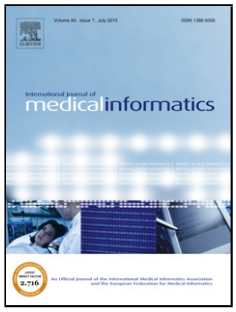

Title: Teaching clinical reasoning and decision-making skills to nursing students: Design, development, and usability evaluation of a serious game

Author: Hege Mari Johnsen Mariann Fossum Pirashanthie Vivekananda-Schmidt Ann Fruhling Åshild Slettebø

PII: S1386-5056(16)30143-5
DOI: http://dx.doi.org/doi:10.1016/j.ijmedinf.2016.06.014
Reference: IJB 3358

To appear in: *International Journal of Medical Informatics*

Received date: 8-4-2016
Revised date: 15-6-2016
Accepted date: 23-6-2016

Please cite this article as: Hege Mari Johnsen, Mariann Fossum, Pirashanthie Vivekananda-Schmidt, Ann Fruhling, Åshild Slettebø, Teaching clinical reasoning and decision-making skills to nursing students: Design, development, and usability evaluation of a serious game, International Journal of Medical Informatics http://dx.doi.org/10.1016/j.ijmedinf.2016.06.014

Teaching clinical reasoning and decision-making skills to nursing students: Design, development, and usability evaluation of a serious game

Hege Mari Johnsen, RN, MSc [a)], Mariann Fossum, RN, PhD [a)], Pirashanthie Vivekananda-Schmidt, DPhil, C.Psychol [b)], Ann Fruhling, PhD [c)], Åshild Slettebø, RN, PhD [a)]

a) Department of Health and Nursing Science, Faculty of Health and Sport Sciences, University of Agder, Grimstad, Norway
b) Medical Education, The Medical School, University of Sheffield, UK
c) College of Information Science and Technology, University of Nebraska, Omaha, USA

Correspondence to:
Hege Mari Johnsen
Department of Health and Nursing Science,
Faculty of Health and Sport Sciences,
University of Agder,
PO Box 509
4898 Grimstad
Norway
E-mail: hege.mari.johnsen@uia.no
Telephone: +47 97515773

Keywords: clinical decision-making, community health nursing, computer simulation, education, problem-based learning, user-computer interface.

Highlights

- We developed an SG for teaching high-quality care to patients with COPD in home healthcare settings.
- Our video based SG was perceived as being useful, usable, and satisfying.
- The different theoretical approaches included in the SG design were an advantage.

Teaching clinical reasoning and decision-making skills to nursing students: Design, development, and usability evaluation of a serious game

ABSTRACT

Background: Serious games (SGs) are a type of simulation technology that may provide nursing students with the opportunity to practice their clinical reasoning and decision-making skills in a safe and authentic environment. Despite the growing number of SGs developed for healthcare professionals, few SGs are video based or address the domain of home health care.

Aims: This paper aims to describe the design, development, and usability evaluation of a video based SG for teaching clinical reasoning and decision-making skills to nursing students who care for patients with chronic obstructive pulmonary disease (COPD) in home healthcare settings.

Methods: A prototype SG was developed. A unified framework of usability called TURF (Task, User, Representation, and Function) and SG theory were employed to ensure a user-centered design. The educational content was based on the clinical decision-making model, Bloom's taxonomy, and a Bachelor of Nursing curriculum. A purposeful sample of six participants evaluated the SG prototype in a usability laboratory. Cognitive walkthrough evaluations, a questionnaire, and individual interviews were used for the usability evaluation. The data were analyzed using qualitative deductive content analysis based on the TURF framework elements and related usability heuristics.

Results: The SG was perceived as being realistic, clinically relevant, and at an adequate level of complexity for the intended users. Usability issues regarding functionality and the user–computer interface design were identified. However, the SG was perceived as being easy to learn, and participants suggested that the SG could serve as a supplement to traditional

training in laboratory and clinical settings.

Conclusions: Using video based scenarios with an authentic COPD patient and a home healthcare registered nurse as actors contributed to increased realism. Using different theoretical approaches in the SG design was considered an advantage of the design process. The SG was perceived as being useful, usable, and satisfying. The achievement of the desired functionality and the minimization of user–computer interface issues emphasize the importance of conducting a usability evaluation during the SG development process.

Keywords:

Clinical decision-making

Community health nursing

Computer simulation

Education

Problem-based learning

User–computer interface

1. Introduction

Education and training that develops healthcare professionals' clinical reasoning skills is emphasized as an important strategy to improve diagnostic performance and reduce overt diagnostic errors. Registered nurses (RNs) play a key role in the diagnostic process while caring for patients. The performance of clinical reasoning among nurses is defined as "the process by which nurses collect cues, process the information, come to an understanding of a patient problem or situation, plan and implement interventions, evaluate outcomes, and reflect on and learn from the process" [1]. RNs with effective clinical reasoning skills may anticipate or identify deteriorating patients and prevent serious adverse events [1,2].

Recent demographic changes and care reforms [3,4] have resulted in a change in

healthcare delivery from hospital to home healthcare services, which has resulted in an increased number of patients with chronic diseases living at home. For instance, the group of patients with chronic obstructive pulmonary disease (COPD) is highly represented in home healthcare services. COPD is expected to become the third leading cause of death worldwide by 2030 [5]. Therefore, it is essential for home healthcare RNs to have a high level of clinical reasoning skills combined with evidence-based knowledge to provide effective and efficient clinical practice and to maintain high-quality nursing care [6,7].

To enable nursing students to respond effectively to the current changes in the healthcare environment, curricula and skills training need to adapt to the evolving healthcare needs in home healthcare services [8-10]. This includes an increased focus on improving nursing students' ability to prevent, recognize, and treat any deteriorating patients to avoid unnecessary hospitalization [3]. Furthermore, nursing education needs to provide simulation training where students are able to apply different types of knowledge in novel, authentic, and practice-based situations [6,8,10].

Recently, simulation technology known as "serious games" (SGs) has appeared in the educational games market [11,12]. SGs are computer-based simulations that combine knowledge and skills development with video game-playing aspects to enable active, experiential, situated, and problem-based learning [13]. SGs represent a learner-centered educational approach in which users control their learning process through interactivity [14,15]. Recently, SGs have been proposed as a type of technology-enhanced simulation that may provide nursing students with an opportunity to practice their clinical reasoning and decision-making skills in a realistic and safe environment [14,16].

The usability issues of some SGs can negatively impact users' experiences and intended learning outcomes [17,18]. Focusing too much on the development of the entertainment-based counterparts of an SG may result in sacrificing learning effectiveness. Learning may also be

impaired if the SG has poor usability, which taxes the users' cognitive resources and decreases their motivation to play the game [17]. To ensure a user-centered design, it is important that the SG contents fit the intended users' learning objectives [17,19,20]. Therefore, it is important to conduct a usability evaluation as part of the development process to ensure the usability and learnability of the SG [17,18,21].

Despite the growing number of SGs developed for healthcare professionals [15,22], limited research addresses the development process of SGs in the domain of nursing education [15,23]. Few researchers have specifically addressed the domain of home health care [20,24,25]. Thus, the aim of this paper is to describe the design, development, and usability evaluation of a video based SG for teaching clinical reasoning and decision-making skills to nursing students who are caring for patients with COPD in home healthcare settings.

2. Materials and methods

2.1. Design and development of the SG

The SG prototype used in this study is a single-player online game that was applied to the Bachelor of Nursing program in the domain of home health care. This SG may be categorized under the genre of simulation games because it attempts to realistically mimic a particular clinical work environment [16,22,26].

The development of the SG required a close collaboration with domain experts [22,27]. The development team consisted of a doctoral student and four Bachelor of Multimedia Technology and Design students. The development team collaborated with a RN practicing home health care, lecturers from the Bachelor of Nursing program, and a physician from a local hospital for quality assurance of the SG content.

In addition to the interdisciplinary collaboration with professionals within the university and from clinical practice, the development of the SG involved different considerations,

processes, and technologies, which will be described in the following sections.

2.1.1. Target users

The target users of the SG were second-year Bachelor of Nursing students. Because the content and objectives of the SG needed to fit the users' knowledge and experience [2,17,22], the syllabus was examined to determine their current expected level of competencies in anatomy, physiology, and subjects in medical treatment and nursing. Based on their level of use of computers and e-learning, we concluded that the nursing students' information and communications technology (ICT) skills were average or above average.

2.1.2. Educational content

In our study, the learning objectives of the SG were to increase nursing students' perception and confidence in clinical situations, to promote their systematic assessment of patients as well as choose appropriate actions in specific situations. In accordance with the clinical decision-making model proposed by O'Neill et al. [28], the intention of the SG was to provide nursing students with a learning environment that promoted situated cognition and fostered experiential learning.

The SG prototype provided a video based simulated scenario set in a home healthcare clinical practice. The scenario was based on an RN's visit to a patient who was recently diagnosed with COPD. Information about the patient, cues about his condition, and different quiz-based tasks or questions were provided during the scenario. For example, users needed to provide the patient with information about his diagnosis, treatment, and exacerbation prevention. In addition, the user needed to respond to a situation in which the patient developed a noninfectious exacerbation of his COPD. Tasks and questions were based on evidence-based knowledge and the Bachelor of Nursing curriculum [29,30], and the formulation of questions was guided by Bloom's taxonomy of educational objectives [31].

Bloom's Taxonomy categorizes learning into the domains of cognitive knowledge, psychomotor skills, and attitude. The cognitive domain consists of six major categories: knowledge, comprehension, application, analysis, synthesis, and evaluation [31]. To promote the development of clinical reasoning and decision-making skills, tasks and questions were formulated to encourage students to apply, analyze and synthesize knowledge based on cues in the scenarios.

2.1.3. User–computer interface design

To ensure a user-centered SG prototype design, we employed a unified framework of usability called TURF (Task, Users, Representation, and Function) [32]. In TURF, usability is referred to as "how useful, usable, and satisfying a system is for the intended users to accomplish goals in the work domain by performing certain sequences of tasks" [32]. This framework was developed for the healthcare environment and is often the underpinning framework for ensuring good usability within the design. Furthermore, it is often a method for usability evaluation. The TURF framework was used as a foundation when designing the different components (gameplay and rules, challenges, interaction, and objectives) of the SG described below.

The SG gameplay [22,27] was designed for users to take part in a home healthcare RN's home visit to a patient. For increased fidelity, filmed video clips were used as the graphical basis, using a female RN and a person with COPD as actors. The intention was for a user to identify with the nurse [33]. The users interacted with the SG by watching a video based scenario (visual/audio) and by using a mouse or touchpad (physical) to solve different quiz-based tasks or questions in the scenario [22,27,34]. Tasks and questions that fit the target user were employed to challenge and engage the user [22,33,34] and meet the SG learning objectives [2,22,26]. Variation in the types of questions (single or multiple answer and drag-and-drop questions) were employed to increase immersion [33]. The rules of the SG [22,27]

were that users were allowed only one attempt for each task or question, and they needed to solve each task before they could continue with the scenario. The SG was linear; users did not have the autonomy to direct the RN and change paths based on their choices. Users were not able to harm the patient as a consequence of their poor choices.

Through their answers, the users dictated the actions for the RN character. When the users submitted their answer(s), the RN in the SG scenario provided feedback by demonstrating the proper things to do and/or say. In addition, users were able to view the correct answers through a link. Users received points for each correct answer, which were summarized and provided as a final score at the end of the scenario. The embedded assessment and feedback in the SG provided informed teaching and active, instructional learning [33]. A tutorial was provided before users started playing the SG to give them the necessary instructions about how to play the SG [34].

2.1.4. Technology

The Bachelor of Multimedia Technology and Design students provided the necessary equipment and technical solutions to create the SG, such as video cameras and microphones. Adobe Captivate 8, Adobe Premiere Pro CC, and Adobe Photoshop CS6 (Adobe Systems Incorporated, San Jose, CA, USA) were the development software programs used in this project. HTML5 (World Wide Web Consortium, Cambridge, MA, USA) was used for programming and uploading to an Internet address. An Internet address was used to avoid limiting students' access through the nursing course's online-learning platform, which made the tool available to collaborative institutions and universities and to RNs working in clinical practice. The SG was made available on several platforms, including personal computers, laptops, and the newest tablets.

2.2. Prototype development

The scenario was video recorded in an apartment at a nursing home facility. A home healthcare RN and a person with COPD participated as actors in the SG. As suggested by Kaczmarczyk et al. [35] and Olsen et al. [17], a storyboard that contained numbered descriptions of each video and questions with correct answers was used as a manuscript. In addition, the actors were asked to improvise if needed.

The video clips and questions were assembled, and the necessary information and instruction of use were integrated. The SG was named “Jeg får ikke puste” (I cannot breathe). As suggested by Olsen et al. [17], the development process included repeated testing of the prototype prior to the usability evaluation. Screenshots of the SG prototype are presented in Figs. 1-3 with permission from the actors.

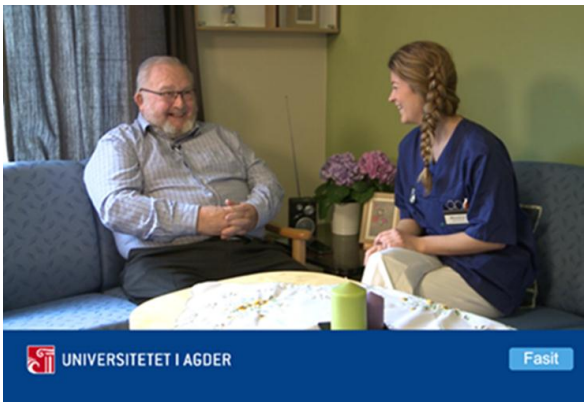

Fig. 1. Screenshot of the home healthcare setting in the SG scenario.

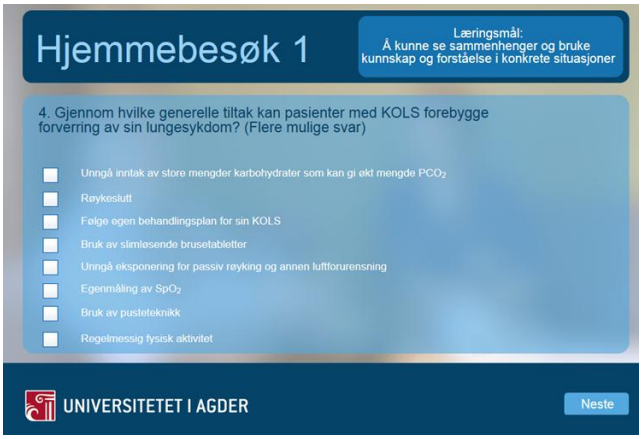

Fig. 2. Screenshot of the multiple-choice question about how the patient can prevent the

deterioration of his COPD. The learning objectives are presented in the upper-right corner.

Fig. 3. Screenshot of the RN explaining the right answers, which is overlaid by a transparency showing the correct answers when the user presses the "Fasit" button to pause the scenario.

2.3. Usability evaluation

2.3.1. Methods

The usability evaluation for the SG prototype involved both in-game and postgame assessment [36] and included the following methods: cognitive walkthrough evaluations, observations, a posttest usability questionnaire, and a follow-up interview with each participant.

The cognitive walkthrough method is used to explore how users interact with an interface, identify where and why problems occur, and suggest areas for improvement [21]. During the usability evaluation, the participants were instructed to vocalize their thoughts when they were having difficulty and had questions or comments while interacting with the game. Users' interactions with the game were recorded using written notes, audio, and video recording [17,18,21].

The survey instrument was developed based on 12 questions from the validated Post-Study System Usability Questionnaire (PSSUQ), which is a research instrument developed for use in scenario-based usability evaluations [37]. The TURF framework and research on the

usability assessment of SGs were used to add and modify questions. The final questionnaire contained 20 questions. A seven-point Likert scale, ranging from strongly disagree (1) to strongly agree (7), was used. Two questions had negative wording [38]. The survey instrument was pretested [38] with four colleagues from health and social science departments.

A semi-structured interview guide for the follow-up interview was developed to evaluate user satisfaction and possible recommendations for improvements. Questions asked were: 1) "What did you like best about the system?" 2) "What did you like least about the system?" 3) "Can you recommend any changes to improve this system?" 4) "Would you recommend this way of learning to others?" and 5) "Any other comments?"

2.3.2. Recruitment

To assess all the components of TURF (task, user, representation and function) in the usability evaluation, a convenience sample of six participants was recruited: two third-year nursing students, two university lecturers from the Bachelor of Nursing program, and two RNs from home healthcare settings. Teachers and nurses were included because they could also be potential users and could identify possible flaws concerning the quiz-based tasks, the difficulty levels of the tasks, and the alignment with curricula and clinical practice. According to Lazar et al. [21], six participants is an acceptable sample in usability evaluations, as long as the aim is to identify usability issues and improve a prototype.

2.3.3. Location and recording of data

The usability evaluation was conducted in a usability laboratory. The evaluation facility contained a test room and an observation room, with a one-way mirror between the rooms. There was a laptop for task performance on a desk in the test room and two video cameras for recording the test. There were four computer screens in the observation room to follow the

process in the test room. Two cameras in the test room recorded the audio and video of the participant and the computer screen, respectively, during the usability evaluation. In addition, all activities on the test computer screen were recorded. To enable participants to comment on survey questions and note possible flaws or ideas for improvement on the SG, the survey and interview were conducted in the test room after the usability evaluation was finished.

2.3.4. Evaluation team

The doctoral student acted as the test leader and moderator in the test room. In case of technical issues during the SG evaluation, one of the four bachelor ICT students was present in the test room. The three other bachelor ICT students were responsible for starting and ending the recordings as they followed the test session through the window and computer screens in the observation room. A technician was available if technical problems occurred.

2.3.5. Procedure

As suggested by Olsen et al. [17], a pretest of the procedure was conducted before the actual usability evaluation. The pretest was conducted to test the equipment and the final pilot version of the SG and to practice the different roles in the usability evaluation.

Before the usability evaluation sessions started, each participant was asked to sign written informed consent. Next, the moderator gave a brief introduction to the content of the SG to participants before their cognitive walkthrough evaluation began. The following instructions were given: interact with the prototype, try to understand how to use the game without receiving any explanation, and vocalize your thoughts, feelings, and opinions about any aspect of the game [21]. The participants were informed that they could receive help from the moderator or technician if they encountered problems or could not manage to go further in the SG. Following the cognitive walkthrough usability evaluation, the participants were asked to complete the survey questionnaire and were interviewed.

Verbal data from both video and audio recordings were transcribed. A coding form [21] was employed during transcription of the videos to take notes on actions and issues related to the different tasks/questions presented during the scenario, such as the time to complete the scenario, the time to complete the different questions, and the number of errors made. These were recorded to identify questions that were perceived as difficult or complex or caused errors.

2.3.6. Analysis

Data from the usability sessions were analyzed using qualitative deductive content analysis [38]. The transcribed data were imported into QSR NVivo 10 (QSR International, Burlington, MA, USA). The text was reviewed and categorized into the different elements of the TURF framework and related Nielsen–Shneiderman usability heuristics [32]. To ensure consistency and reliability, the first author (moderator) conducted the usability evaluations, transcription, and analysis. However, the results from the analysis were reviewed and discussed within the research team.

2.3.7. Ethical considerations

The actors in the SG scenario signed an informed consent that indicated that the videos could be used for educational purposes within and outside the university. The SG was designed and developed in an ethical manner with regard to patient–healthcare professional interaction and how the actors appeared in the scenario [39]. Because the RN in the scenario was considered a potential role model, she did not demonstrate any incorrect responses in the scenario.

The participants in the usability evaluation received oral and written information about the usability evaluation with the assurance of confidentiality, and they signed an informed consent. Approval for the study was obtained from the Norwegian Social Science Data

Service (no. 38298).

3. Results

The results from the cognitive walkthrough, survey, and interviews are presented according to the components of TURF [32]: "task" indicated whether the users perceived the system as easy to learn, easy to use, and error tolerant; "users" showed whether the users perceived the system as useful, usable, and satisfying; "representation" showed whether the users perceived the formats of representation of the system as usable; and "function" represented the system's fit with a specific work domain and intended users [32]. The perceived representation or user–computer interface will be presented according to the following TURF-related usability heuristics [32]: consistency, visibility, match, minimalism, memory, feedback, flexibility, message, error, closure, undo, language, control, and document.

3.1. Tasks

The time to complete the scenario was between 27 and 40 minutes, with an average time of 32 minutes. However, as shown in Table 1, most participants agreed that they were able to efficiently complete the tasks and scenarios using this system (median = 6) and disagreed that it was difficult to learn to use the SG (median = 1).

Table 1 Responses to usability scale statements (n = 6).

Statements:	Median	(Range)
1. It was simple to use this system.	6	(6–7)
2. I was able to efficiently complete the tasks and scenarios using this system.	6	(5–7)
3. I felt comfortable using this system.	6.5	(5–7)

4. It was difficult to learn to use the system.	1	(1–6)
5. The information (such as online help, on-screen messages, and other documentation) provided with this system was clear.	5.5	(4–6)
6. It was easy to find the information I needed.	6	(3–7)
7. The information provided for the system was easy to understand.	6	(6)
8. The information was effective in helping me to complete the tasks and scenarios.	6	(6–7)
9. The organization of information on the system screens was clear.*	6	(3–6)
10. The interface of this system was pleasant.	7	(6–7)
11. This system has all of the functions and capabilities I expected it to have.	5.5	(3–7)
12. The sequence/flow of the tasks in the scenarios was appropriate.	7	(6–7)
13. The system provided informative feedback during the scenarios.*	6	(3–7)
14. The healthcare-related concepts provided in the system were easy to understand.	5.5	(5–7)
15. The learning objectives in the scenarios were difficult to understand.	2	(1–3)
16. The tasks presented in the scenarios were clinically relevant.	7	(6–7)
17. The tasks in the scenarios had an adequate level	6.5	(6–7)

of complexity.		
18. Overall, I am satisfied with this system.	6	(5–7)
19. Overall, I find the content of the system relevant for use in nursing education.	7	(6–7)
20. Overall, I find the content of the system relevant for use in healthcare organizations.	7	(6–7)

Scoring was based on a seven-point Likert scale from 1 = strongly disagree to 7 = strongly agree. *n = 5.

Three of the participants had some trouble knowing how to start the scenario. All participants perceived the drag-and-drop task about COPD medication to be too difficult and verbose. These findings were supported by the time it took to complete this task and the number of errors made by the participants. Five of the six participants did not notice a message at the bottom of the page stating they had only one attempt at the drag-and-drop tasks and could not alter their choices. Consequently, some participants became a bit frustrated and gave up trying to complete this task. However, one of the student participants stated that this question motivated her to learn more about these medications.

Five of the six participants did not notice the two buttons visible at the bottom of the page: one button link was for viewing the correct answers, and the other was for viewing values for measures conducted by the RN, such as pulse and respiration frequency. Consequently, the agreement among the survey participants (Table 1) varied according to whether the organization of information on the system screens was clear (median = 5.5, range = 4-6), and whether it was easy to find the information they needed (median = 6, range = 3-7). Most participants eventually noticed the buttons because they were asked to view the measured values to judge the patient's condition. One of the participants said: "*It*

was very straightforward and simple to use the buttons when I became aware of them." Two participants stated that even if they did not notice the button for viewing the correct answers, they felt they received the correct answers through the RN's demonstration in the scenario.

During the usability test, three of the six participants commented that they would like to be able to view their answers to evaluate what was right or wrong. The lack of functionality for receiving informative feedback about both correct and incorrect answers was also reflected in the survey responses.

Some participants felt that several of the answers on tasks concerning observations or interventions could be correct, even if they were not among the correct answers. Two participants said: *"If measuring his blood pressure would not cause harm, I would have done that."*

3.2. Users

From the results in the survey, five participants judged their computer skills as average and one as above average compared with other students/colleagues. Four out of six had experience with e-learning resources from the field of nursing. Only one had experience with a similar e-learning resource. Based on their experience with computers and e-learning, most participants agreed that the SG was simple (median = 6) and comfortable (median = 6) to use (Table 1). Overall, most participants (median = 6) agreed that they were satisfied with the SG. One participant perceived the variation in types of tasks/questions (multiple-choice questions and drag-and-drop tasks) as motivating. Both teacher participants thought this SG was an effective way of teaching students about caring for patients with COPD. However, one of the teacher participants found the game somewhat tedious and suggested that the scenario could be more "*to the point.*"

Neither of the two student participants had experience with caring for patients with COPD in home health care during clinical placement in the Bachelor of Nursing program.

Both student participants stated that it would have been useful for them to play this SG before attending clinical placement in home health care. One of the students stated that it was useful to learn through the observation of situations in practice instead of just reading books about it. In correlation with the student participants, the teacher participants thought it would be useful for nursing students to watch the communication between a patient and an RN in real situations and that the scenario presented relevant issues regarding patients with COPD that could help prepare students for clinical practice. The teacher participants thought this SG could be a good supplement to training in laboratory and clinical settings. All participants agreed that they would recommend this way of learning to others.

3.3. Representation

The results from the survey regarding the perceived user–computer interface, the sequence/flow of tasks, the organization/provision of information, and feedback in the SG is provided in Table 1. Usability issues identified during the usability evaluation and interviews are presented according to the TURF-related usability heuristics [32] in Table 2.

Table 2 Usability heuristics and issues identified during usability evaluation and interviews.*

Consistency and minimalism	Some specific screens (i.e., the screen about medications and interventions) were perceived to have too much information, and the text sometimes was a bit small.
Visibility and documentation	One participant proposed choosing another color for the buttons and messages at the bottom of the screen so they would be more visible and catch the users' attention more easily. One participant stated that *"there should be a demonstration in the Introduction on how to use the buttons for viewing correct*

	answers and measures."
Match	Two cases of mismatch between tasks or questions and the scenario were noted. The patient was prescribed only three of the six medications in the presented task, and the temperature in one case was improperly taken because the nurse merely placed a hand on the patient's forehead.
Memory	Five of the participants had trouble remembering what they had read in the Introduction about the ability to view measures and correct answers during the scenario. Furthermore, two participants had trouble remembering what they had answered in some of the questions about observations and interventions because of the large amount of possible answers.
Feedback and closure	One participant reported that she missed an explanation from the nurse on what she was going to do and why. Another participant wished for an explanation on why the correct answers were more correct than others. Participants' need to view their own answers varied. One stated that she needed to see her own answers to be able to learn from them. Another participant stated that she would prefer to view the correct answers without being reminded of her own mistakes. Three of the participants proposed showing correct and wrong answers with green and red marks on the screen.
Flexibility, undo, and control	Some participants wished for the ability to solve the same task or question several times, go back to review their answers, and pause or move forward in the scenario.

Message and error	Only one of the participants noticed the message on the bottom of the screen saying that they could not undo their answer.
Language	Five of the participants misinterpreted the first question in the scenario. One of the participants stated: *"The abbreviation of medication names was confusing because I have never used them before."* One of the participants said she had trouble understanding one of the questions because she was not Norwegian.

*Based on Nielsen–Shneiderman usability heuristics [32].

3.4. Function

According to the survey response (Table 1), all participants (median = 7) found the content of the SG relevant for use in nursing education and healthcare organizations and that tasks or questions presented in the scenarios were clinically relevant. The participants also agreed that the tasks/questions in the scenarios had an adequate level of complexity for the intended users (median = 6.5) and disagreed that the learning objectives were difficult to understand (median = 2). This was also expressed during the interviews. In addition, participants expressed that this was a realistic scenario from the domain of home health care and that many important principles regarding care for patients with COPD were present. One of the teacher participants suggested that the SG could serve as a nursing student entrance test before clinical placement in home health care when further developed.

4. Discussion

4.1. Participants' perception of the SG

The participants perceived the clinical scenario in the SG as realistic. Overall, the content in the SG was perceived as clinically relevant for both students and healthcare personnel. The SG was perceived as useful, usable, and satisfying. However, usability issues were identified.

The use of video based scenarios with an RN and a person with COPD as actors contributed to creating a realistic scenario. Despite correlating evidence of positive experiences with simulations using standardized patients in nursing and medical education [40,41], a review of Internet-based simulations showed that video based scenarios have been used less than virtual simulations and that professional actors have most often been used to play patients in previous video based scenarios [16]. Simulated scenarios are also perceived to lack nurse caring aspects [42] because they often focus on teaching acute nursing care [43-45]. On the contrary, the participants in our study perceived that the video based SG managed to demonstrate the caring relationship between the RN and her patient and contributed to immersion.

In addition to providing realistic situations from clinical practice, the content of SGs needs to correspond with course material and learning objectives [33]. The student participants stated that they perceived the content in the SG to be clinically relevant and that it would have been useful to play the SG before attending clinical placement in home health care. Statements such as these correspond with evidence that the use of simulation training in home healthcare visits increased students' confidence to complete home visits [46,47].

To be able to teach clinical reasoning skills to nursing students, an SG should focus on enabling nursing students to develop the ability to understand the nature of a situation by detecting relevant cues and to take the appropriate action at the right time for the right reason [1,6,28]. Consequently, the SG scenario and the correct answers in the quiz-based tasks or questions were designed to comply with the appropriate actions to take in the particular

situations in the scenario. For example, measuring the patient's blood pressure was not the most important assessment at an early point during the scenario and was therefore not among the correct answers. As described earlier, this correspondence between specific situations and correct answers was perceived as challenging by some participants. This result indicates that more feedback should be incorporated in the SG to explain why some actions were more essential and therefore more correct than others.

Another question in developing SGs for nursing education is whether the SG should provide users with the ability to choose incorrect answers deliberately and view the consequences of their choice. Some SGs provide this ability [35,48], while others [34] argue against it. As the RN in this SG plays herself and acts as a role model in the scenario, it would be unethical to request the RN to demonstrate the incorrect answers or to let the patient die.

An SG should provide sufficient feedback within the game [33]. As in the study by Kaczmarczyk et al. [35], some participants wished for more feedback. Some participants wished for an explanation of why some answers were "more right" than others and wanted the ability to view both correct and incorrect answers. One important limitation of computer-based simulations compared with classroom simulations is the lack of debriefing after students have finished the scenario. Debriefing has been shown to be an essential component in simulation [49,50]. To meet nursing students' need for in-game and/or endgame feedback in SGs, an alternative way to play the SGs could be in groups with a teacher present or providing debriefing after the participants complete the game.

Several usability issues were identified in the SG concerning functionality and user–computer interaction. Similar to other studies, our usability evaluation revealed issues with the length of the videos, complex tasks, the lack of ability to skip back and forth in the scenarios [18,35], color schemes, layout, and wording [18]. Similar to the case in Kaczmarczyk et al. [35], our SG had some technical glitches. These technical issues may have

been attributed to the project's low-budget development, where Bachelor of Multimedia Technology and Design students used Adobe Captivate 8, which did not provide all of the functionalities we had planned in the SG design. Consequently, the students had to make appropriate adjustments to the current version of Adobe Captivate 8. This caused some of the usability and technical issues identified in the usability evaluation. For example, participants could not undo drag-and-drop tasks or go back and view their answers, and the SG was not compatible with a Sharable Content Object Reference Model (SCORM). To be SCORM-compatible, the SG has to have the ability to be uploaded directly in a learning management system and to communicate with this system without modifications. Despite these technical issues, participants were still able to complete their assigned tasks successfully.

Improvements in the SG design were conducted based on usability issues identified during the usability evaluation [18] and what was possible within the scripted version of the Adobe Captivate 8 software. Based on lessons learned from this project and the theory employed in the study, Table 3 shows the considerations that should be employed in the SG design process.

Table 3 Usability principles to consider in SG design.*

Consistency/ Minimalism	There should be consistency throughout the SG concerning the font/capitalization, color/layout, and positioning. Avoid elements that distract or cause slowdown, such as too much text, too many features, and long and/or complex questions. Variation in the types of tasks and questions (single or multiple answers and drag-and-drop tasks) may increase perceived immersion as long as they comply with the above principles. Avoid scenarios that are too long because they can decrease perceived immersion.
Visibility/	Information/documentation, such as how to play the SG, possibilities of

Documentation	action, and how to use the different features on the screen should be provided and/or visible on the screen. The SG should be instinctive to use. Colors used on text and screens may influence visibility.
Match	There should be a match between the content of the SG and the real world. Avoid irrelevant information. All answers in the quiz-based tasks or questions should connect to the question and be plausible answers.
Memory	Avoid the need for users to memorize a lot of information about how to play the SG or information related to the story in the SG.
Feedback/ Closure	Both in-game and endgame feedback should be provided about users' actions and performance. Consider the need for debriefing.
Flexibility/ Control/Undo	Consider providing the ability to move back and forth in the SG, pause the game, undo answers, view own answers, and view both right and wrong answers in red and green. Consider the ability to enter wrong answers and view the consequences in the SG.
Error/Message	Prevent errors in the SGs during design. Provide messages/alerts on the screen about possible errors and how to recover from these errors.
Language	Provide clear language and concepts understandable for the intended users.

* Based on Nielsen–Shneiderman usability heuristics [32]

4.2. Methodological considerations and limitations

The results show that it is an advantage to combine different approaches such as theory in human–computer interaction, decision-making, and learning theory in SG design and evaluation. The different approaches employed correspond with the "four-dimensional framework" approach (learner specification, context, mode of representation, and pedagogic considerations) proposed by de Freitas and Liarokapis [19] for the development of

educational games and simulation. However, as suggested by Thompson and Stapley [51], we employed decision theory alongside pedagogical approaches. In addition, we employed a user–computer interaction design framework. The combination of the different approaches enabled us to design a usable, useful, and satisfying SG and to provide educational content and objectives for future measures of effectiveness of the SG. In accordance with Kato [52] and Vivekananda-Schmidt [39], we also found it advantageous that the researchers were involved in the processes of design, development, and usability evaluation of the SG.

As proposed by Olsen et al. [17] and Mayer et al. [36], a mixed-method approach was used in the usability evaluation of the SG prototype. The use of a mixed-method design provided comprehensive information about how the users perceived the SG and enabled us to identify possible improvements. However, widely used usability instruments valid for management tools and applications fall short when applied to SG applications [17,18]. In accordance with Fossum et al. [53] and Fruhling and Lee [54], we found questions from the PSSUQ instrument to be highly relevant in the usability assessment of the SG. Our survey instrument (questionnaire) was validated through pretesting on four colleagues from different disciplines within the health and social science departments. This resulted in rephrasing of difficult words such as “interface” and removing two questions that were too detailed. Three questions about positioning and experience with computers and e-learning resources were added.

Instead of summarizing the number of appearances of the predefined system and user event categories proposed by Moreno-Ger et al. [18] for the usability evaluation of SGs, we chose to employ well-established usability principles used in the heuristic evaluation [55]. The researchers found it useful to employ the Nielsen–Shneiderman heuristics [32,56] in the analysis of the data from the usability evaluation. However, some of the heuristics were perceived to be similar and overlapping, such as the heuristics “consistency” and

"minimalism" in regard to the graphical user interface and "flexibility," "undo," and "control" in regard to user options within the SG. The researchers also found the heuristic "feedback" difficult to separate from the other heuristics because it could have included participants going back to review their own answers.

A possible limitation of this study is that most participants had experience with other e-learning resources, which may have influenced their evaluation of the functionality of the SG. However, in accordance with findings of other studies [35,57,58], the participants perceived the interactive game-based learning resource as a good supplement to traditional learning methods.

4.3. Implications of results for SG design and clinical practice

The reported challenges that impact the ability to provide clinical teaching in current nursing education include limits in the resources and capacity of laboratory-based simulations; a lack of clinical placements; restrictions on the number of students placed in units; and clinical teaching of long-distance students [10]. SGs are computer-based simulations that allow healthcare professionals to experience situations that can be difficult to achieve in reality without compromising patient care or patient safety. In addition, SGs provide active, experiential, situated, and problem-based learning [13]. As the SG in this project proposes a method of enhancing nursing students' clinical reasoning, decision-making skills and evidence-based knowledge, it informs the discussion on how to improve nursing education and especially the transition of nursing students from training to practice [3,8,9]. Furthermore, as this SG is developed in collaboration with professionals from home healthcare services, it may contribute to improving the match between RNs' education and the realities of clinical practice [8].

This project shows that useful, usable, and satisfying SGs can be developed at a low cost by a multidisciplinary in-house team in collaboration with clinical practice. However,

technical solutions are important features to consider when developing SGs [22,34]. For example, it is important to choose design software that fits with the planned quiz-based tasks and questions and user–computer interaction. However, currently, there are few development tools (game engines and frameworks) designed specifically for SG development [59]. This has implications for the further exploration of potential design software appropriate for SG design.

5. Conclusion

The SG was perceived by the study participants as being useful, usable, and satisfying. They proposed that the SG could serve as a supplementary tool to traditional training in laboratory and clinical settings. Using video based scenarios with an authentic COPD patient and a home healthcare registered nurse as actors contributed to increased realism. In addition, using different theoretical approaches in the SG design was considered an advantage of the design process. The achievement of the desired functionality and the minimization of user–computer interface issues emphasizes the importance of conducting a usability evaluation during the SG development process. Further research will focus on the assessment of nursing students' perception of the face, content and construct validity of the SG prototype and their preferences for using this type of e-learning resource in nursing education.

The contribution of this paper is twofold: 1) it describes the development of an SG for nursing education in the domain of home health care, and 2) it provides a description of the development and evaluation process that may serve as a guide for others to develop more SGs to fit current educational program needs.

Acknowledgements

We would like to give a special thanks to associate professor Morgan Konnestad, assistant professor Halvard Øysæd, assistant professor Rune Andersen, and Svein Even Skogen, Daniel Møller-Stray, Christina Terese Lien and Elise Birgitsdatter Haugland, all four bachelor students, who made the development of the SG possible. In addition, we would like to thank the people who contributed as consultants and actors in the development of the SG and the participants in the usability evaluation. We would also like to thank the providers of the usability laboratory for all their support related to the usability evaluation of the SG, associate professor and usability specialist Santiago Martinez and PhD student Berglind Smaradottir.

The research project was financial supported by the Norwegian Nurse Association. However, the funding source had no role in the design or conduct of the study or preparation and approval of the paper.

Statement on conflict of interest

Conflict of interests: none

Authors' Contributions

All authors participated in the design of the study, analysis and interpretation of data. HMJ drafted the article and collected the data. All authors contributed intellectually, reviewed and revised the drafted article, and approved the final version of the article.

References

[1] T. Levett-Jones, K. Hoffman, J. Dempsey, S.Y.-S. Jeong, D. Noble, C.A. Norton, J. Roche, N. Hickey, The 'five rights' of clinical reasoning: An educational model to enhance nursing students' ability to identify and manage clinically 'at risk' patients, Nurse Educ. Today, 30 (2010) 515-520, doi:http://dx.doi.org/10.1016/j.nedt.2009.10.020

[2] K. Hoffman, J. Dempsey, T. Levett-Jones, D. Noble, N. Hickey, S. Jeong, S. Hunter, C. Norton, The design and implementation of an Interactive Computerised Decision Support Framework (ICDSF) as a strategy to improve nursing students' clinical reasoning skills, Nurse Educ. Today, 31 (2011) 587-594, doi:http://dx.doi.org/10.1016/j.nedt.2010.10.012

[3] Ministry of Health & Care Services, White Paper No. 47 (2008-2009), The Coordination Reform [Samhandlingsreformen: Rett behandling - på rett sted - tilrett tid], Ministry of Health & Care Services [Helse- og omsorgsdepartementet], Oslo, 2009.

[4] Ministry of Health & Care Services, White Paper No. 29 (2012-2013), Future Care [Morgendagens omsorg], Ministry of Health & Care Services [Helse- og omsorgsdepartementet], Oslo, 2013.

[5] WHO, Chronic obstructive pulmonary disease (COPD). http://www.who.int/respiratory/copd/en/, 2015 (accessed 18.02.16)

[6] P. Benner, M. Sutphen, V. Leonard, L. Day, Educating nurses: A Call for Radical Transformation, Jossey-Bass, San Francisco, Calif, 2010.

[7] J. Higgs, M.A. Jones, Clinical decision making and multiple problem spaces, in: J. Higgs, M.A. Jones, S. Loftus, N. Christensen (Eds.), Clinical Reasoning in the Health Professions, Butterworth Heinemann ELSEVIER, UK, 2008, pp. 3-17.

[8] WHO, Transforming and scaling up health professionals´ training: WHO Education Guidelines 2013, http://apps.who.int/iris/bitstream/10665/93635/1/9789241506502_eng.pdf, 2013 (accessed 18.02.16).

[9] Ministry of Education & Research, White Paper No.13 (2011-2012), Education for Welfare: Interaction as Key [Utdanning for velferd: Samspill i praksis], Ministry of Education & Research [Kunnskapsdepartementet], Oslo, 2012.

[10] K.B. Gaberson, M.H. Oermann, T. Shellenbarger, Clinical Teaching Strategies in Nursing, Springer, New York, 2014.

[11] C. Girard, J. Ecalle, A. Magnan, Serious games as new educational tools: how effective are they? A meta-analysis of recent studies, J. Comput. Assist. Learn., 29 (2013) 207-219, doi:10.1111/j.1365-2729.2012.00489.x

[12] M. Ma, L.C. Jain, P. Anderson, Future Trends of Virtual, Augmented Reality, and Games for Health, in: M. Ma, L.C. Jain, P. Anderson (Eds.) Virtual, Augmented Reality and Serious Games for Healthcare 1, Springer, UK, 2014, pp. 1-6.

[13] T.M. Connolly, E.A. Boyle, E. MacArthur, T. Hainey, J.M. Boyle, A systematic literature review of empirical evidence on computer games and serious games, Comput. Educ., 59 (2012) 661-686, doi:http://dx.doi.org/10.1016/j.compedu.2012.03.004

[14] S.de Ribaupierre, B. Kapralos, F. Haji, E. Stroulia, A. Dubrowski, R. Eagleson, Healthcare Training Enhancement Through Virtual Reality and Serious Games, in: M. Ma, L.C. Jain, P. Anderson (Eds.) Virtual, Augmented Reality and Serious Games for Healthcare 1, Springer, UK, 2014, pp. 9-27.

[15] F. Ricciardi, L.T. De Paolis, A Comprehensive Review of Serious Games in Health Professions, International Journal of Computer Games Technology, (2014) 1-11, doi:http://dx.doi.org/10.1155/2014/787968

[16] R.P. Cant, S.J. Cooper, Simulation in the Internet age: The place of Web-based simulation in nursing education. An integrative review, Nurse Educ. Today, 34 (2014) 1435-1442, doi:http://dx.doi.org/10.1016/j.nedt.2014.08.001

[17] T. Olsen, K. Procci, C. Bowers, Serious Games Usability Testing: How to Ensure Proper Usability, Playability, and Effectiveness, in: A. Marcus (Ed.) Design, User Experience, and Usability. Theory, Methods, Tools and Practice Springer, 2011, pp. 625-634, doi: http://dx.doi.org/10.1007/978-3-642-21708-1_70

[18] P. Moreno-Ger, J. Torrente, Y.G. Hsieh, W.T. Lester, Usability testing for serious games: Making informed design decisions with user data, Advances in Human-Computer Interaction, (2012) 1-13, doi:http://dx.doi.org/10.1155/2012/369637

[19] S. de Freitas, F. Liarokapis, Serious Games: A New Paradigm for Education, in: M. Ma, A. Oikonomou, L.C. Jain (Eds.) Serious Games and Edutainment Applications, Springer London, 2011, pp. 9-23, doi:10.1007/978-1-4471-2161-9_2

[20] P. Stuckless, M. Hogan, B. Kapralos, Virtual Simulations and Serious Games in Community Health Nursing Education: A Review of the Literature, in: M. Ma, L.C. Jain, P. Anderson (Eds.) Virtual, Augmented reality and Serious Games for Healthcare 1, Springer, UK, 2014, pp. 145-158.

[21] J. Lazar, J.H. Feng, H. Hochheiser, Research Methods in Human-Computer Interaction, John Wiley & Sons, UK, 2010.

[22] V. Wattanasoontorn, I. Boada, R. García, M. Sbert, Serious games for health, Entertain. Comput., 4 (2013) 231-247, doi:http://dx.doi.org/10.1016/j.entcom.2013.09.002

[23] C. Foronda, L. Godsall, J. Trybulski, Virtual Clinical Simulation: The State of the Science, Clinical Simulation in Nursing, 9 (2013) e279-e286, doi:http://dx.doi.org/10.1016/j.ecns.2012.05.005

[24] M. Hogan, B. Kapralos, S. Cristancho, K. Finney, A. Dubrowski, Bringing community health nursing education to life with serious games, Int. J. Nurs. Educ. Scholarsh., 8 (2011), 1-8, doi:http://dx.doi.org/10.2202/1548-923X.2072

[25] I. Popil, D. Dillard-Thompson, A Game-Based Strategy for the Staff Development of Home Health Care Nurses, The Journal of Continuing Education in Nursing, 46 (2015) 205-207, doi:http://dx.doi.org/10.3928/00220124-20150420-14

[26] O.J. Petit dit Dariel, T. Raby, F. Ravaut, M. Rothan-Tondeur, Developing the Serious Games potential in nursing education, Nurse Educ. Today, 33 (2013) 1569-1575, doi:http://dx.doi.org/10.1016/j.nedt.2012.12.014

[27] A.F.S. Barbosa, P.N.M. Pereira, J.A.F.F. Dias, F.G.M. Silva, A New Methodology of Design and Development of Serious Games, International Journal of Computer Games Technology, 2014 (2014) 1-8, doi:10.1155/2014/817167

[28] E.S. O'Neill, N.M. Dluhy, E. Chin, Modelling novice clinical reasoning for a computerized decision support system, J. Adv. Nurs., 49 (2005) 68-77, doi:http://dx.doi.org/10.1111/j.1365-2648.2004.03265.x

[29] The Norwegian Dictorate of Health, COPD: National guideline [KOLS: Nasjonal faglig retningslinje og veileder for forebygging, diagnostisering og oppfølging av personer med kols], The Norwegian Dictorate of Health [Helsedirektoratet], Oslo, 2012.

[30] H. Almås, J. Bakkelund, B.H. Thorsen, A. Dichmann Storknæs, Sykepleie ved lungesykdommer [Nursing at Lung Diseases], in: H. Almås, D.-G. Stubberud, R. Grønseth, K.C. Toverud (Eds.) Klinisk sykepleie : 1, Gyldendal akademisk, Oslo, 2010, pp. 107-163.

[31] B. S. Bloom, M. D. Engelhart, E. J. Furst, W. H. Hill, D. R. Krathwohl, Taxonomy of Educational Objectives: Handbook II. Cognitive Domain, David McKay, New York, NY, 1956.

[32] J. Zhang, M.F. Walji, TURF: Toward a unified framework of EHR usability, J. Biomed. Inform., 44 (2011) 1056-1067, doi:10.1016/j.jbi.2011.08.005

[33] L.A. Annetta, The “I's” have it: A framework for serious educational game design, Rev. Gen. Psychol., 14 (2010) 105-112, doi:http://dx.doi.org/10.1037/a0018985

[34] F. Laamarti, M. Eid, A. El Saddik, An Overview of Serious Games, International Journal of Computer Games Technology, 2014 (2014) 1-15, doi:http://dx.doi.org/10.1155/2014/358152 doi:10.1155/2014/358152

[35] J. Kaczmarczyk, R. Davidson, D. Bryden, S. Haselden, P. Vivekananda-Schmidt, Learning decision making through serious games, Clin. Teach., 12 (2015) 1-6, doi:10.1111/tct.12426

[36] I. Mayer, G. Bekebrede, C. Harteveld, H. Warmelink, Q. Zhou, T. Ruijven, J. Lo, R. Kortmann, I. Wenzler, The research and evaluation of serious games: Toward a

comprehensive methodology, Br. J. Educ. Technol., 45 (2014) 502-527, doi:10.1111/bjet.12067

[37] J.R. Lewis, Psychometric evaluation of the PSSUQ using data from five years of usability studies, Int. J. Hum. Comput. Interact., 14 (2002) 463-488, doi:10.1080/10447318.2002.9669130

[38] D.F. Polit, C.T. Beck, Essentials of Nursing Research: Appraising Evidence for Nursing Practice, Wolters Kluwer/Lippincott Williams & Wilkins, Philadelphia, 2010.

[39] P. Vivekananda-Schmidt, Ethics in the Design of Serious Games for healthcare and medicine, in: S. Arnab, I. Dunwell, K. Debattista (Eds.) Serious Games for healthcare: Applications and Implications, Medical Information Science Reference, USA, 2013, pp. 91-106.

[40] M. Anderson, T.L. Holmes, J.L. LeFlore, K.A. Nelson, T. Jenkins, Standardized Patients in Educating Student Nurses: One School's Experience, Clinical Simulation in Nursing, 6 (2010) e61-e66, doi:http://dx.doi.org/10.1016/j.ecns.2009.08.001

[41] Y. Kowitlawakul, Y.L. Chow, Z.H.A. Salam, J. Ignacio, Exploring the use of standardized patients for simulation-based learning in preparing advanced practice nurses, Nurse Educ. Today, 35 (2015) 894-899, doi:http://dx.doi.org/10.1016/j.nedt.2015.03.004

[42] E. Diener, N. Hobbs, Simulating Care: Technology-Mediated Learning in Twenty-First Century Nursing Education, Nurs. Forum, 47 (2012) 34-38, doi:http://dx.doi.org/10.1111/j.1744-6198.2011.00250.x doi:10.1111/j.1744-6198.2011.00250.x

[43] F. Buttussi, T. Pellis, A. Cabas Vidani, D. Pausler, E. Carchietti, L. Chittaro, Evaluation of a 3D serious game for advanced life support retraining, Int. J. Med. Inform., 82 (2013) 798-809, doi:http://dx.doi.org/10.1016/j.ijmedinf.2013.05.007

[44] Y.S. Liaw, F.L. Wong, W.-C.S. Chan, Y.J.T. Ho, Z.S. Mordiffi, L.S.B. Ang, S.P. Goh, K.E.N. Ang, Designing and Evaluating an Interactive Multimedia Web-Based Simulation for Developing Nurses' Competencies in Acute Nursing Care: Randomized Controlled Trial, J. Med. Internet Res., 17 (2015) e5, doi:http://www.jmir.org/2015/1/e5/ doi:10.2196/jmir.3853

[45] N.F. Cook, T. McAloon, P. O'Neill, R. Beggs, Impact of a web based interactive simulation game (PULSE) on nursing students' experience and performance in life support training - A pilot study, Nurse Educ. Today, 32 (2012) 714-720 doi:http://dx.doi.org/10.1016/j.nedt.2011.09.013

[46] E.L. Richards, V. Simpson, P. Aaltonen, L. Krebs, L. Davis, Public health nursing student home visit preparation: the role of simulation in increasing confidence, Home Healthc. Nurse, 28 (2010) 631-638, doi:10.1097/NHH.0b013e3181f85e10

[47] S.T. Yeager, B. Gotwals, Incorporating High-fidelity Simulation Technology into Community Health Nursing Education, Clinical Simulation in Nursing, 6 (2010) e53-e59, doi:10.1016/j.ecns.2009.07.004

[48] J.M. Tiffany, B.A. Hoglund, Facilitating Learning Through Virtual Reality Simulation: Welcome to Nightingale Isle, in: M. Ma, L.C. Jain, P. Anderson (Eds.) Virtual, Augmented Reality and Serious Games for Healthcare 1, Springer, Berlin, Heidelberg, 2014, pp. 159-174.

[49] K.T. Dreifuerst, Using debriefing for meaningful learning to foster development of clinical reasoning in simulation, J. Nurs. Educ., 51 (2012) 326-333, doi:10.3928/01484834-20120409-02

[50] W.M. Nehring, F.R. Lashley, Nursing Simulation: A Review of the Past 40 Years, Simul. Gaming, 40 (2009) 528-552, doi:10.1177/1046878109332282

[51] C. Thompson, S. Stapley, Do educational interventions improve nurses' clinical decision making and judgement? A systematic review, Int. J. Nurs. Stud., 48 (2011) 881-893, doi:http://dx.doi.org/10.1016/j.ijnurstu.2010.12.005

[52] P.M. Kato, The Role of the Researcher in Making Serious Games for Health, in: S. Arnab, I. Dunwell, K. Debattista (Eds.) Serious Games for Healthcare: Applications and Implications, Medical Information Science Reference, USA, 2013, pp. 213-231.

[53] M. Fossum, M. Ehnfors, A. Fruhling, A. Ehrenberg, An evaluation of the usability of a computerized decision support system for nursing homes, Appl. Clin. Inform., 2 (2011) 420-436, doi:10.4338/ACI-2011-07-RA-0043

[54] A.L. Fruhling, S.M. Lee, The influence of user interface usability on rural consumers' trust of e-health services, Int. J. Electron. Healthc., 2 (2006) 305-321, doi:http://dx.doi.org/10.1504/IJEH.2006.010424

[55] M.W. Jaspers, A comparison of usability methods for testing interactive health technologies: methodological aspects and empirical evidence, Int. J. Med. Inform., 78 (2009) 340-353, doi:10.1016/j.ijmedinf.2008.10.002

[56] J. Zhang, T.R. Johnson, V.L. Patel, D.L. Paige, T. Kubose, Using usability heuristics to evaluate patient safety of medical devices, J. Biomed. Inform., 36 (2003) 23-30, doi:10.1016/S1532-0464(03)00060-1

[57] M.V. López-Pérez, M.C. Pérez-López, L. Rodríguez-Ariza, Blended learning in higher education: Students' perceptions and their relation to outcomes, Comput. Educ., 56 (2011) 818-826, doi:10.1016/j.compedu.2010.10.023

[58] S.E. Kirkley, J.R. Kirkley, Creating next generation blended learning environments using mixed reality, video games and simulations, TechTrends, 49 (2004) 42-54.

[59] B. Cowan, B. Kapralos, A Survey of Frameworks and Game Engines for Serious Game Development, Advanced Learning Technologies (ICALT), 2014 IEEE 14th International Conference on, IEEE, 2014, pp. 662-664, doi: 10.1109/ICALT.2014.194