on performance (right/wrong)
	Scoring
	Change in patients' clinical condition
Feedback after the game	Total score
	Reasoning
	Description of correct performance

"Yeah, then breathing depth, respiratory muscles, respiration rate…" (#ON02)

"…but in a way, there's the importance if you think that ABCDE like it goes airway so you do it in right order, but then there is the issue that if airways are open and there's breathing, is it rasping or how is it". (#OM06)

In the following quotes, students describe how change in a patient's condition during the game as a result of the player's actions is, in itself, immediate feedback. One discusses how the feedback at the end of the game causes the player to consider their actions and to learn from them. Another says that if the effects of the actions on the patient's clinical condition are not visible, the consequences of those actions remain unclear.

"Mmm, but it is a way to give immediate feedback for the student that now it changed and yes, I did something right". (#ON02)

"And then, if the patient's condition changes, it actually is feedback in itself". (#OM06)

"…and then this immediate feedback could be just that when you give oxygen, you see that oxygen saturation has risen; I think that kind of immediate feedback could be really good". (#OM03)

"Isn't this learning, in a way, that when you get the answers at the end and you go through them and then you have to think… why is this and why did I click that and why this seems like this". (#OM06)

"In decision making, I think there have to be some consequences so that you know the effects of your decision; if the condition never changes then you don't know how your decisions work". (#OM01)

5.3 Students' conceptualisation in the 3D simulation game

The data suggest that students conceptualise by applying nursing theory and by internalising procedures (Table 5).

"Application of nursing theory" refers to students' application of previously acquired knowledge in resolving patient scenarios. "Internalising procedures" refers to learning about various procedures (such as clinical protocols) that can be applied to real-life patient situations. Students also had an opportunity to learn prioritisation. The game could be repeated, which helped players to internalise and automatise procedures, and so perform them correctly, in a real nursing situation. Students encountered situations they had not experienced before, and in this way, the game could teach procedures to be applied to new situations.

In the following quotes, students describe the importance of opportunities to apply their theoretical knowledge in practice before actual clinical practice during their nursing education. They also suggest that gaming supports independent learning

Table 5 Students' conceptualisation of knowledge in a 3D simulation game

Themes	Subthemes
Application of nursing knowledge	Use of previously obtained knowledge
	Apply knowledge to solve patient scenarios
Internalising procedures	Protocols
	Priorisation
	Automatisation

because it can be done while they have time and motivation. One student also describes how, in the game, they can practise situations not yet encountered and learn how to approach such situations.

> "This is good for our field of education; quite a few would like to have some practical application, so this could perhaps supplement skill lab, where people could apply theory to practice before they go on to clinical practice". (#OM05)

> "We don't really practise that much in the skill lab; some things are practised maybe once, so it doesn't really give you much preparation for clinical practice, so this can be quite a good support for it". (#OM08)

> "I think that it really supports self-learning, that you can practise whenever you like and a bit beforehand, to have already tried them out and then maybe use them in work for real". (#ON07)

> "…and that is good, in that you can play it whenever you have time and motivation and interest…"(#OM08)

> "…because you have hardly ever seen those [refers to patient deterioration]—at least I have not seen it in working life as you should, some cases of course but not that many—so with that [playing the game], you can remember the approach more easily". (#ON07)

The following comments describe how the game can help with learning approaches, and how these can become automatic actions.

> "Well, I think so anyway—that, in a way, when you have learnt one approach and the patient has it, like a breathing difficulty or whichever symptom, and you are there as a nurse, then you do certain things and you don't pay special attention to it but make sure that airways are open or breathing and blood circulation are okay, that you have some kind of checklist". (#OM06)

> "…it surely helps that it becomes automatic, so that you do it instinctively when you really have to do it". (#OM03)

5.4 Students' experimentation in the 3D simulation game

The data suggest that students experiment by exploring and making decisions (Table 6).

"Exploring" refers to students attempting, making mistakes and learning from those mistakes. The game provided a safe environment in which to make mistakes because real patients would not come to harm. "Repetition" refers to students replaying the game. "Decision making" refers to how students considered choices in relation to the patient's clinical condition and how to react to it. The advantage of this independent decision making was that students had to make decisions based on their own knowledge and then received feedback on their decisions. Collective decision making was advantageous, as it was possible to discuss different options with others, and support was available for decision making.

In the following, one student explains how the game is a safe environment for trial and error without any consequences for a patient. Another student talks about how the game supports learning in combination with other teaching methods in which the student can be an active agent. The feeling is that the game helps players to realise their own actions, and that repetition improves readiness to act in working life.

> "Right, and then there is the fact that you can practise in a safe environment and make mistakes without any serious consequences". (#OM03)

> "By repeating, you do the tasks over and over, and even though it is not concrete but only in your mind, you still remember things better when you work. After you first think and play the game, you realise what you are going to do and then do it, and then you realise that 'Oh this is what I am going to do', and you have deeper memory traces because you have repeated the tasks more". (#OM01)

The following discussion between students during the gaming session reflects their mutual consideration and decision making while assessing the patient's clinical condition, and the observations they make, discussing the order in which they assess clinical condition and which issues they should prioritise.

> "…and the limb status". (#OM08)

> "Yeah". (#ON04)

Table 6 Students' active agency in patient care in a 3D simulation game

Themes	Subthemes
Exploring	Attempting
	Making mistakes
	Repetition
Decision making	Considering choices
	Independent decisions
	Collective decisions

"Probably, yes". (#OM08)

"Shall I click it or will you?" (#ON04)

"You can". (#OM08)

"…which one you then like more". (#ON04)

"Probably the limb status, because wasn't the wound somewhere else, in principle anyway, or where was it, somewhere in the groin? So the wound is not as important as the whole limb". (#OM08)

"Mm". (#ON04)

"Basically, only after this, then the doctor". (#OM08)

"Right, basically yes, because we note that, soon after, the whole leg can fall off". (#ON04)

"Then surely the wound dressings, maybe?" (#OM08)

"They are clean". (#ON04)

6 Discussion

The present findings show that Kolb's experiential learning cycle can usefully be applied to nursing students' experiential learning processes during this 3D simulation game, as students went through the experiential learning cycle several times during one patient scenario. The results also suggest that game-based simulation has good potential as a learning method, although to be effective, games must be able to replicate clinical reality. Because today's learners are familiar with the virtual world and with visually realistic game environments, the required standard for educational games is high. In general, the findings are consistent with previous research, which suggests that computer-based simulations engage students in the learning process (Blakely et al. 2009; Ulrich et al. 2014).

One of the main issues arising from these results is that, in order to provide significant learning experiences, games used in this way need to share familiar characteristics of leisure games, such as interactive 3D environments, high-quality animations, graphics and sounds, scoring and immediate feedback for each action. Previous studies have emphasised that the authenticity of patient scenarios is paramount in simulation games (LeFlore et al. 2012; Forsberg et al. 2011). This investigation produced similar results but also revealed that visual authenticity, interactivity and feedback are very important characteristics of simulation games. Nursing is essentially about interactions between patients and nurses, and the findings here indicate that interaction in the game is also essential: the better the

game enables interaction, the more realistic and engaging the learning experience will be.

The potential of game-based simulation to facilitate learning as knowledge construction lies in giving students an opportunity to be active in decision-making and reflection, both during and after the game; without this potential to be active and to get feedback on their own decisions, they do not learn. Again, these findings confirm previous evidence that simulation games provide opportunities for knowledge acquisition (Blakely et al. 2009; Heinrich et al. 2012; Hogan et al. 2011) and repetition (Foronda et al. 2014; Heinrich et al. 2008). This study indicates that active agency during gameplay prepares students to act correctly in clinical situations. In a 3D simulation game, students can utilise and test their theoretical knowledge and practise procedures that can then be implemented in real-life nursing. In this way, they feel more confident in their abilities. The game provided opportunities for students to be active agents, unlike in clinical practice where, as students, they cannot be in charge of care, especially in situations requiring quick decisions. Making their own decisions and seeing consequences concretely prepares students for decision making situations. Previous studies suggested that students reflected on their learning in debriefing after a simulation scenario (Cook et al. 2010; LeFlore et al. 2012). The findings of this study indicated that feedback provided only at the end of the learning situation comes too late, as the action is over, and the student cannot effectively connect feedback and actions. However, feedback at the end remains necessary, as students can then consider issues of cause and effect and can combine their experiences with their knowledge of nursing and patient care. In particular, students emphasised the significance of reasoning; they wanted to know why something was right or wrong, indicating that their goal is to gain deeper knowledge rather than learning only from memory. The results of this study indicate that students' professional competence can develop through playing a 3D simulation game, making such games suitable for self-directed distance learning, as found in earlier research (Alinier 2007).

One limitation of the study is that only eight students participated, which may undermine the credibility of the results. They were also playing the first playable prototype of the 3D simulation game. Only speech data were analysed from the video, as the video element was considered insignificant for the analysis of actions, given that the prototype was so crude. However, participants' opinions were mutually aligned and supported previous research data. Results may also have been affected by the fact that the researcher had been teaching the participants and is also in charge of the game's development in her own work. Recognising this problem, the researcher adjourned analysis in order to be able to review the data objectively. The strength of the study lies in the researcher's strong expertise in nursing, simulations and design-based research.

7 Conclusion

The use of game-based simulation in healthcare education alongside other teaching methods has been increasing, and in the future may even replace some traditional methods by virtue of its cost effectiveness. The current study provides new knowledge about students' learning processes during a 3D simulation game. In particular, Kolb's (1984) cyclical learning process can be repeated several times during gameplay, so

enhancing learning. This study was the first cycle in a design-based research project to design a 3D simulation game, and it revealed important issues for game designers as to the game's further development. In the next design cycle, the aim is to extend the development team to include a Unity programmer, a 3D artist and animator and an industrial designer to ensure that the game meets the requirements of learners. After redesigning the game on the basis of the results of this study, data will be collected from a larger sample, and the research will focus on how students' decision making competency improves following the use of game-based simulation in nursing education.

References

Alinier, G. (2007). A typology of educationally focused medical simulation tools. *Medical Teacher*, *29*(8), e243–e250 [Online]. doi:10.1080/01421590701551185.

Amiel, T., & Reeves, T. C. (2008). Design-based research and educational technology: rethinking technology and the research agenda. *Educational Technology & Society*, *11*(4), 29–40.

Barab, S., & Squire, K. (2004). Design-based research: putting a stake in the ground. *Journal of the Learning Sciences*, *13*(1), 1–14. doi:10.1207/s15327809jls1301_1.

Bauman, E. B. (2012). *Game-based teaching and simulation in nursing and healthcare*. New York: Springer Publishing Company. ProQuest ebrary Accessed 15 August 2015.

Bellotti, F., Berta, R., De Gloria, A., Ott, M., Arnab, S., de Freitas, S., & Kiili, K. (2011). Designing Serious Games for education: from Pedagogical principles to Game Mechanisms. Proceedings 5th European Conference on Game-Based Learning (pp. 26–34), Oct 2011, Athens, Greece. Reading: Academic Publ. Ltd.

Blakely, G., Skirton, H., Cooper, S., Allum, P., & Nelmes, P. (2009). Educational gaming in the health sciences: a systematic review. *Journal of Advanced Nursing*, *65*(2), 259–269.

Blakely, G., Skirton, H., Cooper, S., Allum, P., & Nelmes, P. (2010). Use of educational games in the health professions: a mixed-methods study of educators' perspectives in the UK. *Nursing and Health Sciences*, *12*, 27–32.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. doi:10.1191/1478088706qp063oa.

Bulman, C., Lathlean, J., & Gobbi, M. (2012). The concept of reflection in nursing: Qualitative findings on student and teacher perspectives. *Nurse Education Today*, *32*(5), e8–e13. doi:10.1016/j.nedt.2011.10.007.

Burns, N., & Grove, S. K. (2005). *The practice of nursing research. Conduct, critique, and utilization*. St. Louis: Elsevier Saunders.

Cant, R. P., & Cooper, S. J. (2014). Simulation in the internet age: the place of web-based simulation in nursing education. An integrative review. *Nurse Education Today*, *34*, 1435–1442.

Carlson-Sabelli, L. L., Giddens, J. F., Fogg, L., & Fiedler, R. A. (2011). Challenges and benefits of using a virtual community to explore nursing concepts among baccalaureate nursing students. *International Journal of Nursing Education Scholarship*, *8*(1), 1–14.

Cook, D. A., Erwin, P. J., & Triola, M. M. (2010). Computerized virtual patients in health professionals' education: a systematic review and meta-analysis. *Academic Medicine*, *85*(10), 1589–1602.

Cook, D. A., Hatala, R., Brydges, R., Zendejas, B., Szostek, J. H., Wang, A. T., et al. (2011). Technology-enhanced simulation for health professions education. A systematic review and meta-analysis. *The Journal of the American Medical Association*, *306*(9), 978–988.

de Freitas, S. (2006). Using games and simulations for supporting learning. *Learning, Media and Technology*, *31*(4), 343–358. doi:10.1080/17439880601021967.

de Freitas, S. (2007). Learning in Immersive Worlds: A review of game-based learning. JICS. http://videogamelc.bgsu.wikispaces.net/file/view/de%20Freitas%202007.pdf/364559316/de%20Freitas%202007.pdf.

de Freitas, S., & Jarvis, S. (2006). A framework for developing serious games to meet learner needs. Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2006. Paper No. 2742.

Derry, S. J., Pea, R. D., Barron, B., Engle, R. A., Erickson, F., Goldman, R., et al. (2010). Conducting video research in the learning sciences: guidance on selection, analysis, technology, and ethics. *Journal of the Learning Sciences*, *19*(1), 3–53. doi:10.1080/10508400903452884.

Foronda, C., Gattamorta, K., Snowden, K., & Bauman, E. B. (2014). Use of virtual clinical simulation to improve communication skills of baccalaureate nursing students: a pilot study. *Nurse Education Today*, *34*(6), 53–57.

Forsberg, E., Georg, C., Ziegert, K., & Fors, U. (2011). Virtual patients for assessment of clinical reasoning in nursing—a pilot study. *Nurse Education Today*, *31*, 757–762.

Gaba, D. M. (2004). The future vision of simulation in health care. *Quality and Safety in Health Care*, *13*(suppl 1), i2–i10.

Graafland, M., Schraagen, J. M., & Schijven, M. P. (2012). Systematic review of serious games for medical education and surgical skills training. *British Journal of Surgery*, *99*, 1322–1330.

Guise, V., Chambers, M., Conradi, E., Kavia, S., & Välimäki, M. (2012). Development, implementation and initial evaluation of narrative virtual patients for use in vocational mental health nurse training. *Nurse Education Today*, *32*, 683–689. doi:10.1136/qshc.2004.009878.

Heinrich, W. L. R., Youngblood, P., Harter, P. M., & Dev, P. (2008). Simulation for team training and assessment: case studies of online training with virtual worlds. *World Journal of Surgery*, *32*(2), 161–170.

Heinrich, C., Pennington, R. R., & Kuiper, R. (2012). Virtual case studies in the classroom improve student knowledge. *Clinical Simulation in Nursing*, *8*(8), 353–361.

Hogan, M., Kapralos, B., Cristancho, S., Finney, K., & Dubrowski, A. (2011). Bringing community health nursing education to life with serious games. *International Journal of Nursing Education Scholarship*, *8*(1), 2072. doi:10.2202/1548-923X.

Ketamo, H., & Suominen, M. (2010). Learning-by-teaching in educational game: educational outcome, user experience and social networks. *Journal of Interactive Learning Research*, *21*(2), 237–255.

Kiili, K. (2005). Digital game-based learning: towards an experiential gaming model. *The Internet and Higher Education*, *8*(1), 13–24.

Kolb, D. A. (1984). *Experiential learning. Experience as the source of learning and development*. New Jersey: Prentice-Hall.

LeFlore, J.-L., Anderson, M., Zielke, M. A., Nelson, K. A., Thomas, P. E., Hardee, G., et al. (2012). Can a virtual patient trainer teach student nurses how to save lives—teaching nursing students about pediatric respiratory diseases. *Simulation in Healthcare Simulations: The Journal of The Society for Medical Simulation*, *7*(1), 10–17.

Petit Dit Dariel, O. J., Raby, T., Ravaut, F., & Rothan-Tondeur, M. (2013). Developing the serious games potential in nursing education. *Nurse Education Today*, *33*(12), 1569–1575.

Roh, Y. S., Lee, W. S., Chung, H. S., & Park, Y. M. (2013). The effects of simulation-based resuscitation training on nurses' self-efficacy and satisfaction. *Nurse Education Today*, *33*, 123–128.

Shaffer, D. W., Squire, K., Halverson, R., & Gee, J.P. (2005). *Video games and the future of learning*. WCER Working Paper No. 2005–4.

Susi, T., Johannesson, M., & Backlund, P. (2007). *Serious games*: *An overview* (Technical Report HS-IKI-TR-07-001). Skövde: University of Skövde [Online]. http://www.diva-portal.org/smash/get/diva2:2416/FULLTEXT01.pdf.

Ulrich, D., Farra, S., Smith, S., & Hodgson, E. (2014). The student experience using virtual reality simulation to teach decontamination. *Clinical Simulation in Nursing*, *10*(11), 546–553.

Vottero, B. A. (2014). Proof of concept: virtual reality simulation of a Pyxis machine for medication administration. *Clinical Simulation in Nursing*, *10*(6), 325–321.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research & Development*, *53*(4), 5–23 ISSN 1042-1629.