Teaching and Learning in Nursing 17 (2022) 42–48

Contents lists available at ScienceDirect

Teaching and Learning in Nursing

journal homepage: www.journals.elsevier.com/teaching-and-learning-in-nursing

Effectiveness of haptic technology in teaching urinary catheterization skill: A randomized controlled study

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ARTICLE INFO

Article History:
Accepted 16 August 2021

Keywords:
Computer-based simulation
Haptic education technology
Nursing education

ABSTRACT

Haptic systems represent some of the highest levels of computer-based education technologies and enable students to learn on a higher level. The purpose of this article is to determine the effectiveness of using haptic technology in teaching urinary catheter application skill on levels of success and satisfaction about this skill. Urinary catheterization application skill was taught with the standard curriculum (demonstration on the model) to the control group, while it was taught with haptic-controlled computer-based simulation technology to the experimental group. The Checklist for Teaching Urinary Catheterization Skills mean score of the students was 58.5 ± 20.1 in the control group and 94.9 ± 3.3 in the experimental group. The catheter application skill scores and level of satisfaction about the teaching method were significantly different in favor of the experimental group ($p < .001$). It is recommended to popularize the use of haptic teaching technologies in nursing education.

Introduction

Urinary catheterization has vital importance in terms of maintaining the functions of the urinary system (Balcı Akpınar, 2014; Şenturan, 2015). This is defined as a nursing intervention (Bulechek et al., 2017). Nursing interventions for persons in need of urinary catheterization include the care of the individual who is catheterized, insertion of the catheter, control of urine output and urine bags and recording of the practices and observations of the applications (Bulechek et al., 2017).

Urinary catheterization training is given in the first years of nursing education, and students are expected to show successful performance in this skill in order to be successful in their courses. Until today, there have been changes in the teaching and evaluation of psychomotor skills such as urinary catheter application. While teaching psychomotor skills such as urinary catheter application training in the past used to consist of memorizing an application checklist, today, the training of these practices takes place in a laboratory based on simulation and in an environment where the instructor evaluates the student by giving feedback (Gonzales, 2014).

Application of urinary catheterization with improper technique leads to problems including serious systemic infection and trauma. This situation may cause worsening of the health level of patients, prolonged hospital stay, as well as increase in workload and costs (Balcı Akpınar, 2014; Öztürk & Dinç, 2014). Looking at the literature, many patients require the insertion of an indwelling urinary catheter during hospitalization, often for long periods of time. Patients are at risk of urinary catheter-associated urinary tract infections due to factors such as poor placement technique by the healthcare provider. Urinary tract infections (UTIs) constitute 40% of hospital infections. The cost of treating an uncomplicated UTI ranges from $600 to $700 based on the cost of hospitalization, while it increases up to $3,000 (or more) if the UTI causes sepsis (Gonzales, 2014). Urinary catheter-related urinary tract infections are of great importance because they cause increased morbidity, mortality, cost and prolonged hospitalization and are some of the most common healthcare-associated infections (HII). It is about proper placement technique and adherence to general infection control principles (Hekimoğlu & Şahan, 2020).

It is very important for nursing students to acquire the ability to apply catheterization after graduation so that they can take the responsibility of such a vital practice, which is stated among their duties, powers and responsibilities. The large number of students, the number of educators and the insufficient clinical practice areas may negatively affect the acquisition of cognitive, affective and psychomotor dimensions related to the intervention of urinary catheterization. However, even if urinary catheterization is performed by a nurse or physician of the same sex, it may cause feelings of embarrassment and discomfort in patients and students, often with some religious and cultural effects. This may limit nursing students' gains

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https://doi.org/10.1016/j.teln.2021.08.001
1557-3087/

regarding this practice in the clinical setting (Choi, 2017; Choi et al., 2015; Öztürk & Dinç, 2014; Şendir & Coşkun, 2016). For these reasons, in education for nursing, which is an applied profession, skill laboratories and innovative practices should be used more effectively to provide students with safe clinical practice opportunities and present appropriate environments for development of nursing interventions (Öztürk & Dinç, 2014). Since the success of old methods used in education is controversial, and today's nursing students are generation "Z," who were born after 2000, and they are also known as the "internet belt" and the "crystal belt" born around technology, it is of great importance to use innovative practices in education to attract attention in teaching and increase permanence in learning (Alan et al., 2020; Göriş et al., 2014). Simulation is one of the innovative teaching methods that enable learners to develop cognitively, affectively and in the psychomotor aspect by providing real-life situations with a realistic learning environment in which they have experiences (Şendir & Coşkun, 2016). The use of innovative technologies such as simulation in nursing education supports learning based on experience and helping students improve their clinical decision-making skills and increase their self-confidence. There are many types of simulations that structure the learning environment with rapidly developing technology, from simple to complex, in increasing resemblance to real situations.

Haptic technology, a type of simulation, is a technology to add the sense of touch and feeling to computers. Sensors in haptic devices detect the touch and push force applied by the user by establishing a connection with the force application area of the brain through the sensory nerves in the muscles and joints. Thus, a person who touches virtual objects with a haptic device can perceive these objects in a concrete and realistic way (Abirami et al., 2018). This technology is defined as one of the highest levels of computer-based educational technologies. The taxonomy developed by Benjamin Bloom classifies learning areas in three areas as cognitive, affective and psychomotor. Computer-based educational technologies such as haptic technology, in addition to development of cognitive, affective and psychomotor skills, offer the opportunity to plan training for behavior development and performance evaluation. Since physical interaction occurs in the virtual environment, it is very effective in learning complex functions (Bayat, 2005; Gündoğdu & Dikmen, 2017; Şendir & Coşkun, 2016).

Relying on faculty input and identifying evidence is very subjective when a student breaks the technique. Faculty members' assessments of students' skills are often vague and lacking in objectivity. Therefore, students may not be aware of the basic principles that must be followed while applying aseptic techniques, or they may be confused about core competencies. Poor technical application, a result of not learning to use the catheter correctly, is the primary cause of catheter-acquired urinary tract infections and leads to increased morbidity, mortality, cost and prolonged hospitalization (Gonzales, 2014). On the other hand, haptic technology provides an effective learning environment to the student with the feedback it provides (Şendir & Coşkun, 2016).

There are similar studies in the international literature examining the effects of haptic or virtual reality technology in nursing education (Bowyer et al., 2005; Jamisonet al., 2006; Jung et al., 2012; Smith & Hamilton, 2015). In Turkey, haptics and IV catheter applications of virtual reality technology have been found in studies examining their effects on the ability of students in subcutaneous injection (Gündoğdu, 2017; İsmailoğlu, 2015). However, there is no study examining the effects of haptic technology on teaching urinary catheterization skills.

This study was conducted to determine the effects of using haptic technology in teaching urinary catheterization skills to nursing students on students' skill performance and satisfaction with educational methods. Thus, by expanding the use of innovative training methods in nursing education, it is aimed to respond to the educational needs of the new generation, which is called the digital generation.

Method

Design

This study was conducted with a randomized-controlled experimental design. The study complied with the Consolidated Standards of Reporting Trials (CONSORT) Checklist. The Clinical Trials registration number was received as "NCT04653233."

Hypotheses

Hypothesis 1 (H_1): In teaching urinary catheterization skills, the skill performance of the nursing students who are trained using haptic technology is higher than the students who are trained with low-fidelity task trainers.

Hypothesis 2 (H_2): In teaching urinary catheterization skills, the satisfaction levels of the nursing students who receive education using haptic technology are higher than the students who are trained with low-fidelity task trainers.

Participants

This study was conducted in the academic year of 2018-2019. The population of the study consisted of students enrolled in the Fundamentals of Nursing course at a state university in Istanbul in Turkey between December 2018 and March 2019 (n = 96).

All students enrolled in the Fundamentals of Nursing course were included without sample selection. This course is the students' first experience with the specified skill. The inclusion criteria in the study were being 18 years old or older, not being a graduate of Vocational High Schools of Health, enrolling for the first time in the Fundamentals of Nursing course, not having previously performed urinary catheterization, participating in the study completely and volunteering to participate in the study. One student in the control group declined to participate. Eight students didn't attend to lesson. Accordingly, the study was completed with 79 students (Fig. 1).

Randomization

In the randomization part of the study, the students were assigned to the experimental (n = 39) and control (n = 40) groups according to their number in the class list using the www.random.org program.

Data Collection Tools

The data were collected using a "Structured Student Identification Form," the "Checklist for Teaching Urinary Catheterization Skill," and the "Satisfaction Questionnaire."

Structured Student Identification Form

The form included questions about the students' educational status and sociodemographic characteristics such as age, gender and place of living. It consisted of 10 questions in total.

Checklist for Teaching Urinary Catheterization Skill (CTUCS)

The 25-item checklist prepared by the researchers based on the literature included the application steps of urinary catheterization skills (Bulechek et al., 2017; Potter et al., 2016). Each item was grouped to be of equal importance. For example, one item was "washing hands and explaining the procedure to the patient. Checking the patient's identity," and the other item was "placing a protective cover under the patient." Each item was scored as "unsatisfactory" "needs to improve" or "satisfactory" as 0, 2, or 4 points. A higher score indicates that the urinary catheterization skill of the participant is more satisfactory, and a lower score indicates

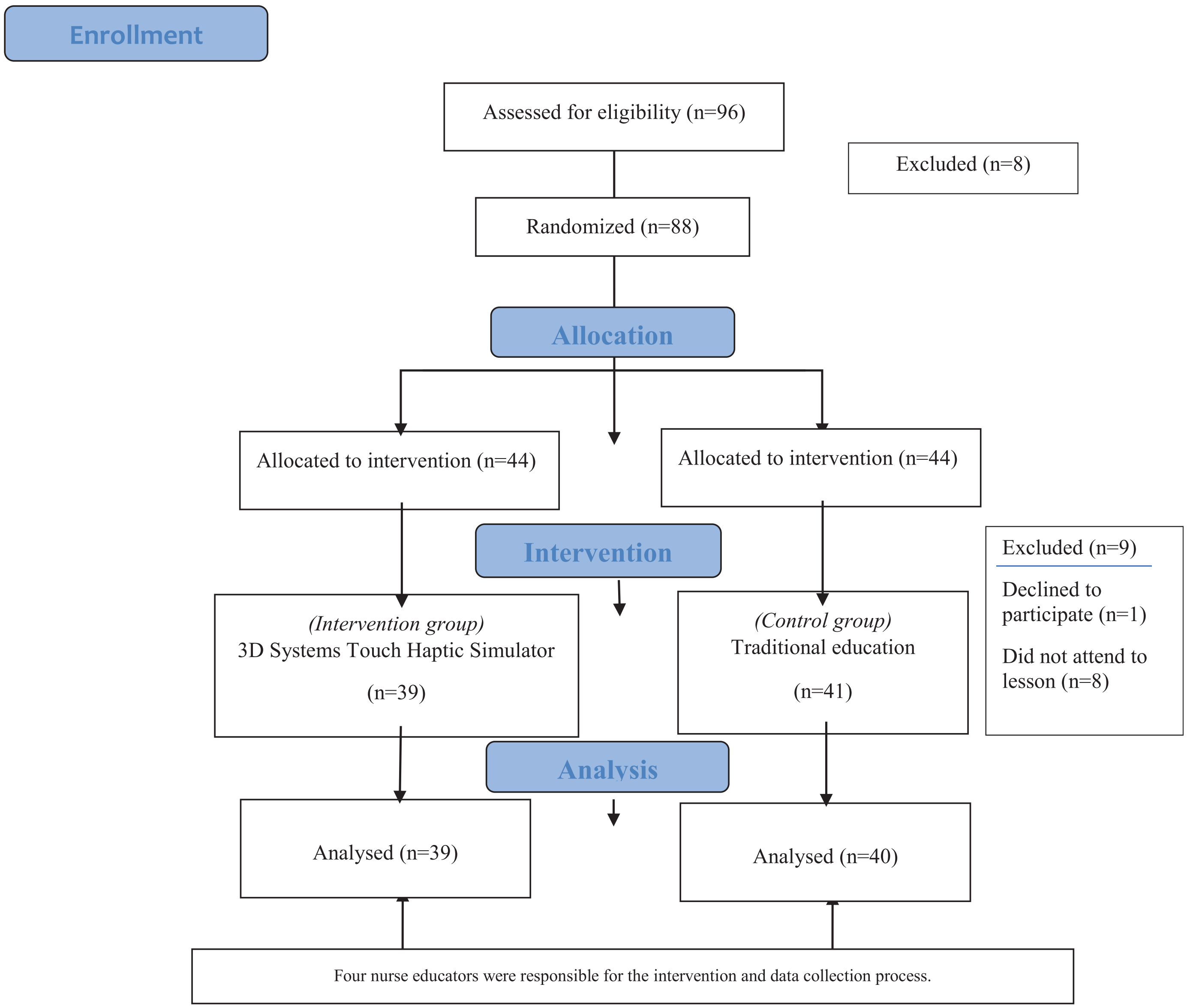

Fig. 1. Allocation of subjects according to the CONSORT 2010 flow diagram.

more unsatisfactory skills. The lowest score that could be obtained from the checklist was "0," and the highest score was "100." The same two researchers applied the checklist to the students in the control and experimental groups. The interobserver reliability coefficient was found as .76.

Satisfaction Questionnaire

The Satisfaction Questionnaire was developed by Gürpınar (Cronbach's alpha: 0.84) and used in their studies (Gürpınar, 2007; Gürpınar et al., 2009). The questionnaire consists of 16 statements, and the participants are asked to give a score for each instruction method on a five-point Likert-type scale between 1 and 5 (1-absolutely disagree, 5-absolutely agree). Higher scores indicate higher levels of satisfaction of the participant with the educational method, while lower scores indicate lower levels of satisfaction. In the evaluation of the scale, students are given a minimum of 16 and a maximum of 80 points for their satisfaction with their educational methods. In this study, the Cronbach's alpha coefficient of the scale was determined to be .95.

Data Collection

The four-hour theoretical course on Urinary Catheterization was given to all students at the same time in the classroom environment. After the theoretical training, the participants were divided into the experimental (3D Systems Touch Haptic Simulator) and control (Low-Fidelity Task Trainer) groups. The "Structured Student Identification Form" was applied to both groups.

Implementation in the Control Group: After the theoretical class, the control group was taken to the Fundamentals of Nursing Skills Laboratory. The laboratory consists of 3 practice rooms, 1 control room and 1 analysis room. One researcher, who was responsible for the Fundamentals of Nursing course, explained the Low-Fidelity Task Trainer by applying the steps of the "Checklist for Teaching Urinary Catheterization Skills." The students were allowed to ask questions, and their questions were answered. All students in the control group were then taken to an empty class. The two researchers prepared the necessary materials for the urinary catheterization skill practice in the same way in separate rooms. The doors were closed to keep the environment calm during the application. One student was taken to each laboratory room in order for the student to not be affected by other students. The researcher took a position so that they could see the student's practice, and the student could not see the forms. While the student was practicing, both researchers filled in the Checklist for Teaching Urinary Catheterization Skills. The Satisfaction Questionnaire was given to the student who completed the implementation, and the student was asked to fill it. The student left the lab, and another student was called into the room for the practice. Each student was given 10 minutes, and the researchers took a 30-minute break once. The implementation took 4 hours in total.

Implementation in the Experimental Group: After the theoretical class, the students in the experimental group were taken to the laboratory room where the 3D Systems Touch Haptic Simulator was located. This simulator is computer-aided and allows us to see this practice on the computer screen while practicing with a haptic arm. It gives real-like feedback in hand manipulations. The simulator has a choice of 45 minutes of full instruction, 5 minutes of haptic arm only instruction or the option to select different settings together. Since the preparation of the material in the full teaching method in the simulator takes a long time, these steps were removed to achieve a similar process to that in the control group. The skill practice option for an average of 5-10 minutes, where all steps of the Checklist for Teaching Urinary Catheterization Skill could be applied, was selected. Urinary catheterization with the 3D Systems Touch Haptic Simulator was explained by 1 researcher who was responsible for the Fundamentals of Nursing course. The students were allowed to ask questions, and their questions were answered. Then, all students in the experimental group were taken to an empty class one by one. While the student was practicing, two researchers filled out the Checklist for Teaching Urinary Catheterization Skills for an equal number of students. The Satisfaction Questionnaire was given to the student who completed the implementation, and the student was asked to fill it. Then, the student left the lab, and the next student was taken in for the practice.

Ethical Considerations

In order to conduct the study, approval was obtained from the Health Sciences University Hamidiye Non-Interventional Ethics Committee with the decision numbered 18/98 dated 28 December 2018. Written permission was obtained from the institution where the research was conducted. Written consent was obtained from each participant. It was also stated verbally that participating or not participating in the study would not affect the grades of the students. Four researchers who carried out the intervention phase of the research work at the Fundamentals of Nursing Department (3 researchers are doctoral students and lecturers, 1 researcher is a faculty member in the field of Fundamentals of Nursing).

Analysis

SPSS 16.0 (Statistics Package for the Social Sciences for Windows, Version 16.0) was used for data analysis. The nominal variables were evaluated as frequency and percentage, while the ordinal variables were evaluated as mean and standard deviation. The data showed normal distribution according to the Shapiro-Wilk test that was conducted. For this reason, independent-samples t-test and one-way ANOVA were used to compare the mean scale scores. The results were evaluated in a 95% confidence interval and at a significance level of $p < .05$.

Results

Demographic Survey

Ninety-nine students volunteered to participate in the study, and they were randomized into the control or the experimental group. It was observed that 75.9% of the students were female, 61.5% were 20 years old, the majority of the students' parents had high school or higher education levels. It was determined that 98.7% of the students used technological tools, mostly phones, and 93.6% thought using technology in education is beneficial.

Table 1 shows the mean Checklist for Teaching Urinary Catheterization Skill (CTUCS) score of all participants, their mean level of satisfaction according to their introductory characteristics and the statistical analysis of the relationships between these mean values. Accordingly, only the satisfaction level of the students differed significantly according to the place where they lived the longest ($p < .05$).

When the mean CTUCS scores of the students in terms of their introductory characteristics and their levels of satisfaction were analyzed according to the groups, no significant difference was found between the skill scores and satisfaction levels in both groups based on the students' sociodemographic characteristics ($p > .05$).

Table 1
Distribution of Descriptive Characteristics of Students According to Checklist for Teaching Urinary Catheterization Skill (CTUCS) and Satisfaction Questionnaire.

		CTUCS		Satisfaction	
		Mean ± SD	p	Mean ± SD	p
Gender	Female (n = 60)	72 ± 25	.35*	63 ± 11	.74*
	Male (n = 19)	78 ± 23		62 ± 12	
Longest-lived place of residence	Metropolitan City	77 ± 22	.18**	63.44 ± 12.65	.02*
	City	85 ± 20		68.37 ± 8.10	
	District	68 ± 24		55.73 ± 11.47	
	Village	66 ± 34		60.83 ± 12.45	
Using technological tools	Yes (n = 78)	76 ± 23	.356*	62 ± 12	.737*
	Partially (n = 1)	98		67	
Most used information/communication tool	Phone (n = 76)	76 ± 23	.103*	62 ± 11	.06*
	Computer (n = 3)	98 ± 2		75 ± 4	
View on the use of technological methods in education	I find it useful (n = 74)	76 ± 23	.84**	62 ± 12	.44**
	I find it complicated (n = 2)	76 ± 34		61 ± 5	
	I find it unnecessary (n = 2)	70 ± 40		69 ± 4	
	Other (n = 1)	96		80	

n, number of participants; SD, standard deviation.
$p < .05$.
* Independent-samples t-test.
** One-way ANOVA.

Table 2
Comparison of Score Averages From the Checklist for Teaching Urinary Catheterization Skill (CTUCS) and Satisfaction Questionnaire According to Groups.

	Experiment (n = 39)	Control (n = 40)	Test	
	Mean SD	Mean SD	t*	p
CTUCS	94.9 ± 3.3	58.5 ± 20.1	.284	<.001
Satisfaction	70.4 ± 6.8	55.8 ± 11.7	8.328	<.001

n, number of participants; SD, standard deviation.
$p < .001$.
* Independent sample t-test.

Urinary Catheterization Skill

The Cronbach's alpha for CTUCS was 0.91, providing evidence for the reliability of the checklist items. The mean total CTUCS score was 58.5 ± 20.1 for the control group and 94.9 ± 3.3 for the experimental group. The experimental group made significantly greater gains (t = .284, p < .001; Table 2).

Satisfaction Questionnaire

The Cronbach's alpha coefficient for the questionnaire was .95, providing evidence for the reliability of the questionnaire items. The total mean scale score of the control group was 55.8 ± 11.7, whereas the total mean score of the experimental group was 70.4 ± 6.8. There was statistically significant difference in the scores of the questionnaire items and the total score for the two groups. The findings of the study showed that the mean satisfaction level of the experimental group was significantly higher than that of the control group (t = 8.328, $p < .001$).

Discussion

Different teaching methods have been used to teach urinary catheterization skills from the past to the present. Demonstration with a low-fidelity task trainer or three-dimensional human anatomical organ models is the most widely used one among conventional teaching methods. In teaching the skills of urinary catheterization practice according to conventional teaching methods, educators explain the purpose, indications, complications, application method, necessary materials and nursing interventions to be considered in the classroom. Then, demonstration training is applied with the low-fidelity task trainer in order to transform theoretical knowledge into behavior in nursing skills laboratories. When clinical practice is used to reinforce the behavior, since it is a complicated procedure, and students are not allowed to apply urinary catheterization, the development and reinforcement of the said nursing skill are left to the process after graduation. However, innovative teaching methods have been preferred instead of classical teaching methods due to changing education requirements, decreasing clinical work practice opportunities, increasing numbers of students and insufficient numbers of educators. Teaching urinary catheter application, a nursing skills, with haptic technology creates an effective and permanent teaching opportunity for generation Z, who are born in the digital age, without requiring a clinical and laboratory environment (Balcı Akpınar, 2014; Kızıl & Şendir, 2019).

The results of this study supported the view that using haptic technology to teach the skill of urinary catheter application increases the level of success and achievement about the skill. In this study, the Urinary Catheterization Skill Checklist mean score of the students was 58.5 ± 20.1 in the control group, while it was 94.9 ± 3.3 in the experimental group. The Urinary Catheterization Skill Checklist scores were significantly different in favor of the experimental group ($p < .001$). Haptic systems represent some of the highest levels of computer-based education technologies and enable students to learn on a higher level (Chamorro-Moriana et al., 2018; Francone et al., 2019; Rangarajan et al., 2020). With haptic interactive computer-based simulation, the student is guided to follow the steps in order. It cannot proceed to the next step without completing a process step. If the student clicks on the "skip the process step" button, they know that their score will decrease. When they perform an incorrect operation, it appears on the screen as an information note where the error originated. When all process steps are completed, the student can see on the screen how their performance in the process steps is in the simulation evaluation form, which process step is correct and which one is incorrect. These practices increase the student's focus and success by providing active participation in education (Kızıl & Şendir, 2019; Şendir & Doğan, 2015; Şendir & Kızıl, 2019). Previous studies have reported that haptic systems are effective and successful in developing psychomotor skills, thus, supporting the results of this study (Choi et al., 2015; Heuer & Lüttgen, 2014; Si et al., 2019; Solaro et al., 2020; Van der Meijden & Schijven, 2009; Williams & Carnahan, 2014; Zhou et al., 2012). Choi et al. (2015) stated that haptic technology is an effort to modernize clinical nursing education and provides superiority over traditional methods in teaching clinical practice. Jung et al. (2012) found that the success score of students who received education with haptic technology in teaching intravenous application skills was higher than those who received education with the traditional anatomical arm model. Heuer and Lüttgen (2014) determined that haptic technology increases the level of success in developing motor skills. Kusins et al. (2018) reported that haptic technology is effective and reliable in teaching complex surgical practices that require fine motor skills. Lai et al. (2020) found that haptic technologies that provide feedback outperform other methods in terms of cost effectiveness as well as success. Data collected from the literature supported the findings of this study. In addition to many advantages of haptic interactive computer-based simulations, there are also disadvantages such as high cost and being limited to certain nursing skills. However, there are limited studies in the literature that talk about the disadvantages of haptic systems (Choi et al., 2015).

The level of satisfaction of the students about the teaching method was 55.8 ± 11.7 in the control group and 70.4 ± 6.8 in the experimental group in this study. The level of satisfaction of the students about the teaching method was significantly different in favor of the experimental group ($p < .001$). Choi found that virtual reality-based haptic technology in gaining nasogastric tube application skills increases the satisfaction level of the student about the education process. Additionally, their study revealed that haptic technology is a teaching method that may increase teaching opportunities, enable asynchronous self-learning and accelerate the learning curve (Choi, 2017). The literature has reported that the level of satisfaction about education and teaching is effective on academic achievement (Egelioglu et al., 2011; Türkmen et al., 2009). Thus, it is important to benefit from teaching methods to increase students' satisfaction levels. Moreover, it is stated that haptic technologies are also successful and increase the level satisfaction in patient education (Baur et al., 2018; McWilliams et al., 2017; Piggott et al., 2016; Rabin et al., 2015). Piggott et al. used haptic feedback to improve rehabilitation in patients with upper extremity paralysis. They reported that haptic feedback creates safe environments in developing patients' motor skills, and interactive games provide improvement in ROM movements by increasing the level of satisfaction with the therapy (Piggott et al., 2016). Solaro et al. (2020) stated that haptic technology is effective in improving upper extremity dysfunction in patients with multiple sclerosis. Rossi et al. (2020) used wearable haptic rings to improve the walking of patients with Parkinson's disease and reported that this technology improved the patients' walking speed, step variance and interaction with the environment. The finding in this study that haptic technology increased the students' satisfaction levels was similar to those reported in the literature.

This study found that some sociodemographic characteristics of the students affected their levels of satisfaction. The levels of satisfaction significantly differed based on place of residence where the students had lived for the longest time. The satisfaction levels of those who lived in metropolitan cities and cities were higher than those who lived in counties. This finding may indicate that technology is more commonly used in metropolitan cities, and technology-based haptic practices are accepted quicker there. Gürpınar et al. (2009) stated that those who use computers in a limited time and do not like to use computers may have low levels of satisfaction with e-learning. Another study showed that students' sufficient knowledge of computer and internet use was one of the most significant reasons for their satisfaction with an e-learning application (Gürpınar, 2007). The finding of this study was similar to those in the literature.

Limitations and Strengths of the Study

The strengths of the study were assigning students randomly to the groups, including a control group, applying the skill in line with the literature, having an appropriate environment to prevent students from being affected by each other during the implementation, and spending time for students to perform different applications after the research was completed.

Explaining the practices to the groups at the same time and not having the opportunity to practice beforehand was determined as a limitation of the study as it could have affected the students negatively.

Although it was an expected method that the success rates of the students assigned to the experimental group who tried an innovative teaching method were compared to those of the students assigned to the control group, it was determined as a limitation of the study. However, the aim of this study was to introduce innovative teaching methods to the profession of nursing and to carry out studies that enable these methods to be used in other nursing skill applications.

Conclusion

This study revealed that the levels of success and satisfaction about urinary catheter application skills were higher in the students who used haptic technology, and some socio-demographic characteristics affected the levels of success and satisfaction of the students. Haptic systems, which are among systems with advanced technology, have become an important tool in practices on which real-time studies have been performed in recent years. It is recommended to include more haptic technologies that are distinguished from other peripheral units due to their ability to provide a sense of touch to the user and enable the perception of sense of touch with the haptic arm and haptic interactive glove in a virtual environment in the nursing curriculum and to increase the use of technology in teaching methods.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The authors would like to declare that there is no issue related to conflict of interest for this study.

Acknowledgments

The authors would like to thank the nursing staff for their help, as well as the pediatric patients and their parents for participating in this study.

References

Abirami, B., Pradeepa, K., Vithrapathy, N., & Shafiq, N. (2018). Haptic technology. *International Research Journal of Engineering and Technology (IRJET)*, *5*(2), 719–721.

Alan, H., Peker, E., Arslan, D., Toprak, F., & Eşkin Bacaksız, F. (2020). Evaluation of national studies about "Generations of Nursing" which had been published between the years 2014-2019 in Turkey: A systematic review. *Journal of Vocational School of Health Service*, *8*(3), 1002–1017. doi:10.33715/inonusaglik.745269.

Balcı Akpınar, R. (2014). Urinary elimination. In T. Atabek Asti (Ed.), *Fundamental of nursing: Nursing science and art* (pp. 970–1015). Academy Printing and Publishing.

Baur, K., Speth, F., Nagle, A., Riener, R., & Klamroth-Marganska, V. (2018). Music meets robotics: A prospective randomized study on motivation during robot aided therapy. *Journal of Neuroengineering and Rehabilitation*, *15*(1), 79.

Bayat, M. (2005). Teaching process and nursing. *Journal of Health Sciences*, *14*(Ek Sayı: Hemşirelik Özel Sayısı), 66–72.

Bowyer, M., Pimentel, E., Fellows, J., Scofi eld, R., Ackerman, V., Horne, P., & Scerbo, M. (2005). Teaching intravenous cannulation to medical students: Comparative analysis of two simulators and two traditional educational approaches. *Studies in Health Technology and Informatics*, *111*, 57–63.

Bulechek, G., Butcher, H. K., & Dochterman, J. M. et al. (2017). Nursing Interventions Classification (NIC). F. Erdemir, S. Kav, & ve A. A. Yılmaz (Çev) 6. Baskı. Nobel Tıp Kitapevi.

Chamorro-Moriana, G., Moreno, A. J., & Sevillano, J. L. (2018). Technology-based feedback and its efficacy in improving gait parameters in patients with abnormal gait: A systematic review. *Sensors*, *18*(1), 142.

Choi, K.-S. (2017). Virtual reality in nursing: Nasogastric tube placement training simulator. *Studies in Health Technology and Informatics*, *245*, 1298.

Choi, K.-S., He, X., Chiang, V. C.-L., & Deng, Z. (2015). A virtual reality-based simulator for learning nasogastric tube placement. *Computers in Biology and Medicine*, *57*, 103–115.

Egelioglu, N., Arslan, S., & Bakan, G. (2011). The effect of satisfaction status of nursing students on their academic achievement. *Turkish Journal of Research & Development in Nursing*, *13*(1).

Francone, A., Huang, J. M., Ma, J., Tsao, T.-C., Rosen, J., & Hubschman, J. P. (2019). The effect of haptic feedback on efficiency and safety during preretinal membrane peeling simulation. *Translational Vision Science & Technology*, *8*(4), 2.

Gonzalez-Badillo, G., Medellin-Castillo, H., Lim, T., Ritchie, J., & Garbaya, S. (2014). The development of a physics and constraint-based haptic virtual assembly system. *Assembly Automation.Emerald Insigt*, *34*(1), 1–5.

Göriş, S., Bilgi, N., & Bayındır, S. K. (2014). Use of simulation in nursing education. *Journal of Duzce University Health Sciences Institute*, *1*(2), 25–29.

Gündoğdu, H. (2017). *The effect of computer-based simulation system designed for subcutaneous drug application skills on the students anxiety levels and psychomotor skills performance*. Online Master Thesis.

Gündoğdu, H., & Dikmen, Y. (2017). Simulation in nursing education: Virtual reality and haptic systems. *Journal of Human Rhythm*, *3*(4), 173–176.

Gürpınar, E. (2007). *Instruction technologies in medical education: Integration of e-learning and problem-based learning.* (Online Master Thesis), Sakarya University.

Gürpınar, E., Zayim, N., Başarıcı, İ., Gündüz, F., Asar, M., & Oğuz, N. (2009). E-Learning and problem-based learning integration in cardiology education. *The Anatolian Journal of Cardiology*, *9*, 158–164.

Hekimoğlu, C. H., & Sahan, S. (2020). Investigation of death related factors in urinary catheter-associated urinary tract infections. *Turkish Bulletin of Hygiene & Experimental Biology*, *77*(3), 325–332.

Heuer, H., & Lüttgen, J. (2014). Motor learning with fading and growing haptic guidance. *Experimental Brain Research*, *232*(7), 2229–2242.

Jamison, R. J., Hovancsek, M. T., & Clochesy, J. M. (2006). A pilot study assessing simulation using two simulation methods for teaching intravenous cannulation. *Clinical Simulation in Nursing*, *2*(1), e9–e12.

Jung, E.-Y., Park, D. K., Lee, Y. H., Jo, H. S., Lim, Y. S., & Park, R. W. (2012). Evaluation of practical exercises using an intravenous simulator incorporating virtual reality and haptics device technologies. *Nurse Education Today*, *32*(4), 458–463.

Kızıl, H., & Şendir, M. (2019). Innovative approaches in nursing education. *Journal of Human Sciences*, *16*(1), 118–125.

Kusins, J. R., Strelzow, J. A., LeBel, M.-E., & Ferreira, L. M. (2018). Development of a vibration haptic simulator for shoulder arthroplasty. *International Journal of Computer Assisted Radiology and Surgery*, *13*(7), 1049–1062.

Lai, W., Cao, L., Tan, R. X., Tan, Y. C., Li, X., Phan, P. T., & Phee, S. J. (2020). An integrated sensor-model approach for haptic feedback of flexible endoscopic robots. *Annals of Biomedical Engineering*, *48*(1), 342–356.

McWilliams, L. A., Malecha, A., Langford, R., & Clutter, P. (2017). Comparisons of cooperative-based versus independent learning while using a Haptic Intravenous Simulator. *Clinical Simulation in Nursing*, *13*(4), 154–160.

Öztürk, D., & Dinç, L. (2014). Effect of web-based education on nursing students' urinary catheterization knowledge and skills. *Nurse Education Today*, *34*(5), 802–808.

Piggott, L., Wagner, S., & Ziat, M. (2016). Haptic neurorehabilitation and virtual reality for upper limb paralysis: A review. *Critical Reviews in Biomedical Engineering*, *44* (1-2).
Potter, P. A., Perry, A. G., Stockert, P., Hall, A., & Castaldi, P. (2016). *Study Guide for Basic Nursing-E-Book*. Elsevier Health Sciences.
Rabin, E., Demin, A., Pirrotta, S., Chen, J., Patel, H., Bhambri, A., & Di Francisco-Donoghue, J. (2015). Parkinsonian gait ameliorated with a moving handrail, not with a banister. *Archives of Physical Medicine and Rehabilitation*, *96*(4), 735–741.
Rangarajan, K., Davis, H., & Pucher, P. H. (2020). Systematic review of virtual haptics in surgical simulation: A valid educational tool? *Journal of Surgical Education*, *77*(2), 337–347.
Rossi, S., Lisini Baldi, T., Aggravi, M., Ulivelli, M., Cioncoloni, D., Niccolini, V., & Prattichizzo, D. (2020). Wearable haptic anklets for gait and freezing improvement in Parkinson's disease: A proof-of-concept study. *Neurological Sciences*, *41*, 3643–3651.
Şendir, M., & Coşkun, E. Y. (2016). A technological step in nursing education: IM ventro-sim. *JAREN*, *2*(2), 103–108.
Şendir, M., & Doğan, P. (2015). Use of simulation in nursing education: A systematic review. *Florence Nightingale Hemşirelik Dergisi*, *23*(1), 49–56.
Şendir, M., & Kızıl, H. (2019). Innovative approach in nasogastric drug practice teaching: NAZO-AR. *Journal of Duzce University Health Sciences Institute*, *9*(2), 86–90.
Senturan, L. (2015). Urinary System Applications. In N. Sabuncu (Ed.), *Clinical skills* (pp. 476–477). Nobel Medical Bookstores.
Si, W.-X., Liao, X.-Y., Qian, Y.-L., Sun, H.-T., Chen, X.-D., Wang, Q., & Heng, P. A. (2019). Assessing performance of augmented reality-based neurosurgical training. *Visual Computing for Industry, Biomedicine, and Art*, *2*(1), 6.
Smith, P. C., & Hamilton, B. K. (2015). The effects of virtual reality simulation as a teaching strategy for skills preparation in nursing students. *Clinical Simulation in Nursing*, *11*(1), 52–58.
Solaro, C., Cattaneo, D., Basteris, A., Carpinella, I., De Luca, A., Mueller, M., & Sanguineti, V. (2020). Haptic vs sensorimotor training in the treatment of upper limb dysfunction in multiple sclerosis: A multi-center, randomised controlled trial. *Journal of the Neurological Sciences*, *412*, 116743.
Türkmen, E., Işıl, I., Balci, S., Topçu, S. A., Abali, S., & Karaçay, P. (2009). Success, expectations, and satisfaction levels of nursing/health school students attending to the basic life support course. *Journal of Intensive Care Nursing*, *13*(2), 55–62.
Van der Meijden, O. A., & Schijven, M. P. (2009). The value of haptic feedback in conventional and robot-assisted minimal invasive surgery and virtual reality training: A current review. *Surgical Endoscopy*, *23*(6), 1180–1190.
Williams, C. K., & Carnahan, H. (2014). Motor learning perspectives on haptic training for the upper extremities. *IEEE Transactions on Haptics*, *7*(2), 240–250.
Zhou, M., Tse, S., Derevianko, A., Jones, D., Schwaitzberg, S., & Cao, C. (2012). Effect of haptic feedback in laparoscopic surgery skill acquisition. *Surgical Endoscopy*, *26*(4), 1128–1134.