The Effect of Flipped Classroom Model and Kahoot for Intramuscular Injection Training on Nursing Students' Knowledge, Skills and Self-Efficacy Levels

İntramüsküler Enjeksiyon Eğitimi İçin Ters Yüz Sınıf Modeli ve Kahoot'un Hemşirelik Öğrencilerinin Bilgi, Beceri ve Özyeterlilik Düzeyleri Üzerindeki Etkileri

Banu TERZİ[1]　　iD
Ayşegül ILGAZ[2]　　iD

[1]Akdeniz University, Faculty of Nursing, Department of Fundamentals of Nursing, Antalya, Türkiye
[2]Akdeniz University, Faculty of Nursing, Department of Public Health Nursing, Antalya, Türkiye
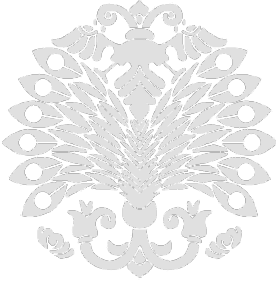
ABSTRACT

Objective: To investigate the effects of using a flipped classroom model and Kahoot for intramuscular injection skill training on the knowledge, skill, and self-efficacy levels of nursing students.

Methods: The quasi-experimental study was conducted with a total of 180 nursing students (intervention group n=95, control group n=85). Data were collected using a "Knowledge Level Questionnaire," "Psychomotor Skill Control Form," and the "General Self-Efficacy Scale". The flipped classroom model was used in the intervention group. In addition, the multiple-choice questions in Kahoot were asked to both groups.

Results: The final test knowledge scores and general self-efficacy scores of the students in the intervention group were found to be statistically higher than the students in the control group (*P*<.001). The psychomotor skill scores of the students in the intervention group were statistically higher than the students in the control group (*P*=.010). Regarding the use of Kahoot, the percentage of correct answers for each question was significantly higher for the intervention group than the control group (*P*<.05).

Conclusion: It can be said that the flipped classroom model and Kahoot are effective in intramuscular injection training. The flipped classroom model and Kahoot could also be used for the teaching of other basic nursing skills.

Keywords: Basic nursing skills, flipped classroom, intramuscular injection, Kahoot, nursing students, self-efficacy

ÖZ

Amaç: İntramüsküler enjeksiyon beceri eğitimi için ters yüz sınıf modeli ve Kahoot kullanımının hemşirelik öğrencilerinin bilgi, beceri ve öz yeterlilik düzeylerine etkisini araştırmaktır.

Yöntemler: Yarı deneysel çalışma toplam 180 hemşirelik öğrencisi ile yürütülmüştür (müdahale grubu n=95, kontrol grubu n=85). Veriler "Bilgi Düzeyi Anketi", "Psikomotor Beceri Kontrol Formu" ve "Genel Öz Yeterlilik Ölçeği" kullanılarak toplanmıştır. Müdahale grubunda ters yüz edilmiş sınıf modeli kullanılmıştır. Ayrıca, Kahoot'taki çoktan seçmeli sorular her iki gruba da sorulmuştur.

Bulgular: Müdahale grubundaki öğrencilerin son test bilgi puanları ve genel öz yeterlik puanları kontrol grubundaki öğrencilere göre istatistiksel olarak daha yüksek bulunmuştur (*P*<.001). Müdahale grubundaki öğrencilerin psikomotor beceri puanları kontrol grubundaki öğrencilerden istatistiksel olarak daha yüksektir (*P*=.010). Kahoot kullanımı ile ilgili olarak, her bir soru için doğru cevap yüzdesi müdahale grubunda kontrol grubuna göre anlamlı derecede daha yüksektir (*P*<.05).

Sonuç: Ters yüz sınıf modeli ve Kahoot'un intramüsküler enjeksiyon eğitiminde etkili olduğu söylenebilir. Ters yüz sınıf modeli ve Kahoot diğer temel hemşirelik becerilerinin öğretiminde de kullanılabilir.

Anahtar Kelimeler: Temel hemşirelik becerileri, ters yüz sınıf, intramüsküler enjeksiyon, Kahoot, hemşirelik öğrencileri, öz yeterlilik

INTRODUCTION

Basic concepts of nursing care and basic nursing skills are taught in the Fundamentals of Nursing course, which is a mandatory course at undergraduate-level nursing schools in Turkey. Traditional methods of theoretical courses, demonstrations, and videos are used for the teaching of the most basic nursing skills within the scope of the Fundamentals of Nursing course. Also, professors frequently share their own experiences during courses. Students are always passive listeners during the the Fundamentals of Nursing course.[1] Intramuscular injection (IM), one of the most important basic nursing skills included in the curriculum, aims to ensure patient safety and requires sufficient knowledge and skills. IM injection is defined as the injection of a drug into the deep and large muscles.[2,3] IM injections are one of the most common basic nursing skills used for parenteral drug applications, but it is also a complex process that requires nurses to have psychomotor skills and to be able to make critical decisions about the application method and tools.[4] However, when not performed with a safe and accurate injection technique, it is known that IM injections can cause serious complications such as local and systemic infections, hematoma, ecchymosis, pain, and vein and nerve damage.[5,6] It is stated that these complications caused by IM injections are mostly caused by a lack of knowledge and skills.[7] Therefore, it is critically important that the nurses who perform this intervention have sufficient knowledge and psychomotor skills to prevent complications associated with IM injections.[8-10] To safely administer IM injections in clinical practice, this skill must be acquired during nursing education. On the other hand, some studies in the literature indicate that the IM injection knowledge and skill levels of nursing students are not sufficient.[7,11] Therefore, different teaching methods should be developed to improve the knowledge and skill levels of nursing students on IM injections.[12] For nursing education in Turkey, IM injection skills are generally taught using traditional methods such as theoretical lectures, demonstrations, videos, and practice on task-trainer models. However, parallel with the technological developments in recent years, it has become inevitable that learner-centered teaching methods (invention, teaching with scenario, experimental method and teaching with games) are used. One of the learner-centered teaching methods is the flipped classroom model.[13]

The flipped classroom model, developed by Bergmann and Sams,[14] is defined as "flipping the order of typical activities in the classroom lectures with traditional teaching methods and home assignments and usually supporting or integrating it with instructive videos".[15] This method enables reading and access to information before courses and ensures the performance of learner-centered activities during courses. In this method, lecture content and related interactive training videos are shared with the students beforehand and sample cases are studied, techniques are explained, and interactive discussions are held during the lectures.[16,17] Kahoot, one of the most common interactive applications, is an easy, free, real-time, and game-based learning platform.[18] Kahoot is a free tool used for preparing exams and questionnaires. The tool can be used for the introduction to the subject, summary of the subject, and the verification of student's knowledge. The tool allows for setting a time limit to complete the task according to the difficulty level and the progress of the students. The instructor can view the student's progress and their answers. The results are obtained as a percentage after completing the test, which eases evaluating the results.[18,19]

The flipped classroom model has become one of the most important teaching methods commonly used in nursing education in recent years.[13] The efficiency of the flipped classroom model in nursing education was assessed in a meta-analysis study and it was identified that it positively affected nursing students' clinical sufficiency, critical thinking skills, self-management, and learning satisfaction.[13] In a randomized controlled trial examining the effect of gamified flipped classroom on improving nursing students' skill competence and motivation to learn, it was found that compared to traditional flipped classrooms, gamified flipped classrooms increased nursing students' motivation, preparation intensity, skill knowledge and self-confidence during laboratory clinical practice.[20] The effects of the flipped classroom model on anatomy and physiology courses of nursing students were investigated in another study. In this study, it was stated that the academic success of the students who were educated using the flipped classroom model was higher than those who were educated with traditional teaching methods; 78% of the students stated that the model enhanced learning and increased the interest in the course.[21] In another quasi-experimental study examining the learning effects of the flipped classroom model on the vital signs skills of nursing students, it was found that the use of the flipped classroom model in nursing education positively affected both theoretical knowledge and psychomotor skill acquisition.[22] In another study examining the effect of flipped classroom technique on nursing students' knowledge and self-efficacy regarding the care of COVID-19 infected pregnant women; it was suggested that the flipped classroom applied in online formats can be a

very useful resource for designing active learning environments where university students can improve their knowledge and sense of self-efficacy.[23]

Instead of traditional teaching methods that are still frequently used in nursing education, it is recommended to use effective teaching methods that can provide students with the opportunity to perform procedures such as IM injections without time and space limitations, which students cannot find enough observation and practice opportunities in the clinical environment or cannot experience enough due to concerns about patient safety.[7,24] In the literature, the flipped classroom model and Kahoot were used for different areas such as medicine, pharmacy, dentistry, and nursing.[25-28] However, no study was found that evaluated the effects of these two methods together on IM injection training. It was stated in a meta-analysis study that using the flipped classroom model for nursing education would improve clinical skills, learning motivation, and self-efficacy.[13]

AIM

The present study aimed to investigate the effects of the flipped classroom model and Kahoot for IM injection training on the knowledge, skill, and self-efficacy levels of first-year nursing students.

Hypotheses of the Research:
H_0: The flipped classroom model and Kahoot for IM injection training do not affect the knowledge, skill, and self-efficacy levels of nursing students.
H_1: The flipped classroom model and Kahoot for IM injection training are effective on the knowledge, skill, and self-efficacy levels of nursing students.

METHODS

Study design
The quasi-experimental study aimed to evaluate the effects of the flipped classroom model and Kahoot for IM injection training on the knowledge, skill, and self-efficacy levels of first-year nursing students.

Population and sample of the study
IM injections are taught to first-year nursing students in the Fundamentals of Nursing course. IM injection training includes 4 hours of theoretical lectures and 4 hours of laboratory practice. The population of the research comprised first-year nursing students who took the Fundamentals of Nursing course in the spring semester of 2021-2022. Students are divided into two branches, A and B, in this course, because the number of first-year nursing students is very high. This course is given in two branches on different days (A branch on Tuesday-Wednesday, B

branch on Thursday-Friday). Students choose these branches themselves during course registration. Half of the students were enrolled in one branch and the other half were enrolled in the other branch. In the study, branch A was chosen as the intervention group and the branch B was chosen as the control group. A total of 246 students took the Fundamentals of Nursing course. Twenty-two of these students who took the class for the second or third time were excluded from the study and first-year nursing students who took the Fundamentals of Nursing course for the first time were included in the study. The population of the research comprised 224 students. The G*Power software package was used for calculating the sample of the research. In a meta-analysis study by Park and Sub,[13] the effect size of the effect of the flipped classroom model in nursing education on clinical skills was calculated as 0.53. The sample size of the research was primarily calculated using the t-test for independent groups of a total of 114 students (57 students in each group) by using 80% power, 95% confidence intervals, and the effect size value (d=0.53). Assuming a 10% loss in the sample, it was aimed to reach at least 126 students. The study was conducted with students who agreed to participate. Ninety-five students were included in the intervention group and 85 students were included in the control group.

Application
In the research, the theoretical part of the Fundamentals of Nursing course is given for a total of 14 weeks during the spring semester. IM injection techniques were explained in theoretical courses for 4 hours per week in the morning and then, laboratory practice of IM injections was performed for 4 hours for both groups (intervention and control groups) on the same day in the afternoon. Nursing students participated in laboratory practices in groups of 15-20 and performed IM injections on the task-trainer models one by one. Each student practiced on the models at least three times until they learned the IM skill. Final tests were collected from both groups at the end of the laboratory practice and Kahoot with five questions being given to both groups immediately after the practice.

Intervention group: Students in the intervention group forming branch A received IM injection training by using the flipped classroom model and Kahoot on Tuesday. The intervention group was provided with theoretical lecture notes a week before. Moreover, students were provided with links to both interactive videos about the subject and animated videos on IM injection skills on the Edpuzzle platform, which is a free online interactive learning tool that was used specifically for this study. Only the students in the intervention group were given access to these videos. These videos also included multiple-choice

questions, true-false questions, and notes. During the theoretical classes, the instructor and students held discussions about the interactive videos, and the parts that the students did not understand were explained. Moreover, the instructor performed a demonstration using task-trainer models during the theoretical class. Each student in the intervention group performed IM injections on task-trainer models during the laboratory practice. Kahoot was used at the end of the laboratory practice.

Control group: Students in the control group forming branch B were given IM injection training using traditional teaching methods on Thursday. Traditional teaching methods included PowerPoint presentations and demonstrations using task-trainer models. Each student performed IM injections on task-trainer models during the laboratory practice. Kahoot was used at the end of the laboratory practice.

Data collection

The research was conducted in a nursing faculty located in the south of Turkey. The data of the research were collected using pre-tests and post-tests. Pre-tests were collected before the theoretical classes and post-tests were collected at the end of the laboratory practice. In addition to the socio-demographic characteristics (age, sex) of the participating students, a Knowledge Level Questionnaire and General Self-Efficacy Scale were used for the pre-tests and post-tests. Task-trainer models and low-fidelity simulations were also used by the instructor during the laboratory practice for both groups. Each student was asked to perform IM injections on the task-trainer model following the simulation. The students' skill levels were evaluated by the instructors of the Fundamentals of Nursing course by using the Psychomotor Skill Control Form. Post-tests (Knowledge Level Questionnaire and General Self-Efficacy Scale) were administered at the end of the laboratory practice. Pre-tests and post-tests were completed by the students (Figure 1).

Measurements

Data from the research were collected using the "Knowledge Level Questionnaire," "Psychomotor Skill Control Form," and "General Self-Efficacy Scale."

Knowledge Level Questionnaire: Experts in the field were consulted in the creation of the knowledge level questionnaire, and questions regarding the technique of IM injection administration skills were included. The questionnaire, prepared by the researcher, consists of 10 questions on IM injection training. All questions are multiple-choice. Each question is evaluated as 10 points

and the total score of the questionnaire is 100 points. Item analysis was performed on knowledge-level questions. The item difficulty index (p) for 10 questions of knowledge level varies between 0.21 and 1.00. These values mean that the questions range from very hard to very easy. The item distinctiveness index (r) ranges from 0.38 to 0.58, which shows that item discrimination ranges from good to excellent discrimination.[29]

Psychomotor Skill Control Form: The Psychomotor Skill Control Form was prepared by the researchers according to the literature[4,30-33] and an expert's opinion. The form was completed by seven instructors who give the Fundamentals of Nursing course. The form includes information on ventrogluteal IM injections and consists of a total of 17 items ("6 right principles," "ensuring privacy," "positioning the patient," "determining the ventrogluteal IM site," " IM injection administration technique," "removal of contaminated materials," and "recording the procedure"). Each item is scored differently. Each student was given a total skill score after evaluating each item as "Performed" or "Not performed". Accordingly, the form is scored as "0-30 points: Inadequate," "31-69 points: Needs improvement," and "70 points and above: Adequate".

General Self-Efficacy Scale: The original form of the scale including 23 items was developed by Sherer et al.[34] The scale was adapted into Turkish by Yıldırım and İlhan.[35] The scale is a five-point Likert scale with responses ranging from "not at all true" to "completely true" to the question "How well does it describe you?" Items 2, 4, 5, 6, 7, 10, 11, 12, 14, 16, and 17 are reverse scored. The scale consists of three sub-dimensions, "Initiative" (2, 4, 5, 6, 7, 10, 11, 12, 17), "Effort" (3, 13, 14, 15, 16), and "Persistence" (1, 8, 9). The total score that can be obtained from the scale ranges from 17 to 85. A higher score indicates an increase in self-efficacy. Cronbach's alpha coefficient for the Turkish validity and reliability study of the scale was 0.80.[35] In this study, Cronbach's alpha coefficient for the pre-test General Self-Efficacy Scale was found as 0.858 and Cronbach's alpha coefficient for the post-test General Self-Efficacy Scale was found as 0.877.

Kahoot! Test

The Kahoot! test includes a total of five multiple-choice questions with five options. Each question has only one correct answer. This test was performed by asking the same questions to both groups immediately after the post-tests. The questions in this test are different from those in the Knowledge Level Questionnaire.
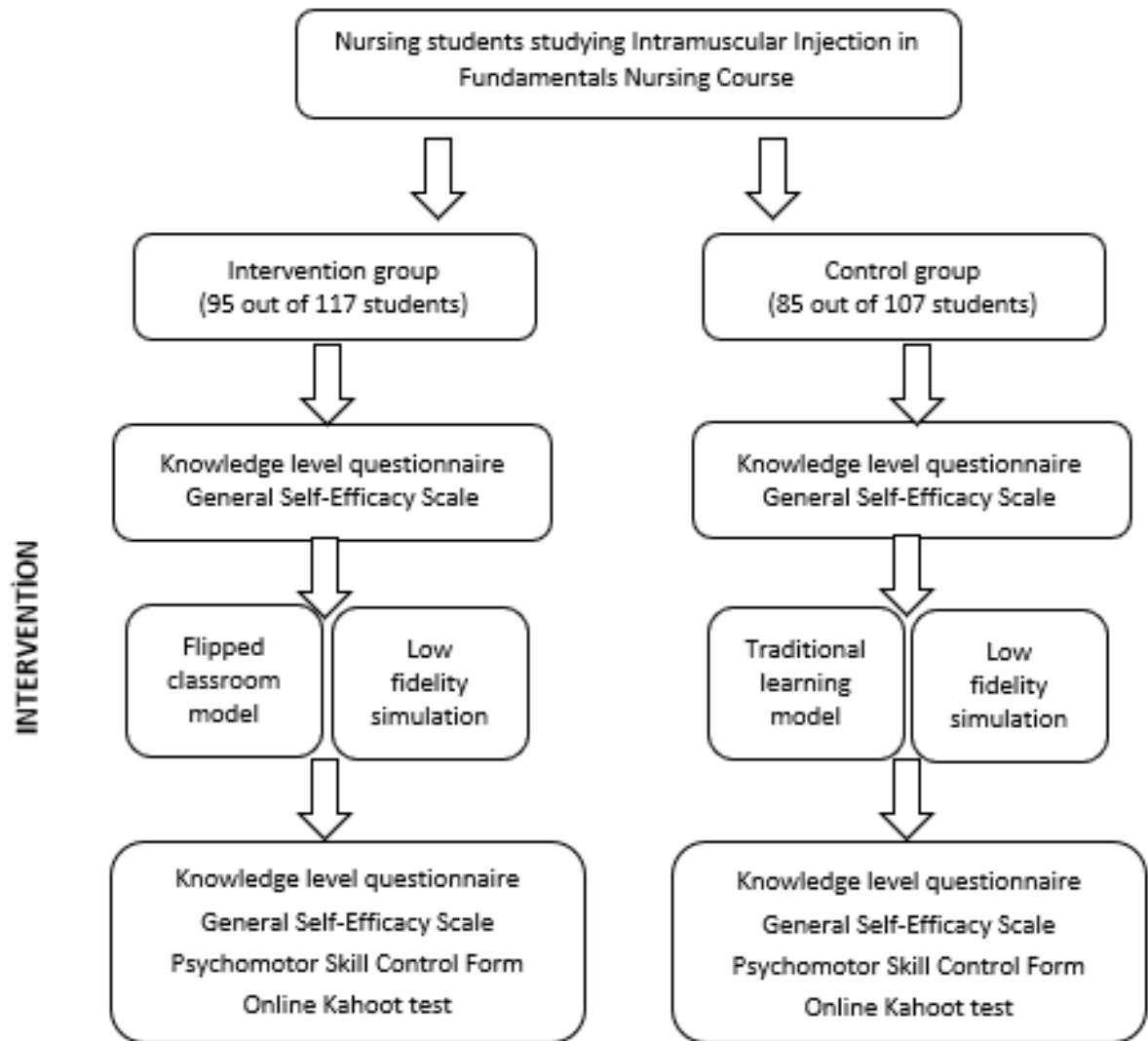
Figure 1. Flow-Chart of Study

Data analysis

A licensed IBM SPSS 23.0 statistical program was used for data analysis. The conformity of the data to normal distribution was evaluated using normality tests and it was identified that the data were not normally distributed. The Wilcoxon signed-ranks test was used for the in-group comparison of the knowledge scores, psychomotor skill scores, and scores obtained from the General Self-Efficacy test. The Mann-Whitney U test was used to compare the pre-test and post-test scores of the two groups (comparison between groups). The Chi-square test was used for the comparison of the students' answers to the Kahoot questions (comparison between groups). The level of statistical significance (α) was accepted as 0.05.

Ethical approval

The Declaration of Helsinki was abided by throughout the research and students' willingness and voluntariness to participate in the research was taken into account. Written consents were obtained from Akdeniz University Faculty of Medicine Clinical Research Ethics Committee (Date: 16/03/2022, Number: KAEK-175) and the institution at which the research was conducted. Written consent from the students who agreed to participate in the research was obtained. The flipped classroom model and Kahoot were applied to all students in the intervention group. However, to be ethical, Edpuzzle videos were shared with the students in the control group after completing the post-tests.

RESULTS

The average age of the first-year nursing students who participated in the research was 19.36±1.07 years and 68.9% of the participants were female. In the comparison

of the knowledge scores of the students between groups, there was no difference between the pre-test knowledge scores of the intervention and control groups. However, the post-test knowledge score of the intervention group was significantly higher than the control group (*P*<.001). In the in-group comparison of knowledge scores, the post-test scores of both groups were higher than their pre-test scores (*P*<.001) (Table 1). The psychomotor skill scores of the nursing students were compared, and the psychomotor skill scores of the students in the intervention group were significantly higher than those in the control group (Table 2).

Table 1. Participants' Knowledge Scores on Intramuscular Injections

	Pre-test Knowledge Score Mean (SD) Median (IQR)	Post-test Knowledge Score Mean (SD) Median (IQR)	z and *P*-value
Intervention group (n=95)	49.68 (20.90) 50.00 (30.00)	88.52 (11.38) 90.00 (20.00)	-8.30 / **<.001****
Control group (n=85)	48.00 (18.63) 50.00 (20.00)	74.23 (14.00) 70.00 (20.00)	-7.08 / **<.001****
z and *P*-value	-0.58/ .560*	-6.67/ **<.001***	

SD, Standard deviation; IQR, Interquartile range; *Mann-Whitney U test; **Wilcoxon signed-ranks test

Table 2. The Psychomotor Skill Scores Regarding Intramuscular Injection of The Nursing Students in The Intervention And Control Groups

	Psychomotor Skill Score for Intramuscular Injections Mean (SD) Median (IQR)	z and *P*-value
Intervention group (n=95)	91.28 (9.65) 95.00 (13.00)	-2.58/ **.010***
Control group (n=85)	80.43 (26.47) 82.00 (14.00)	

SD, Standard deviation; IQR, Interquartile range; *Mann-Whitney U test

General self-efficacy scores of the nursing students were compared both in-group and between groups. The pre-test general self-efficacy scores of the two groups were similar (*P*>.05). However, there was a statistically significant difference between the post-test scores of the two groups (*P* <.05). The post-test general self-efficacy scores of the intervention group were higher than the control group. In an in-group comparison, the post-test general self-efficacy scores of the intervention group were found higher than the pre-test scores. No significant difference was found between the pre-test and post-test general self-efficacy scores of the control group (*P* >.05) (Table 3).

As a result of Kahoot being used with the nursing students, the percentage of correct answers for each question was significantly higher in the intervention group than in the control group (*P*<.05). Most mistakes were made in the fifth question and the students in the intervention group had a higher correct answer rate (Table 4).

DISCUSSION

In the Fundamentals of Nursing course, nursing students learned about an invasive intervention for the first time during the IM injection skill training. Students usually have difficulties in fully remembering the steps of IM injection processes after watching demonstrations. Therefore, different methods should be used to teach nursing students IM injections to teach it with the correct steps. Moreover, it is essential to increase the students' self-efficacy for them to gain IM injection skills. In this study, the flipped classroom model and Kahoot were used to increase the knowledge, skill, and self-efficacy levels of the students in IM injection skill training.

Table 3. The Change in General Self-Efficacy Levels of Nursing Students in The Intervention and Control Groups

	Pre-test Knowledge Score Mean (SD) Median (IQR)	Post-test Knowledge Score Mean (SD) Median (IQR)	z and P-value
Intervention group (n=95)	65.09 (10.70) 67.00 (13.00)	72.18 (8.21) 75.00 (10.00)	-6.54 / **<.001****
Control group (n=85)	65.90 (9.20) 67.00 (11.50)	67.38 (10.35) 70.00 (13.00)	-1.78 / .075**
z and P-value	-0.12/ 0.909*	-3.35/ **.001***	

*Mann Whitney U test; **Wilcoxon signed-ranks test

Table 4. Responses of Nursing Students in The Intervention and Control Groups to Kahoot Questions

		Intervention Group*		Control Group*		χ^2	P
		n	%	n	%		
Question 1	Correct answer	84	58.3	60	41.7	5.873	**.015**
	Wrong answer	22	39.3	34	60.7		
Question 2	Correct answer	68	61.8	42	38.2	7.631	**.006**
	Wrong answer	38	42.2	52	57.8		
Question 3	Correct answer	79	58.1	57	41.9	4.417	**.036**
	Wrong answer	27	42.2	37	57.8		
Question 4	Correct answer	81	57.9	59	42.1	4.420	**.036**
	Wrong answer	25	41.7	35	58.3		
Question 5	Correct answer	42	79.2	11	20.8	19.940	**<.001**
	Wrong answer	64	43.5	83	56.5		

*All students in the class were included

In the study, the average score of the post-test knowledge level of IM injections was higher in the students in the intervention group than in the control group. In a study by Özaras Öz and Ordu,[10] it was found that web-based education and Kahoot had positive effects on nursing students' knowledge of IM injections. In another study that investigated nursing students' knowledge levels of IM injections, it was stated that students had low average scores for the IM injection success test according to their self-reports.[7]

In the literature, in other studies investigating nursing students' knowledge levels of IM injections, it is emphasized that students' theoretical knowledge and application skills of IM injections should be improved.[36,37] On the other hand, in another study in which the flipped classroom model was used to teach a biostatistics class, it was identified that the flipped classroom model was a method that integrated technology into the teaching process and provided benefits to education in terms of variables such as academic success, student participation, and motivation.[38]

The flipped classroom model eases the interaction between students with various skills and learning preferences, and it is also stated that this model could increase students' participation in learning. In this teaching method, students can individually study the education material and actively participate in class discussions. In a flipped teaching environment, instructors can provide more opportunities for the students to actively participate in the class.[17] According to the results of the study, which are compatible with the literature, learner-centered teaching methods such as the flipped classroom model should be developed and integrated into the curriculum for the skill training of nursing students.

According to the results, the flipped classroom model and Kahoot in teaching IM injection increased the psychomotor skill scores of the students. It is stated that the web-based tool, which was developed by Márquez-Hernández et al.[39]

to evaluate nursing students' clinical skills, is an effective strategy. In a similar study by Özaras Öz and Ordu[10], web-based education and Kahoot showed positive effects on nursing students' IM injection skills. In another study, it was identified that the flipped classroom model increased nursing students' psychomotor skills for subcutaneous injection.[40] Although there is no study in the literature comparing the flipped classroom model with the traditional training model in IM injection training, the flipped classroom model eliminates time and space limitations and allows students to gain knowledge outside the classroom environment. In addition, it facilitates interactive interaction between the student and the instructor outside the classroom. In this way, it makes it easier for the student to reinforce the information learned and make it permanent. Therefore, it can be used in IM injection teaching.[20,41]

Kahoot and interactive videos on the Edpuzzle platform about IM injection skills offer a non-traditional learning environment for students. Students can benefit from the features such as access to the lecture videos whenever and wherever they want, ease of study, pausing videos when needed, rewinding, rewatching, and progressing by answering the questions in the videos and learning from the quick facts in the video. Therefore, the success of the students in the intervention group can be attributed to the independence of self-learning by the flipped classroom model and to the positive effects of gamifying assessments with Kahoot. Our result is compatible with the results of other studies.

The general self-efficacy scores of the intervention group in this study increased. In a study conducted with Korean nursing students, it was confirmed that simulation training using flipped classroom model had positive effects on the students' self-efficacy and learning satisfaction.[40] In a systematic review by Banks and Kay,[42] it was stated that the self-efficacy levels of healthcare students increased considerably with the flipped classroom model. In a qualitative study by Chu-Ling[1] that investigated the efficiency of IM injection techniques on nursing students using interactive software, it was stated that the application increased the students' self-confidence and sense of achievement, fulfilled their need for learning, and the techniques taught in the classes increased their motivation of learning.

Self-efficacy is defined as "the ability to take an action to manage a future situation".[43] Therefore, nursing students' self-efficacy towards IM injection skills is an important element that can help students to improve their knowledge, practice, and professional skills. Once the nursing students achieve an adequate level of self-efficacy for IM injection skills, they can achieve positive learning results and efficiency in basic nursing skills. Thereby, in this study, it can be said that using the flipped classroom model for IM injection skills was effective, and hypothesis (H1) was confirmed.

The flipped classroom model, a method that allows students to actively participate in classes, may have a positive effect on students' general self-efficacy. Moreover, increasing general self-efficacy with this method may have facilitated the performance of other nursing skills. Thus, the flipped classroom model and Kahoot can also be used for the teaching of other skills.

According to the Kahoot results in the study, it was found that the students in the intervention group who used the flipped classroom model were more successful. In another similar study, it was stated that Kahoot was effective in increasing students' IM injection skills.[10] Kahoot, a game-based, fun, online learning tool, has features that provide instant feedback, are interactive, and create an energetic competition between students.[44,45] Hence, it can be concluded that the students in the study reinforced their knowledge of IM injections, they had fun while testing themselves, and became successful by increasing their motivation. Kahoot can be integrated into the evaluation of all classes in nursing education. Foundations such as necessary equipment and uninterrupted internet access could be improved to effectively use this fun online tool.

Moreover, it was identified that the students mostly made mistakes on the fifth question on Kahoot. In the study, the interactive animated video shared on Edpuzzle platform explained IM injections in the ventrogluteal site, all of the IM injection sites were demonstrated on the model during the laboratory practice, and students were asked to perform IM injections in the ventrogluteal site. The fifth question on Kahoot was about the fact that the dorsogluteal site should be avoided for IM injections, which suggests that the question could be a distracter for students. Although current evidence[4] suggests that the ventrogluteal site is the safest site for IM injection, it is a known and ongoing issue that clinical nurses still prefer the dorsogluteal site to ventrogluteal site for IM injections and nursing students cannot put this correct information into practice.[7] As a result of the study, the H1 hypothesis was confirmed by identifying that the flipped classroom model and Kahoot for IM injection training were effective in increasing the students' knowledge, skill, and self-efficacy levels.

Limitations of the Study

There were some limitations to the research. One of the limitations was not being able to perform randomization. Another is that due to the high number of students, they were divided into groups during the laboratory practice, and the psychomotor skill control forms were completed by different observer instructors. Although these instructors had been supporting the laboratory practice of the fundamentals of the nursing course for at least 5 years, the interobserver agreement index could not be calculated for the form because they were completed by different instructors and for different students.

It is very important to develop and use different technological teaching methods that allow active participation and interactive interaction for students to gain the basic nursing skills necessary as future nursing professionals. In this study, the effects of the flipped classroom model and Kahoot on gaining IM injection skills were evaluated. As a result of the study, it was found that the flipped classroom model and Kahoot increased students' knowledge, psychomotor skills, and self-efficacy levels for IM injection skills. Based on the results of this study, it can be suggested that the flipped classroom model should be included in the nursing curriculum and Kahoot should be used as an alternative tool for assessment and evaluation.

REFERENCES

1. Chu-Ling C. Effectiveness of learning intramuscular injection techniques with aid of an interactive APP. *JNEP*. 2022;12(8):1-6. https://doi.org/10.5430/jnep.v12n8p1
2. Kaasalainen S. Medication Administration. In: Astle BJ, Duggleby W, Potter PA, Pery AG, Stockert PA, Hall AM, eds. Canadian Fundamentals of Nursing. 6 th ed. Canada: Elsevier, 2019:736-794.
3. Shaw H. Intramuscular injection. *Nurs Stand*. 2015;30(6):61-2. https://doi.org/10.7748/-ns.30.6.61.s48
4. Kaya N, Salmaslıoğlu A, Terzi B, Turan N, Acunaş B. The reliability of site determination methods in ventrogluteal area injection: a cross-sectional study. *Int J Nurs Stud*. 2015;52(1):355-360. https://doi.org/10.1016/j.ijnurstu.2014.07.002
5. Ayinde O, Hayward RS, Ross JDC. The effect of intramuscular injection technique on injection associated pain; a systematic review and meta-analysis. *PLoS One*. 2021;16(5):e0250883. https://doi.org/10.1371/journal.pone.0250883
6. Nicoll LH, Hesby A. Intramuscular injection: an integrative research review and guideline for evidence-based practice. *Appl Nurs Res*. 2002;15(3):149-62. https://doi.org/10.1053/-apnr.2002.34142
7. Sönmez M, Gürlek Kısacık Ö, Doğan ML, Aslan S. Investigation of some variables that predicted intramuscular injection knowledge levels of nursing students: chaid analysis. *BAUN Health Sci. J*. 2022;11(2):218-226.
8. Kajander-Unkuri S, Suhonen R, Katajisto J, et al. Self-assessed level of graduating nursing students' nursing skills. *JNEP*. 2014;4(12):51-64. https://doi.org/10.53424/balikesirsbd.993213
9. Karaahmetoğlu GU. Examining the knowledge level of nursing students about intramuscular injection application. *Abant Medic. Journal*. 2019;8(3):155-161. https://doi.org/10.5505/-abantmedj.2019.81894
10. Özaras Öz Ö, Ordu Y. The effects of web based education and Kahoot usage in evaluation of the knowledge and skills regarding intramuscular injection among nursing students. *Nurse Educ. Today*. 2021;103:104910. https://doi.org/10.1016/j.nedt.2021.104910
11. Unal KS, Alkan SA. Determining the knowledge levels of nursing students about intramuscular injection. *IJCS*. 2019;12(3):1321-1331. https://www.international-journalofcaringsciences.org/docs/2_kevser_original_12_3.pdf
12. Awad SA, Mohamed MHN. Effectiveness of Peyton's Four-Step Approach on nursing students' performance in skill-lab training. *J Nurs Educ Pract*. 2019;5:1-5. https://doi.org/10.5430/jnep.v9n5p1
13. Park I, Suh Y. Meta-analysis of flipped learning effects in nursing education. *Int J Environ Res Public Health*. 2021;18(23):12814. https://doi.org/-10.3390/ijerph182312814
14. Bergmann J, Sams A. Flip Your Classroom: Reach Every Student in Every Class Every Day. 1st ed. Eugene, Oregon: International Society for Technology in Education; 2012:13-7.

15. Hung HT. Flipping the classroom for English language learners to foster active learning. *CALL*. 2015;28(1):81-96. https://eric.ed.gov/?id=EJ1047667

16. Erkut E. Post-Covid-19 higher education. *Journal of Higher Education*. 2020;10(2):125-33. https://doi.org/10.2399/yod.20.002

17. Pasaribu TA, Wulandari V. EFL teacher candidates' engagement in mobile-assisted flipped classroom. *TOJDE*. 2021;22(3):Article 1. https://doi.org/10.17718/tojde.961774

18. Lohitharajah J, Youhasan P. Utilizing gamification effect through Kahoot in remote teaching of immunology: Medical students' perceptions. *J Adv Med Educ Prof*. 2022;10(3):156-162. https://doi.org/10.30476/JAMP.2022.93731.1548

19. Wang AI, Tahir R. The effect of using Kahoot! for learning-a literature review. *Comput Educ*. 2020;149:103818. https://doi.org/10.1016/j.compedu.2020.103818

20. Elzeky ME, Elhabashy HM, Ali WG, Allam SM. Effect of gamified flipped classroom on improving nursing students' skills competency and learning motivation: A randomized controlled trial. *BMC Nurs*. 2022;21(1):316. https://doi.org/10.1186/s12912-022-01096-6

21. Joseph, M.A., Roach, E.J., Natarajan, J. Suja Karkada & Arcalyd Rose Ramos Cayaban. Flipped classroom improves Omani nursing students performance and satisfaction in anatomy and physiology. *BMC Nurs*. 2021;20(1):1-10. https://doi.org/10.1186/s12912-020-00515-w

22. Taşkın Erdem D, Bahar A. The learning effects of flipped classroom model on nursing student's vital signs skills: a quasi-experimental study. *IGUSABDER*. 2022;17:470-484. https://doi.org/10.38079/igusabder.1066201

23. Oddme S, Kruachottikul S. The Effect of Flipped Classroom Technique on Nursing Students' Knowledge and Self-Efficacy in Nursing for Pregnant Women Infected with COVID-19. *NU J. Nurs Health Sci*. 2023;17(3):66-74. https://he01.tci-thaijo.org/index.php/NurseNu/article/view/262073

24. Kurt Y, Öztürk H. The effect of mobile augmented reality application developed for injections on the knowledge and skill levels of nursing students: An experimental controlled study. *Nurse Educ. Today*. 2021;103:104955. https://doi.org/10.1016/j.nedt.2021.104955

25. Eunicia T, Andrew B, Gregory L. Acceptability of the flipped classroom approach for in-house teaching in emergency medicine. *Emerg Med Australas*. 2015;27(5):453-459. https://doi.org/10.1111/1742-6723.12454

26. Amit V, Shanthi V, Othman W. Flipped classroom in dental education: A scoping review. *Eur J Dent Educ*. 2020;24(2):213-226. https://doi.org/10.1111/eje-.12487

27. Wang Z, Kohno EY, Fueki K, Ueno T, Inamochi Y, Takada K, Wakabayashi N. Multilevel factor analysis of flipped classroom in dental education: A 3-year randomized controlled trial. *PLoS One*. 2021 Sep 10;16(9):e0257208. https://doi.org/10.1371/journal.pone.0257208

28. Wong Kenneth CHU, David WK. Is the flipped classroom model effective in the perspectives of students' perceptions and benefits?. In: Hybrid Learning. Theory and Practice: 7th International Conference, ICHL 2014, Shanghai, China, August 8-10, 2014. https://www.researchgate.net/publication/300398261_Is_the_Flipped_Class-room_Model_Effective_in_the_Perspectives_of_Students'_Perceptions_and_Benefits

29. Hassan S, Hod R. Use of item analysis to improve the quality of single best answer multiple choice question in summative assessment of undergraduate medical students in Malaysia. *EIMJ*. 2017;9(3):33-43. https://doi.org/10.21315/eimj2017.9.3.4

30. Lynn P. Medication. In: Taylor's Clinical Nursing Sklils: A nursing Process Approach. 5 th ed. China: Wolters Kluwer; 2019:656-668.

31. Ogston-Tuck S. Intramuscular injection technique: an evidence-based approach. *Nurs. Stand*. 2014;29(4):52-59. https://doi.org/10.7748/ns.29.4.52.e9183

32. Sisson H. Aspirating during the intramuscular injection procedure: a systematic literature review. *J. Clin. Nurs*. 2015;24:2368-2375. https://doi.org/10.1111/jocn.12824

33. Strohfus PK, Paugh O, Tindell C, Molina-Shaver P. Evidence calls for practice change in intramuscular injection techniques. *JNEP*. 2018;8(2):83-92. https://doi.org/10.5430/-jnep.v8-n2p83

34. Sherer M, Adams C. The Self-Efficacy Scale: A Construct Validity Study. 1983.

35. Yildirim F, Ilhan IÖ. The validity and reliability of the general self-efficacy scale-Turkish form. *Turkish Journal of Psychiatr*. 2010;21(4):301. https://pubmed.ncbi.-nlm.nih.gov/21125505/

36. Alan S, Çalışkan N. Knowledge levels of nursing senior students about intramuscular injection application. *JEUNF*. 2018;34(1):36-53. https://dergipark.org.tr/-en/pub/egehemsire/issue/36787/340142

37. Özveren H, Gülnar E, Yılmaz ED. Determination of the knowledge level of nursing students on the use of ventrogluteal region in intramuscular injection. *DEUHFJ*. 2018;11(4):300-305. https://dergipark.org.tr/tr/pub/deuhfed/issue/46759/934880

38. Ilgaz A. Flipped classroom with interactive videos in the teaching of biostatistics knowledge applied to nursing students: A mixed method study. *J Nursology*. 2022;25(4):245-253. https://doi.org/10.5152/JANHS.2022.2281132

39. Márquez-Hernándeza VV, Gutiérrez-Puertasb L, Granados-Gámeza G, et al. Development of a web-based tool to evaluate competences of nursing students through the assessment of their clinical skills. *Nurse Educ. Today*. 2019;73:1-6. https://doi.org/10.1016/j.nedt.2018.11.010

40. Gu M, Sok SR. Effects of simulation practicum using flipped learning for Korean nursing students. *Int. J. Environ. Res. Public Health*. 2020;17:6829. https://doi.org/10.3390/-ijerph17186829

41. Youhasan P, Chen Y, Lyndon M, Henning MA. Exploring the pedagogical design features of the flipped classroom in undergraduate nursing education: a systematic review. *BMC*

Nurs. 2021;20(1):1-13. https://doi.org/10.1186/s12912-021-00555-w

42. Banks L, Kay R. Exploring flipped classrooms in undergraduate nursing and health science: A systematic review. *Nurse Educ. Pract*. 2022;64:103417. https://doi.org/10.1016/j.nepr.2022.103417

43. Alosaimi D. Learning self-efficacy as predictor of nursing students' performance of clinical skills. *Educ. Sci. Theory Pract*. 2021;21(3):120-131. https://doi.org/10.12738/jestp.2021.3.009

44. Baszuk PA, Heath ML. Using Kahoot! to increase exam scores and engagement. *J. Educ. Bus*. 2020;95(8):548-552. https://doi.org/10.1080/08832323.2019.1707752

45. Clara Sabandar GN, Supit NR, Effendy Suryana HT. Kahoot!: bring the fun into the classroom!. *IJIE*. 2018;2(2):127-134. https://doi.org/10.20961/ijie.v2i2.26244