The effectiveness of a simulation game on nursing students' self-evaluated clinical reasoning skills: A quasi-experimental study

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ABSTRACT

Good learning outcomes can be achieved in clinical reasoning using gamified simulations; however, research on the effectiveness of learning clinical reasoning skills through simulation games is still very limited. The purpose of this study is to evaluate the effectiveness of a simulation game on nursing students' clinical reasoning skills. This study uses a quasi-experimental, one group, pre-post-test design with one-week interventions that consist of playing five surgical patient scenarios in a simulation game. The data were collected at three universities of applied sciences in Finland (1.3.2018–31.5.2019). The participants (n=376) filled out the Clinical Reasoning Skills Scale before and after playing the game. Descriptive and multivariable analyses were used. Statistically significant differences were found between the background variable categories when examining gaming activity and self-evaluated clinical reasoning skills. The

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TIIVISTELMÄ

Simulaatiopelin vaikuttavuus hoitotyön opiskelijoiden kliinisiin päätöksentekotaitoihin

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Hyviä oppimistuloksia kliinisen päätöksenteon osalta on mahdollista saavuttaa käyttämällä simulaatiopelejä hoitotyön koulutuksessa. Tutkimusnäyttö simulaatiopelien vaikuttavuudesta on vielä vähäistä. Tämän tutkimuksen tarkoituksena oli arvioida simulaatiopelin vaikuttavuutta hoitotyön opiskelijoiden kliinisiin päätöksentekotaitoihin. Tutkimusasetelma oli kvasikokeellinen. Aineisto kerättiin kolmessa ammattikorkeakoulussa (1.3.2018–31.5.2019). Tutkimukseen osallistujat (n = 376) pelasivat simulaatiopeliä yhden viikon ajan ja täyttivät Clinical Reasoning Skills scale (CRSs) -mittarin ennen ja jälkeen pelaamisen. Aineisto analysoitiin monimuuttuja-analyysillä.

participants rated their clinical reasoning skills as significantly better after playing than before playing the simulation game. The evidence from this study suggests that simulation games are effective for gaining clinical reasoning skills.

Key Words: Clinical reasoning skills, simulation game, nursing students, quasi-experimental

Tulosten mukaan miehet pelasivat enemmän ei-digitaalisia ja digitaalisia pelejä kuin naiset ja sairaanhoitajaopiskelijat pelasivat enemmän ei-digitaalisia, digitaalisia pelejä sekä oppimispelejä kuin kätilöopiskelijat. Erot olivat tilastollisesti merkitseviä. Ennen simulaatiopelin pelaamista osallistujat arvioivat kliiniset päätöksentekotaidot parhaimmaksi hoidon arvioinnissa ja heikoimmaksi tavoitteiden asettamisessa. Pelaamisen jälkeen osallistujat arvioivat kliiniset päätöksentekotaidot parhaimmaksi tiedon keräämisessä ja heikoimmaksi tavoitteiden asettamisessa. Osallistujat arvioivat kliiniset päätöksentekotaidot paremmiksi pelaamisen jälkeen kuin ennen pelaamista. Ero oli tilastollisesti merkitsevä. Tulosten mukaan simulaatiopelit ovat tehokkaita kliinisten päätöksentekotaitojen oppimisessa ja niiden hyödyntämistä hoitotyön koulutuksessa voidaan suositella.

Avainsanat: Kliiniset päätöksentekotaidot, simulaatiopeli, hoitotyön opiskelijat, kvasi-kokeellinen

What is already known about the research topic?

- Simulation games provide significant learning experiences for nursing students.
- Clinical reasoning skills can be enhanced by using simulation games in nursing education.

What new information does the article bring?

- Simulation games are effective for gaining clinical reasoning skills.
- Students experienced improved skills, especially in terms of utilising the 'ABCDE' approach to assessing patients' clinical status.

What is the significance of the research for nursing, nursing education and management?

- Simulation games are recommended to be used in gaining clinical reasoning skills and in learning assessment and treatment protocols.
- Simulation games can be utilised in clinical studies in higher education, in vocational education and in continuing training.
- Simulation games can be used as a part of regular staff education within healthcare organisations for maintaining and developing clinical reasoning skills.

Introduction

Nursing students should be able to practice clinical reasoning (CR) regularly (Furze et al. 2015), and good learning outcomes in CR can be achieved by gamifying simulations (Koivisto et al. 2018). Educational games are effective methods to engage students in learning activities since such games promote concentration, interest, motivation, satisfaction and enjoyment (Hamari et al. 2016). The most used games in healthcare education are simulation games (Connolly 2012). Simulation games refer to 'artefacts (software) that replicate decision making processes in real-world situations' (Koivisto 2017). Game elements, such as goals, feedback, scores, leaderboards, rewards, and progress (Hamari et al., 2014) are utilised especially in engaging students in the learning experience. Simulation games en-

able nursing students to internalise and automate clinical protocols in order to perform them in real-life (Koivisto et al. 2017), and therefore they have been used in nursing education to learn CR (Forsberg et al. 2011; Johnsen et al. 2016). However, incorporating game elements into nursing games is still limited (Havola et al. 2020).

Overall, there seems to be some evidence to indicate that simulation games promote learning CR skills (Pittiglio et al. 2011, Georg & Zary 2014). In particular, the utilisation of previously acquired theoretical knowledge affects learning by playing (Koivisto et al. 2016a). In simulation games, the CR process (Levett-Jones et al. 2010) can be integrated into game mechanics (Koivisto et al. 2018) enabling the game to guide learners through the phases of the CR process. For example, Koivisto et al. (2016b) found that students improved in terms of collecting information about the clinical condition of the patient and taking action in patient care. However, the game did not support learning to establish goals and evaluate the effectiveness of interventions as well. Other studies have shown clear progression in students' CR abilities, ability to identify the concept of CR (Forsberg et al. 2016) and ability to make correct diagnoses and adequate clinical decisions (Forsberg et al. 2011). However, Forsberg et al. (2011) found that students were not able to explain their CR processes. Previous gaming activity is one factor that has been shown to affect learning through gaming; students who played digital games frequently, or even infrequently, learned CR more successfully than those who did not play at all (Koivisto et al. 2016b). Other factors that affect learning through gaming include the age of the learner, gaming easiness, perceived educational value and transfer of learnt skills (Zhonggen 2019).

Several studies on the use of simulation games in nursing education have been conducted, but they focus mainly on learning through gaming (Forsberg et al. 2011, Koivisto et al. 2016a) and developing games for educational purposes (Johnsen et al. 2016, Bracq et al. 2019). Research on the effectiveness of learning CR skills through simulation games is still very limited.

Purpose and research questions

The purpose of this study is to evaluate the effectiveness of a simulation game on nursing students' clinical reasoning skills.

Research questions:

1. How were nursing students' clinical reasoning skills before and after playing the simulation game?
2. What is the difference between nursing students' clinical reasoning skills before and after playing the simulation game?

Materials and Methods

Description of the simulation game

The three-dimensional (3D) simulation game used in this study consists of patient scenarios played on a computer (Koivisto et al. 2018). The simulation game was developed as part of Koivisto's (2017) doctoral dissertation and it combines game elements, simulation and learning objectives. The development of the game used participatory methodologies and user-oriented game design and thus, it was developed in collaboration with researchers, programmers, 3D artists, interface designers, nurse educators and students. The game was developed by using iterative cycles enabling end-user feedback to be considered in the development (Koivisto et al. 2018). Thus, the content and structure of the game were piloted several times. The game mechanics were built around the CR process (Levett-Jones et al. 2010). The Unity development platform was used to create the game. Gameplay is non-linear, which allows the

player to proceed with patient care based on the patient's clinical condition.

Direct patient care, including checking vital signs, is an essential part of surgical nursing work (van Oostveen et al. 2015). It is important for nursing students to learn how to synthesise and analyse facts in order to identify clinically at-risk patients using the 'Airway, Breathing, Circulation, Disability, Exposure' (ABCDE) approach (Thim et al. 2012), as well as make nursing diagnoses and select expedient courses of action (Levett-Jones et al. 2010, Soar et al. 2015). ABCDE approach refers to a systematic assessment and treatment of critically ill patients (Thim et al. 2012). Therefore, five surgical patient scenarios were used: (1) pre-operative assessment of an orthopaedic surgery patient, (2) post-operative observation (3) post-operative care after cholecystectomy, (4) blood transfusion after transurethral resection of the prostate (TURP) and (5) postoperative care of a peripheral artery bypass surgery patient. In order to ensure the validity of the content, the scenarios were developed based on the best available research evidence and clinical expertise (Jordan et al. 2016) from an expert group that consisted of a Doctor of Education, two senior lecturers holding master's degrees in nursing science and one master's degree student. The scenarios were developed by using in-game editor, and the learning goals were translated into mechanical elements of gameplay (Arnab et al. 2015, Carvalho et al. 2015).

Research design

This study uses a quasi-experimental, one group, pre-post-test design, and all of the participants participated in a one-week intervention.

Data collection

The participants (n=376) were enrolled in one of the following bachelor's degrees: nursing, nurse-deaconess, paramedic, midwifery or public health. The data were collected at three universities of applied sciences in Finland (1.3.2018–31.5.2019) using self-report electronic questionnaire in two phases: before (pre-test) and after (post-test) intervention.

The Clinical Reasoning Skills scale (CRSs) used in this study was a modified version of a previously developed scale (Koivisto et al. 2016b). The CRSs consists of seven demographic items: age, gender, educational background, study phase, work experience in social and health services, degree programme and gaming activity. The CRSs consist of six subscales and 25 items (Cronbach Alpha 0,85–0,92; Table 2). The items are rated using a five-point Likert scale where a score of five indicates a response of 'very good', and a score of one indicates a response of 'very poorly'.

Intervention

The duration of the intervention was one week. The intervention week began with self-reported CRSs during the pre-test phase. Then, students were instructed to play each of the five surgical patient scenarios at least once, but the number of played scenarios and the playing time was unlimited. The students' work during the intervention week was not controlled in any way. At the end of the intervention week, the participants filled in the CRSs again (post-test).

Data analysis

Statistical analyses were carried out using the SAS system for Windows, release 9.4. The demographics were presented using a descriptive analysis of the background variables. Multivariable analyses (a single multivariate ANOVA model of each dependent variable with background variables and time, pre-test and post-test, as categorical independents) were conducted to assess the relationships between dependents (gaming activity and self-evaluated CR skills) and independents.

Ethical considerations

This research was conducted according to the guidelines for responsible conduct of research and procedures (Finnish National Board on Research Integrity 2012). Permission to conduct the research was granted by the directors of the higher education organisations. Ethical approval was obtained from the Ethics Committee of Satakunta Higher Education Institution. Participation in the study was voluntary and based on informed consent.

Results

Demographics

Less than half of the respondents (44,7%) were in the 21–25 age group. The majority were female (85,6%), and approximately 65% had taken The Finnish Matriculation Examination. The largest group of respondents (67,5%) was enrolled in the nursing programme, and most of the respondents (73,3%) were in their first year of study. Furthermore, most of the respondents had less than one year of work experience in social and health services.

Statistically significant differences in gaming activity were found between the background variable categories (Table 1). The male respondents played more non-digital (p=0,042) and digital (p<0,0001) games than the female respondents, and the nursing students played more non-digital (p=0,033) and digital games (p=0,005), as well as educational games (p=0,011), than the midwifery students.

Table 1. Differences in gaming activity and independent variables.*

		Non-digital games	Digital games	Educational games
Age				
26-30 vs 15-20	p Difference between means	0.0385 -0.35 (-0.68, -0.01)	NS	NS
Gender				
Male vs female	p Difference between means	0.0353 0.22 (0.01, 0.42)	<.0001 1.10 (0.73, 1.46)	NS
Work experience in social and health services				
1-5 years vs >10 years	p Difference between means	0.0003 -0.71 (-1.14, -0.26)	NS	NS
> 1 year vs >10 years	p Difference between means	0.0007 -0.78 (-1.27, -0.25)	NS	NS
Educational background				
Matriculation examination** vs vocational upper secondary education, practical nurse	p Difference between means	NS	NS	0.0004 0.48 (0.21, 0.74)
Degree programme				
Midwife vs nurse	p Difference between means	0.0331 -0.36 (-0.70, -0.02)	0.0053 -0.77 (-1.38, -0.16)	0.0112 -0.43 (-0.79, -0.07)

*Scale of gaming activity was 5 'daily' – 1 'not at all'. Data are presented as differences in means between categories of background variables, 95% confidence intervals in brackets together with p-values. A positive value indicates higher mean in the first category given in the beginning of each row.
**The Finnish Matriculation Examination is taken at the end of secondary education to qualify for entry into University. The test also constitutes the final high school exam(s).

Nursing students self-evaluated clinical reasoning skills before and after playing the simulation game

Before playing the simulation game, the participants rated their CR skills strongest in evaluating outcomes and weakest in establishing goals (Table 2). After playing the simulation game, the participants rated their CR skills best in collecting information strongest and weakest still in establishing goals.

The difference between clinical reasoning skills before and after playing the simulation game

The participants rated their CR skills higher after playing the simulation game than before playing the simulation game (Table 2). The difference was statistically significant for almost all of the items. The largest difference between the means was observed for 'I can utilise the ABCDE approach in the assessment of a patient's clinical condition' and smallest for 'Evaluate whether a patient's clinical condition has improved, deteriorated or is unchanged'.

Discussion

This study was designed to determine the effectiveness of a simulation game on nursing students' self-evaluated CR skills. The results of this study show that nursing students rated their CR skills to be better after playing the simulation game compared to before playing. This result supports the previous finding that gamified simulations lead to good learning outcomes if the games reflect realistic CR processes (Forsberg et al. 2011, 2016, Koivisto et al. 2016a). A note of caution is due here since the results may have been influenced by other formal and informal learning during the intervention week. One interesting finding is that the students improved their ability to use the 'ABCDE' approach to assess patients' clinical status. This could be explained by the fact that the 'ABCDE' approach (Thim et al. 2012) was used in all of the scenarios, thus enabling the students to practice the protocol repeatedly and helping them to internalise and automate the clinical procedures (Koivisto et al. 2017). The findings of this study also support previous research indicating that students' ability to establish goals does not improve through gaming that effectively (Koivisto et al. 2016b).

The present study also contributes to our understanding of nursing students' previous gaming activities. Interestingly, students with upper secondary school education levels played more educational games than students with practical nursing backgrounds. This could indicate that gamification has been used more in general education than in vocational training, which may be due to the limited availability of nursing games. This study also found that male students play more games than female students, which has practical significance because previous studies have shown that gaming activity is related to learning CR (Koivisto et al. 2016a). Therefore, it could be assumed that male students can especially benefit from gamified learning methods.

The generalisability of the results could be undermined because the data were collected using students' self-reported questionnaires that were collected from only three universities of applied sciences in one country. Nevertheless, the internal consistency of the instrument was good (Cronbach alpha 0.85–0.92). The validity of the study is enhanced by the fact that almost 400 students participated in the research. Since there was no control group the validity of the results may be impaired. On the basis of this study, it is not possible to argue what is the most effective way to learn CR skills, but the results indicate that simulation games could have their role as one method alongside others. Moreover, simulation

Table 2. Nursing students self-reported clinical reasoning skills and differences in skills before and after playing the simulation game.

Item I can	
Collecting information Cronbach Alpha 0.85	
1	Collect information about a patient by interviewing
2	Collect information about a patient by observing
3	Collect information about a patient with different measuring methods
4	Utilise the ABCDE approach in the assessment of a patient's clinical condition
Processing information Cronbach Alpha 0.90	
5	Analyse the information I have collected
6	Assess the importance of the information collected about a patient
7	Distinguish essential information from non-essential
8	Predict the effects of my decisions on a patient's clinical condition
9	Assess the cause and effect relationships related to a patient's clinical condition
Identifying problems/issues Cronbach Alpha 0.86	
10	Recognise a patient's need for care
11	Make a nursing diagnosis
12	Recognise changes in a patient's clinical condition
13	Prioritise a patient's nursing needs
Establishing goals Cronbach Alpha 0.90	
14	Establish nursing goals
15	Plan nursing activities
16	Make decisions regarding a patient's care independently
17	Make decisions regarding a patient's care quickly
Taking action Cronbach Alpha 0.92	
18	Provide symptomatic care to a patient
19	Make choices between different care alternatives
20	Choose the nursing interventions required by a patient's clinical condition
21	Care for patient whose clinical condition has deteriorated
22	Prevent the deterioration of a patient's clinical condition
Evaluating outcomes Cronbach Alpha 0.90	
23	Evaluate implemented nursing care
24	Evaluate the care outcomes in relation to care needs
25	Evaluate whether a patient's clinical condition has improved, deteriorated or is unchanged

Scale of clinical reasoning skills was 5 'very good' to 1 'very poorly'
* Data are presented as differences in means between categories of background variables, 95% confidence intervals in brackets together with p-values. A positive value indicates higher mean in the first category given in the beginning of each row.

	PRETEST					POSTTEST					POSTTEST VS PRETEST*	
	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	Difference between means	p
	372	3.81	0.72	2.0	5.0	351	4.00	0.59	2.0	5.0	0.19 (0.09, 0.30)	0.0003
	369	3.63	0.69	2.0	5.0	349	3.88	0.60	2.0	5.0	0.26 (0.16, 0.36)	<.0001
	369	3.78	0.72	2.0	5.0	350	3.94	0.61	2.0	5.0	0.14 (0.03, 0.24)	0.0147
	370	3.50	0.77	2.0	5.0	348	3.85	0.66	2.0	5.0	0.34 (0.23, 0.46)	<.0001
	373	3.47	0.69	2.0	5.0	351	3.62	0.64	2.0	5.0	0.15 (0.06, 0.26)	0.0053
	372	3.62	0.67	2.0	5.0	351	3.72	0.67	2.0	5.0		NS
	371	3.53	0.73	2.0	5.0	349	3.66	0.68	2.0	5.0	0.16 (0.05, 0.27)	0.0058
	372	3.26	0.75	2.0	5.0	348	3.47	0.67	2.0	5.0	0.18 (0.06, 0.29)	0.0026
	370	3.20	0.73	2.0	5.0	350	3.48	0.70	2.0	5.0	0.24 (0.13, 0.36)	<.0001
	372	3.60	0.68	2.0	5.0	350	3.77	0.63	2.0	5.0	0.16 (0.06, 0.27)	0.0022
	367	2.97	0.76	2.0	5.0	348	3.25	0.73	2.0	5.0	0.27 (0.15, 0.39)	<.0001
	371	3.67	0.68	2.0	5.0	348	3.85	0.64	2.0	5.0	0.16 (0.05, 0.27)	0.0041
	369	3.58	0.74	2.0	5.0	348	3.72	0.70	2.0	5.0	0.14 (0.02, 0.25)	0.0242
	369	3.58	0.74	2.0	5.0	350	3.71	0.69	2.0	5.0	0.13 (0.02, 0.24)	0.0285
	366	3.49	0.75	2.0	5.0	351	3.58	0.72	2.0	5.0		NS
	367	3.05	0.82	2.0	5.0	351	3.268	0.81	2.0	5.0	0.21 (0.08, 0.33)	0.0012
	366	3.02	0.83	2.0	5.0	348	3.30	0.82	2.0	5.0	0.28 (0.16, 0.41)	<.0001
	374	3.56	0.75	2.0	5.0	350	3.73	0.66	2.0	5.0	0.15 (0.03, 0.26)	0.0106
	373	3.37	0.76	2.0	5.0	349	3.56	0.73	2.0	5.0	0.19 (0.07, 0.30)	0.0021
	372	3.33	0.74	2.0	5.0	349	3.56	0.71	2.0	5.0	0.20 (0.08, 0.31)	0.0010
	372	3.39	0.78	2.0	5.0	349	3.61	0.74	2.0	5.0	0.20 (0.08, 0.30)	0.0014
	371	3.29	0.73	2.0	5.0	347	3.49	0.72	2.0	5.0	0.14 (0.03, 0.26)	0.0159
	372	3.70	0.67	2.0	5.0	351	3.86	0.62	2.0	5.0	0.14 (0.04, 0.25)	0.0053
	371	3.58	0.73	2.0	5.0	350	3.73	0.71	2.0	5.0	0.15 (0.04, 0.27)	0.0084
	373	3.90	0.64	2.0	5.0	348	4.01	0.62	2.0	5.0	0.12 (0.02, 0.22)	0.0192

games could replace more traditional ways of learning, especially now when digital content is increasingly needed to strengthen nursing students' clinical competence.

Conclusion

The main result of this study is that students' self-evaluated CR skills improved after playing a simulation game. The evidence from this study suggests that simulation games are effective, at least to some extent, for gaining CR skills in nursing education. Therefore, simulation games are recommended for nursing students to practice the management of different clinical conditions. However, to provide stronger evidence of the effectiveness of the simulation game, the study should be repeated using a control group. Additionally, further research should examine nursing students' performance in various scenarios in the simulation game using data that is stored during gameplay to model learners' skill profiles.

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AREAS OF RESPONSIBILITY

Conception and design: JMK, KR, TB, EH, acquisition of data: JMK, KR, TB, analysis of data: JMK, JE, drafting the manuscript: JMK, JE, revising manuscript critically: JMK, KR, TB, JE, EH

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