

Effect of a game-based virtual reality phone application on tracheostomy care education for nursing students: A randomized controlled trial

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ABSTRACT

Background: A game-based virtual reality phone application is used as a simulation to teach psychomotor skills in nursing education.

Objective: This study aims at determining the effect of a game-based virtual reality phone application on tracheostomy care education for nursing students.

Design: Single-blind randomized controlled trial conducted from March–April 2017.

Setting: Department of Nursing, Faculty of Health Sciences, Central Anatolia of Turkey.

Participants: A total of 86 first-year nursing students registered in Fundamentals of Nursing-II were included in this study. The students were divided at random into two groups, control ($n = 43$) and experimental ($n = 43$).

Method: The data were collected with an informative features form, a tracheostomy care knowledge test and skill checklists, and a performance assessment form. The control group commenced the study first so that the students did not affect each other. After the students completed the theoretical class, laboratory class, and small group study, they had their knowledge test and skills evaluation. The application featured tracheostomy care and was designed in support of formal education. It was uploaded to the mobile phones of the experimental group at a different phase of the study from the control group. After the experimental group made use of this application for seven days, their last knowledge test and skills evaluation were conducted.

Results: The results of this study determined that the suctioning a tracheostomy tube and peristomal skin care average final test scores of the students in the experiment group were higher than the average scores of the students in the control group; this was statistically significant ($p = 0.017$, $p = 0.003$).

Conclusion: The game-based virtual reality phone application was effective in teaching the skill of suctioning a tracheostomy tube for nursing students in the short term, and it is recommended that this application be used in psychomotor skill training.

1. Introduction

Psychomotor skills education begins with the teacher lecturing on the skill using the demonstration method and continues with practice opportunities and feedback for the student until practical competence is achieved (Baillie and Curzio, 2009). In this teaching process, in an environment that represents the actual hospital environment, various simulation methods are used for students to acquire experience without risking patient safety (Cant and Cooper, 2010; Oermann and Gaberson, 2014). Recent evidence suggesting that teachers must use individual games such as crossword puzzles or games, video gaming and multi-player online health care simulations. Games actively involve learners, promote teamwork, may require problem solving skills, motivate, stimulate interest in a topic, enhance information retention and support

learning (Oermann and Gaberson, 2014). Also virtual reality games can add to these teaching methods nowadays. Virtual reality is a three-dimensional computer-based simulation that gives the sense of being anywhere by providing our sense organs with various data (Jenson and Forsyth, 2012; Durmaz Edeer and Sarikaya, 2015). The virtual reality application allows as much repetition as required by identifying mistakes in a safe virtual laboratory environment (Göris et al., 2014). Therefore, this type of simulation is a powerful learning tool that engages the active participation of students, improves conveyance and persistence of learning, and allows interactive learning and problem analysis (Rogers, 2008; Huang et al., 2010).

The game-based virtual reality application dramatizes a real-life situation in a computer environment. Game-based virtual reality applications offer easy access to information. Moreover, they enhance

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information retention in the learning process and enhance the high-level thinking ability and motivation of users (Ma et al., 2014; Sezgin, 2016). In related literature, game-based virtual reality practices are used to teach about suctioning a tracheostomy tube (Noyudom et al., 2011), chronic obstructive lung disease (Tsai et al., 2015), post-op morphine treatment (Lancaster, 2014), and cardiopulmonary resuscitation (Boada et al., 2015).

This is the only study in which a game-based virtual reality phone application is used in nursing education in Turkey. The difference of this study from other studies is that students can repeat the game from their phones at the time and place they want. This study focuses on tracheostomy care education, in which the students of the Fundamentals of Nursing II course were challenged to practice psychomotor skills and did not have an opportunity to practice in the clinic.

2. Background

In nursing education, the use of different teaching methods that strengthen students' skills enables the transfer of knowledge to practice in clinical application (Jenson and Forsyth, 2012). For this reason, the employment of game based virtual reality is on the increase nowadays (Ma et al., 2014; Mayo, 2007; Boada et al., 2015). Virtual reality is a computerized simulation that promotes the students to learn in clinical environments, which are three dimensional and realistic, without risking patient safety (Jenson and Forsyth, 2012). The games, which were designed using virtual reality application, are important games having educational content (Ma et al., 2014). The most important feature of virtual reality is that it brings a realistic and interactive feeling (Lee and Wong, 2008; Simpson, 2002). Three-dimensional educational virtual worlds provide to reach the information easily, and increase user's motivation by providing active usage of information during learning. In the meantime, these environments support the social aspects (interact with patient or team member in virtual environment) and skill development of the users providing their lifelong learning and developing their collusive labor skills (Erbas and Demirer, 2015). The game-based virtual reality application is the gamification of a real life situation that is later transferred to the computer environment. It can be played on computers, tablets and mobile phones. Playing the application on mobile phones worlds provides to reach the information easily, and allows them to use it as supportive material for formal education at any time and place (Ma et al., 2014). It is stated that the game-based virtual reality application developed the knowledge and skills of nursing students, increased their motivation and self-confidence, made the learning process fun and ensured them to take part in the process actively by giving them feedback (Chia, 2013; Koivisto et al., 2017; Lancaster, 2014; Smith and Hamilton, 2015).

Tracheostomy care requires students to employ surgical asepsis skills and fulfill the procedural steps in the right order without mistakes. When the order of steps is not respected and failed to comply with the principles of surgical asepsis serious complications can occur in the individual. Students need to frequently repeat the lesson to learn to prevent complications and fulfill the procedural steps in the right order, complying with asepsis principles. The game-based virtual reality phone application allowed students to repeat lessons on their mobile phones at any time and place, supporting the students' formal education. This study was conducted to determine the effect of the game-based virtual reality phone application on tracheostomy care education for nursing students.

3. Materials and methods

3.1. Participants

The study population comprised 238 first-year students enrolled in the Fundamentals of Nursing II course in the spring semester of

2016–2017 academic year in the Nursing Department of the Faculty of Health Sciences at Gazi University located in a metropolitan city in Turkey. As this study targeted this population, no sample was selected.

The inclusion criteria for this study:

- To be enrolled in Fundamentals of Nursing II for the first time,
- To be have an Android system on the mobile phones,
- To be have internet access,
- To be have no previous experience in tracheostomy care.

The exclusion criteria for this study:

- To be having attended at least one of the theoretical classes, demonstrations, and small group studies,
- To be not having taken the first or last skill performance assessments.

The study began with a total of 118 students who met these criteria and was completed with 86 students (Fig. 1). The type of sampling was block randomization. The students' university entrance scores and academic average scores were collected and sorted from small to large. According to this order, students were randomly assigned to control and experimental groups. Group assignments of students and skill assessments were blinded to reduce risk of bias. The power analysis was carried out using G*Power 3.1. According to the results of the study conducted by Boada et al. (2015), it was determined that the number of individuals required to reject the null hypothesis, with 83% power and a significance level of 0.05, was at least 86 students (43 experimental group and 43 control group) with an effect size 0.56.

Written approvals for this study were obtained from the university ethics board (July 11, 2016, decision no: 10) and from the University Department of Nursing where the study was performed. The students were informed of the aim and plan of the study, and written consent was obtained from all students.

3.2. Data collection and instruments

The data were collected using the “Descriptive Characteristics Questionnaire,” “Tracheostomy Care Information Test” and “Tracheostomy Care Skill Checklists.” The Descriptive Characteristics Questionnaire has six questions in total; this part was filled out by the students.

The “Tracheostomy Care Knowledge Test” was created by the researchers according to the literature (Russell and Matta, 2004; DeLaune and Lander, 2006; Irwin and Rippe, 2008; Morris and Sherif, 2010; Paul, 2010; Taylor et al., 2011; Craven et al., 2013; Potter and Perry, 2013; Dawson, 2014). This test comprises 23 five-option multiple choice questions. The lowest possible score on this test is zero, and the highest is 23 points. This test was evaluated by 76 nursing students in second year. Validity of this test was evaluated with KR21 (0,583) and KR20 (0,633) (Cronbach's Alpha = 0.706).

After the test was prepared, opinions were obtained from an academic member specializing in measurement and assessment, an academic member who specialized in Turkish Language and Literature, and three academic members specializing in the Fundamentals of Nursing in terms of validity of scope. The specialists assigned appropriateness points to the knowledge test questions and procedural steps based on a four-point Likert scale (1: Not appropriate; 2: Slightly appropriate, revision required in the procedural step; 3: Fairly appropriate, minor changes required in the procedural step; 4: Highly appropriate). The compatibility of specialist opinions was analyzed with the Kendall's W test. The specialist opinions on the knowledge test were found to be statistically average compatible (Kendall's W = 0.302; $p = 0.589$). The knowledge test was modified regarding the expert recommendations.

The “Tracheostomy Care Skill Checklists” were created by the

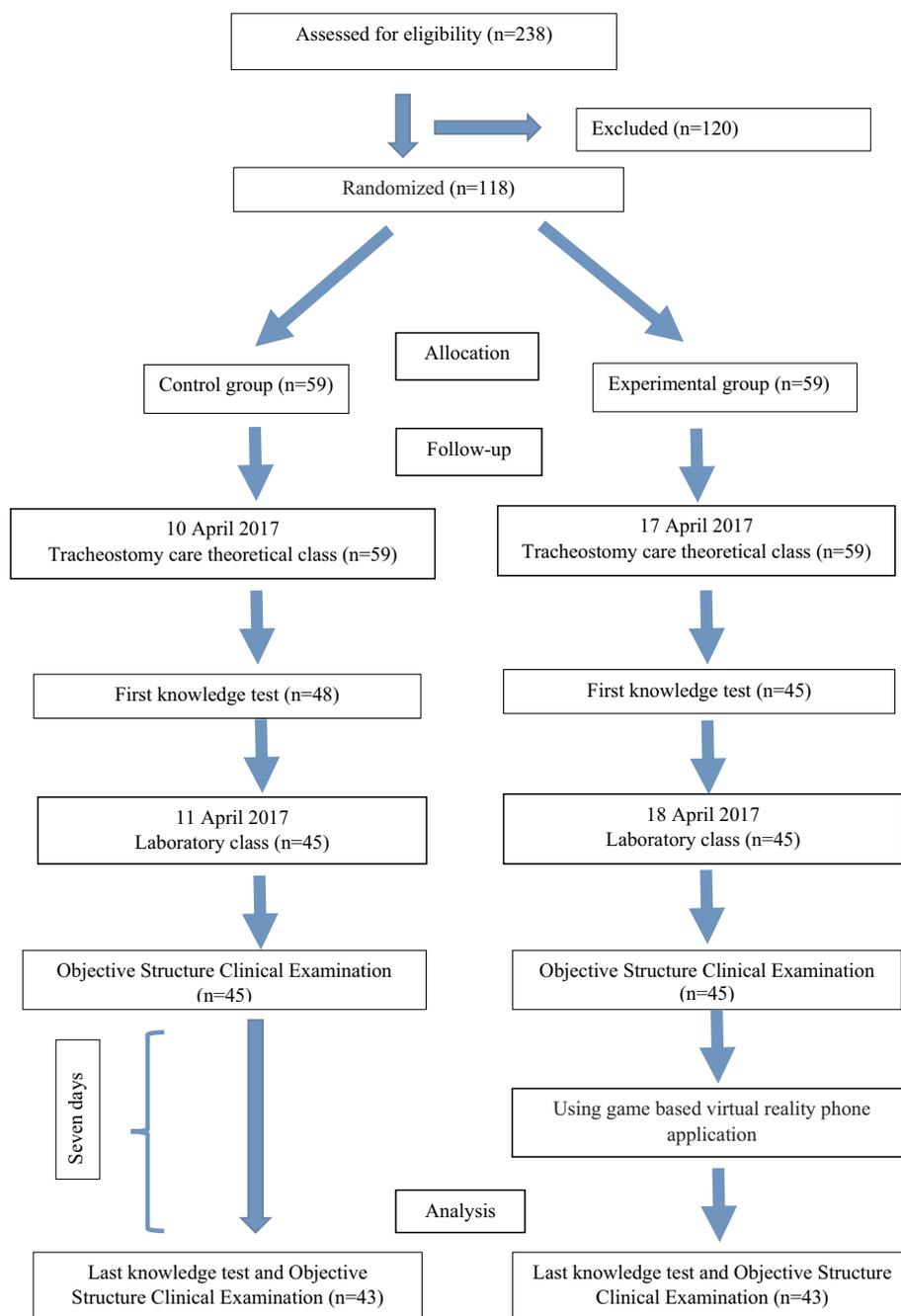


Fig. 1. CONSORT diagram of this study.

researchers according to the literature (Russell and Matta, 2004; DeLaune and Lander, 2006; Taylor et al., 2011; Craven et al., 2013; Potter and Perry, 2013; Dawson, 2014; Berman et al., 2016). The “Tracheostomy Care Skill Checklists” are made of three separate skill checklists and include tracheostomy tube suctioning, inner cannula cleaning, and peristomal skin care checklists. These were finalized based on the opinions of three specialists in the Fundamentals of Nursing department, one measurement and assessment expert and one language expert.

3.3. Preparation of the game-based virtual reality application

The researchers shot a video according to the “Tracheostomy Care Skill Checklists.” The video content includes demonstration of the steps of the “Tracheostomy Care Skill Checklists” by the researcher on the

model. The researchers then prepared a game scenario that included pictures, according to the video content. The game-based virtual reality phone application for tracheostomy care was designed using Adobe Flash Professional CC and Adobe Flash CS6. The application could be played anywhere without internet connection, and students started the game by registering with their name and surname.

In the game, students must ensure the character of Nurse Demet performs tracheostomy care on a patient, Mrs. Melek, and record the results, following the procedural steps through three stages. The game starts with Nurse Demet sharing her brief observations about her patient, Mrs. Melek. Nurse Demet guides the student from the beginning to the end of the game.

The tracheostomy care game-based virtual reality phone application comprises the following six stages, for a total play time of 10 min. Stage 1: Preparing correct materials for suctioning (25 s), Stage 2: Preparing

correct materials for inner cannula cleaning (20 s), Stage 3: Preparing correct materials for peristomal skin care (23 s), Stage 4: Suctioning tracheostomy tube (3 min, 10 s), Stage 5: Cleaning tracheostomy inner cannula (2 min, 40 s) and Stage 6: Conducting peristomal skin care (3 min, 2 s).

Students recorded the procedure when all stages were completed and e-mailed the time taken for the procedure to the researcher. The researcher recorded the information sent by e-mail.

3.4. Intervention

The study was conducted between April 10, 2017 and April 24, 2017. To prevent interactions between the two groups, first the control group, then the experimental group were included in the study.

Tracheostomy care was explained to the students in the control group on April 10, 2017, and the students in the experimental group on April 18, 2017, using theoretical class, representation, question-answer, and discussion methods in a 60-minute PowerPoint presentation by the researcher. The next day, the students were taken into the laboratory class, where the researcher gave a 60-minute tracheostomy care demonstration on the mannequin, following the steps of the “Tracheostomy Care Skill Checklists.” The students who took part in the study and followed the theoretical class and demonstration were given the “Tracheostomy Care Knowledge Test” to obtain their first knowledge score. After the test, the students conducted 90-minute small group studies in groups of 20 on average; specialists in the Fundamentals of Nursing department were available in the laboratory. The students performed tracheostomy care on the mannequin in this small group studies. After the small group studies, the researcher briefed the students about the Objective Structure Clinical Examination. Then, the students were given readily prepared directives and the “Tracheostomy Care Skill Checklists.” The next day, the students were taken into the Objective Structure Clinical Examination for a skill assessment to obtain their first skill checklist score.

In the Objective Structure Clinical Examination, every station was assigned a number; station 1 featured the tracheostomy tube suctioning skill, station 2 tested the inner cannula cleaning skill, and at station 3, peristomal skin care skill was evaluated by experts. The researchers organized the stations but did not evaluate skills due to possibility of bias and did not intervene with the stations during the Objective Structure Clinical Examination. The observers monitored the students at the stations without providing any feedback and filled out the “Tracheostomy Care Skill Checklists” as students completed the steps. The observers were not told that the skill assessment was being applied to the control group first; they were told that the control and test groups were mixed.

No additional steps were taken with the control group for seven days following the first knowledge and skill performance assessments. After seven days, the students were given the “Tracheostomy Care Knowledge Test” again to obtain their final knowledge test score, and the “Tracheostomy Care Skill Checklists” were filled out with the Objective Structure Clinical Examination in the laboratory to obtain their final skill checklist score. The experimental group began their tracheostomy training after researchers received the data for the control group.

After the experimental group's first knowledge and skill performance assessment, the tracheostomy care game-based virtual reality phone application was downloaded to the mobile phones of the students, who were told that they could play the game as long as they wanted at any time and place. The students were given seven days to play the game. As the game-based virtual reality phone application was prepared according to the “Tracheostomy Care Skill Checklists,” the student was not able to progress to the next step until the current procedural step was completed accurately. After seven days, the students were given the “Tracheostomy Care Knowledge Test” again to obtain their final knowledge test scores, and the “Tracheostomy Care

Skill Checklists” were filled out with the Objective Structure Clinical Examination in the laboratory to obtain their final skill performance scores. After the experimental group finished, the tracheostomy care game-based virtual reality phone application was also downloaded to the mobile phones of the students in the control group for make use of game.

3.5. Data analysis

The data obtained from the study were analyzed using the SPSS version 22.0 software package. Number, percentage, mean and standard deviation values were used in descriptive statistical evaluation of the data. One-Sample Kolmogorov Smirnov Test was used to evaluate data with normal or non-normal distribution. Nonparametric tests were used for indicate non-normal distribution ($df = 86, p < 0.05$). The Mann Whitney-*U* test was used for comparison of quantitative continuous data among the two independent groups. The relation between the grouped variants was tested with the chi-square (χ^2) analysis. The Wilcoxon test was used for the matched groups to determine the differences between the first and last scores. The data were evaluated at a 95% confidence interval and at a $p < 0.05$ significance level.

4. Results

No statistically significant difference was observed between the control and experimental groups in the distribution of student descriptive characteristics ($p > 0.05$) (Table 1).

No statistically significant difference was observed between the first knowledge and last knowledge scores, with the last knowledge scores of the control and experimental groups increased ($p > 0.05$).

No statistically significant difference was observed between the first scores for the suctioning skill of the control and experimental groups ($p > 0.05$). The last skill performance scores of the students in the experimental group were significantly higher than those of the control group ($p = 0.017$). The control group took a significantly longer time to complete the first suctioning skill assessment than the experimental

Table 1
Distribution of students according to descriptive characteristics.

Characteristics	Groups		χ^2	p
	Control <i>n</i> = 43 (%)	Experimental <i>n</i> = 43 (%)		
Graduated school				
High school	34 (79.1)	38 (88.4)	1.556	0.459
Pre-licence	1 (2.3)	1 (2.3)		
Other ^a	8 (18.6)	4 (9.3)		
Nursing preference				
Willing	34 (79.1)	35 (81.4)	0.073	0.500
Not willing	9 (20.9)	8 (18.6)		
Being satisfied nursing preference				
Satisfied	36 (83.7)	39 (90.7)	0.938	0.260
Not satisfied	7 (16.3)	4 (9.3)		
Status of using digital driving while studies				
User	29 (67.4)	37 (86)	4.170	0.036
Not user	14 (32.6)	6 (14)		
Digital tool used during course work ^b				
Computer	4 (9.3)	7 (16.3)		
Mobile phone	23 (53.5)	25 (58.1)	2.761	0.251
Tablet	2 (4.7)	–		
None	14 (33.5)	11 (25.6)		
Virtual game play status				
Play	23 (53.5)	29 (67.4)	1.751	0.135
Not play	20 (46.5)	14 (32.6)		

^a High school and vocational high school with a foreign language.

^b Since more than one answer was given, they were taken over the percentages.

Table 2

Comparison of first and last knowledge scores and suctioning a tracheostomy tube skill performance scores and Objective Structure Clinical Examination times at control and experimental groups.

	Knowledge test scores				Suctioning a tracheostomy tube skill performance							
					Skill score (min: 19–max: 57)				OSCE ^a time (second)			
	Control		Exp. ^b		Control		Exp. ^b		Control		Exp. ^b	
Groups	Median (min–max)	Median (min–max)	p ^c	U	Median (min–max)	Median (min–max)	p ^c	U	Median (min–max)	Median (min–max)	p ^c	U
First	17 (12–23)	18 (9–22)	0.441	836.0	53 (37–57)	53 (40–57)	0.997	901.0	340 (228–360)	330 (162–360)	0.022	911.5
Last	19 (8–23)	19 (13–23)	0.568	859.0	54 (46–57)	55 (46–57)	0.017	671.5	260 (190–360)	260 (180–360)	0.723	883.5
Z	–1.60	–1.80			–1.944	–3.537			–5.308	–4.329		
p ^d	0.109	0.071			0.000	0.000			0.000	0.000		

^a Objective Structure Clinical Examination.

^b Experimental.

^c Mann Whitney-U test.

^d Wilcoxon test.

group ($p = 0.022$). The control group completed the final suctioning skill assessment in a shorter time than the experimental group, but not to a significant degree ($p > 0.05$) (Table 2).

The first mean scores for the inner cannula cleaning skill of the students in the experimental group were significantly higher than the control group ($p = 0.000$). The last scores for this skill were also higher in the experimental group than the control group, but no significant difference was observed between the groups ($p > 0.05$). The control group took longer to conduct the inner cannula cleaning the first time than the experimental group ($p = 0.001$). The control group conducted the last suctioning skill assessment over a longer time than the experimental group, but no significant difference was observed between the groups ($p > 0.05$).

The first and last peristomal skin care skill performance scores of the students in the experimental group were higher than those of the control group at a statistically significant level ($p = 0.033$, $p = 0.003$). The control group took longer to complete the first peristomal skin care skill performance than the experimental group ($p = 0.003$). The control group conducted the last peristomal skin care skill performance over a longer time than the experimental group, but no significant difference was observed between the groups ($p > 0.05$) (Table 3).

5. Discussion

Teaching psychomotor skills is an important process that involves conveying students' theoretical knowledge to practice and developing their skills (White and Evan, 2002). Students practice the basic psychomotor skills they have learned in the laboratory and learn by repetition. New technological advancements such as game-based virtual reality applications can be used to support the knowledge and skill development of students through computers, tablets, or mobile phones, at any time and place (Huang et al., 2010).

It is reported in the literature that game-based virtual reality applications have a positive effect on the knowledge levels of nursing students (Noyudom et al., 2011; Buttussi et al., 2013; Lancaster, 2014; Tsai et al., 2015; Boada et al., 2015). Students who used a game-based virtual reality phone application had statistically significantly improved mean test scores ($p < 0.05$) on the final knowledge tests in Noyudom et al.'s (2011) study on suctioning, in Tsai et al.'s (2015) study on chronic obstructive lung disorder, Lancaster's (2014) study on post-op morphine treatment, and Boada et al.'s (2015) study on cardiopulmonary resuscitation. Buttussi et al. (2013) reported that information levels statistically significantly improved for nurses who played an advanced life support game-based virtual reality application.

In this study, the increase in the knowledge score of the

experimental group was greater than that of the control group. However, in this study, as opposed to the study results of Buttussi et al. (2013), no statistically significant difference was observed between the first and last mean knowledge scores of both groups ($p > 0.05$).

As game-based virtual reality phone applications are a way of conveying theoretical knowledge to practice, an increase is expected in the knowledge level of students who use them. However, in this study, the increase in the information score of the students in the experimental group was not significant difference. This was not significant difference in the knowledge level is suggested to be caused by the students using this kind of educational game for the first time, technical problems with their mobile phones, and issues with game progression. The students could only progress in the game when each procedural step was completed accurately.

In this study, an increase was observed in the final mean scores for the skill of suctioning a tracheostomy tube in both control and experimental group students. Similar to this study, Noyudom et al. (2011) have reported that the suctioning skill mean score statistically significantly improved for students who used a game-based virtual reality application ($p < 0.05$). Suctioning, the first stage of tracheostomy care, is a practice which requires the surgical asepsis technique. When the order of procedural steps provided in the application is not respected, important complications such as infection and hypoxia might develop in the patient. The application allows nurses to learn to perform the tracheostomy tube suctioning skills without mistakes according to the procedural steps, so might have helped the student employ this skill on the model properly during the laboratory class. Therefore, the use of game-based virtual reality applications has proven to be beneficial in teaching psychomotor skills, such as suctioning a tracheostomy tube, that are too complicated to fully learn through a single observation in the laboratory and rare practice in clinics.

In this study, an increase was observed in the last mean scores for the inner cannula cleaning skill in control and experimental groups. No statistically significant difference was observed between the first and last mean scores of both groups. However, the increase in the score of the control group is higher than the experimental group ($p > 0.05$). Because, the first skill scores of the students in the experimental group were higher than those of the control group. Moreover, it should be considered that inner cannula cleaning is a mechanical procedure that is rather easier than other skills, and can be learned by watching the demonstration and repeating the procedural steps only once.

A comparison of the last skill performance times between the groups in this study reveals that the final skill performance times for inner cannula cleaning and peristomal skin care were not observed statistically significant difference was between two groups ($p > 0.05$). The

Table 3
Comparison of inner cannula cleaning skill and peristomal skin care skill performance score and Objective Structure Clinical Examination times at control and experimental groups.

	Inner cannula cleaning skill performance						Peristomal skin care skill performance							
	OSCE ^a time (second)			Skill score (min: 19–max: 57)			OSCE ^a time (second)			Skill score (min: 17–max: 51)				
	Control Median (min–max)	Exp. ^b Median (min–max)	p ^c	Control Median (min–max)	Exp. ^b Median (min–max)	p ^c	Control Median (min–max)	Exp. ^b Median (min–max)	p ^c	Control Median (min–max)	Exp. ^b Median (min–max)	p ^c		
First	46 (28–50)	48 (30–51)	0.000	566.0	297 (230–360)	0.001	911.5	33 (20–42)	36 (28–61)	0.033	681.0	360 (300–360)	0.003	752.5
Last	49 (29–51)	49 (43–51)	0.230	786.0	240 (165–355)	0.819	883.5	39 (29–45)	42 (32–50)	0.003	581.0	360 (330–360)	0.082	817.0
Z	-5.163	-3.352			-4.277			-4.785	-4.700			-1.342	-0.768	
p ^d	0.000	0.001		0.000	0.000		0.000	0.000	0.000		0.180	0.443		

^a Objective Structure Clinical Examination.
^b Experimental.
^c Mann Whitney-U test.
^d Wilcoxon test.

suctioning performance time of the experimental group decreased less than that of the control group; this may be because the students using the game-based virtual reality phone application worked harder to complete the procedure in order and without error in the laboratory as they had in the performance, which might have prolonged the procedure.

6. Limitations of the study

Several limitations of this study must be acknowledged. This study was carried out only seven days following the intervention and that the students had access to the game up until then. The researcher can only see the student play the game when the student completes the game. When he leaves the game, he cannot have information about the student.

7. Conclusions

Using a game-based virtual reality phone application as a support for formal nursing education develops the knowledge and skills of students. These applications also allow students to learn and repeat lessons at any time and place. This application is especially useful for practices in which the order of procedural steps is important in teaching psychomotor skills, or for practices that require surgical asepsis conditions, are complicated, are hard for students to visualize and learn, or are rarely practiced in the clinic. These can be prepared in the game-based virtual reality environment, so the students' learning environments can be diversified. This study determined that a game-based virtual reality phone application can be used to support formal education in tracheostomy care. Acknowledgements

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