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A comparison of 3D game-based simulation versus traditional methods in vital signs education

Fatma Tanrikulu^{1*} , Handenur Gündoğdu² , Funda Erol³ and Yurdanur Dikmen⁴

Abstract

Background Vital signs measurement is a fundamental nursing responsibility that requires cognitive and psychomotor competence. In alignment with the ethical principle of nonmaleficence, it is important to provide learning environments where students can practice and make mistakes without causing harm. This study aims to examine the effect of a 3D game-based simulation application developed for vital signs on students' academic achievement, learning satisfaction and self-confidence levels.

Methods A randomized controlled experimental design was employed with 73 nursing students, assigned to either the intervention group ($n=37$) or the control group ($n=36$). The intervention group used a game-based simulation developed with 3D animation technology, while the control group received traditional instruction. Data were collected using the Student Introductory Characteristics Form, Academic Achievement Test of Vital Signs Measurement Skills, and the Student Satisfaction and Self-Confidence in Learning Scale. Statistical analyses were conducted using SPSS version 25, with significance set at $p < 0.05$.

Results The results indicated that students' current learning satisfaction subscale scores were high in the traditional teaching group and that there was a statistically significant difference between the groups ($p=0.047$). There was no statistically significant difference between the groups in terms of academic achievement ($p=0.932$) and self-confidence levels in learning ($p=0.375$). However, both groups had high mean scores in academic achievement, satisfaction with current learning, and self-confidence in learning.

Conclusions The game simulation method supported by 3D animation may be insufficient for significantly improving nursing students' academic performance, satisfaction with the learning process, and self-confidence in learning. Therefore, it is recommended that such technology-supported methods be used in blended learning environments alongside traditional teaching methods in nursing education.

Trial registration ClinicalTrials.gov: NCT07009275; retrospectively registered.

Keywords Nursing education, Vital signs, Animation, Academic achievement, Satisfaction

*Correspondence:

Fatma Tanrikulu
ftanrikulu@subu.edu.tr

¹Nursing Department, Faculty of Health Sciences, Sakarya University of Applied Sciences, Sakarya, Türkiye

²Nursing Department, Faculty of Health Sciences, Sakarya University of Applied Sciences, Sakarya, Türkiye

³Nursing Department, Faculty of Health Sciences, Kocaeli University, Kocaeli, Türkiye

⁴Nursing Department, Faculty of Health Sciences, Kocaeli Health and Technology University, Kocaeli, Türkiye



Background

The nursing profession is a discipline that requires competence in both cognitive and psychomotor skills in order to protect and improve the health of individuals and provide appropriate care in cases of illness [1]. In this context, the effective acquisition of psychomotor skills is considered to be one of the fundamental objectives of nursing education [2]. During the education process, students are expected to acquire many skills of varying degrees of difficulty and complexity and become proficient in their application [3]. Among these skills, the accurate assessment, measurement and monitoring of vital signs is one of the important responsibilities of nurses [4].

Importance of vital signs

Vital signs are key physiological indicators used to determine the general health status of a patient [5]. Objective data obtained from vital signs enable healthcare professionals to make clinical assessments of the patient's general condition and initiate necessary interventions in a timely manner [6, 7]. Therefore, the accurate measurement, recording and interpretation of vital signs are essential for monitoring a patient's response to care and treatment [8].

During clinical rotations, the responsibility for monitoring vital signs is often assigned to nursing students with basic knowledge of the procedure [9]. Owing to the non-invasive nature of these tasks, students usually perform these applications with minimal or no supervision from clinical instructors or nurses. However, due to the non-invasive nature of vital signs applications, students often perform these applications with minimal or no supervision from a clinical nurse educators or nurses [6, 10]. The literature indicates notable deficiencies in students' knowledge [9], practical application skills [11], and attitudes [10] regarding vital signs. However, it is essential that students apply the clinical skills they acquired correctly and consistently to enhance patient safety and quality of care [12, 13]. Therefore, more effective and contemporary teaching strategies are needed to improve instruction in vital signs measurement.

Challenges encountered in teaching

Vital signs are an important topic in nursing education, requiring the integration of both cognitive and psychomotor skills [1]. The demonstration method is traditionally used in teaching psychomotor skills. However, contemporary skills training faces challenges such as increased student enrolment, shortages of teaching staff, limited laboratory resources, insufficient opportunities for students to safely repeat practical exercises, and difficulties in applying theoretical knowledge in clinical settings [14]. At the same time, the fact that students

belong to the millennial and Z generations has caused their learning needs to change [15]. For this reason, it has become essential to align nursing education with current needs by incorporating technology into training programmes [16].

An innovative approach to nursing education: 3D game-based simulation

Virtual game simulation is a form of simulation that transfers real-life situations into a computer environment and incorporates game elements [17]. Recently, the use of virtual simulation games has increased in nursing education as a means of addressing challenges associated with face-to-face simulation, such as instructor competence, equipment costs, and accessibility [18]. By design, these applications enable students to actively participate in their own learning in an environment without time and space constraints [19–21]. They also provide immediate feedback, performance monitoring, objective assessment [22] and the opportunity to repeat the game until they are satisfied with their performance [20]. Therefore, virtual game simulations can improve academic achievement [22] and increase permanence of information [23]. At the same time, virtual gaming simulation as a teaching strategy enables students to participate in a realistic clinical scenario, reducing their anxiety and supporting their self-confidence [21, 24]. Gentry et al. (2019) provide a strong theoretical basis for this approach through their systematic review of 171 studies on serious gaming in health professions education, which found that serious games improve knowledge retention and skill competence [25]. These findings support the investigation of 3D animation as a serious game strategy in nursing education. Similarly, Toqan et al. (2023) reported that high-fidelity simulation applications significantly increased nursing students' self-confidence and satisfaction levels, serving as a precedent for the outcome variables evaluated in the present study [26]. Previous research on virtual game simulations has typically focused on tracheostomy care [21], urinary catheterisation [27], decontamination [28], advanced cardiac life support [29], and cardiopulmonary resuscitation [30]. However, no studies were identified that compared the effectiveness of virtual game simulations with traditional methods in teaching vital signs. This may be because vital signs monitoring is often regarded as one of the most basic and easily learned skills in nursing practice. Educators may also perceive it as a routine, straightforward skill due to its non-invasive nature and the relative independence with which students can practice it [10]. However, in a study examining nursing students' knowledge levels and attitudes towards measuring vital signs, it was reported that students had negative attitudes towards basic parameters, especially critical indicators such as respiratory rate. Some students

view such measurements as boring and time-consuming, which can reduce motivation to learn [31]. Furthermore, existing literature indicates that nursing students have poor knowledge and attitudes regarding monitoring and interpreting vital signs in patient care [10, 32]. This suggests that, contrary to common assumptions, teaching vital signs requires not only the acquisition of basic technical skills but also more comprehensive and interactive instructional approaches aimed at fostering accurate interpretation, patient safety awareness, and the development of appropriate attitudes. In line with this, this study aims to examine the effect of a 3D game-based simulation application developed for vital signs on students' academic achievement, learning satisfaction and self-confidence levels. The hypotheses of the study are as follows:

H1: The academic achievements of students who use a 3D game-based simulation application are higher than those who use traditional learning methods.

H2: Students who use a 3D game-based simulation application have higher levels of satisfaction and self-confidence in learning than those who use traditional learning methods.

Methods

Research design

A randomized controlled experimental design was used with two groups of students. The intervention group consisted of students using the game-based simulation application developed using 3D animation technology, while the control group consisted of students using traditional learning methods.

Study setting and sample

The study was conducted at the Faculty of Health Sciences in the province of Sakarya, Türkiye. The population of this study consisted of first year nursing students in the academic year 2023–2024 ($N=121$). Inclusion criteria were as follows: enrolment in the Faculty of Nursing; willingness to participate in the study; no prior theoretical or practical training in vital signs; non-international student status; and no transfer from other health sciences programs with differing examination practices.

The sample size for this study was calculated using G.Power 3.1.9.4 with a coefficient of reliability of $\alpha=0.05$ and a confidence level of 95%. When calculating the sample size, the effect size was determined to be 1.03 using the study by Dincer et al. (2019) entitled 'The Effect of 3D Animation Supported Education on Nursing Students' Knowledge Levels for Respiratory Assessment' as an example [33]. The sample size of the study was calculated with a theoretical power of 0.95, and the minimum sample size was 52, with 26 in the control group and 26 in the intervention group.

A total of 121 first-year nursing students were enrolled in the Faculty of Health Sciences where the study was conducted. Students were excluded from the study because 28 of them held international student status, 9 of them were enrolled in the Department of Nursing from other areas of health sciences with different exams, and 6 of them had previously received training in vital signs. This left 78 students who met the inclusion criteria. A stratified random sampling method (lottery) was applied to these students. They were stratified into five equal performance-based groups according to their cumulative grade point averages (CGPAs). Within each stratum, simple randomization was performed using a computer-generated random number list to assign students to either the intervention or control group. The random sequence was generated by an independent researcher not involved in the implementation or evaluation phases of the study and was used to ensure unbiased allocation.(Fig.1)

Data collection tools

This study collected data using the 'Student Introductory Characteristics Form', the 'Academic Achievement Test of Vital Signs Measurement Skills', and the 'Student Satisfaction and Self-Confidence in Learning Scale'.

Student introductory characteristics form

This was prepared by the researchers to determine some socio-demographic characteristics of the students participating in the study. In this form, there were a total of six questions including gender, age, academic grade average, willingness to choose the profession, information about the simulation, and participation in the simulation-related practice.

Academic achievement test of vital signs measurement skills

The researchers developed the Academic Achievement Test of Vital Signs Measurement Skills to measure vital signs. The researchers first identified the gains that students should make in measuring vital signs. In line with the literature [6, 10, 34], five-choice multiple-choice questions were prepared covering the goals and behaviours determined for each outcome. A total of 58 questions, including 23 questions on blood pressure measurement skills, 12 questions on apical pressure measurement skills, 10 questions on body temperature measurement skills, 7 questions on pulse taking skills, and 6 questions on respiration counting skills, were submitted for expert opinion by email. The questions were rearranged according to the experts' feedback. The revised questions were administered to 303 nursing students as a pretest. Internal consistency was assessed using the Kuder-Richardson Formula 20 (KR-20), appropriate for dichotomously scored items [35]. The final 26-item version of the test

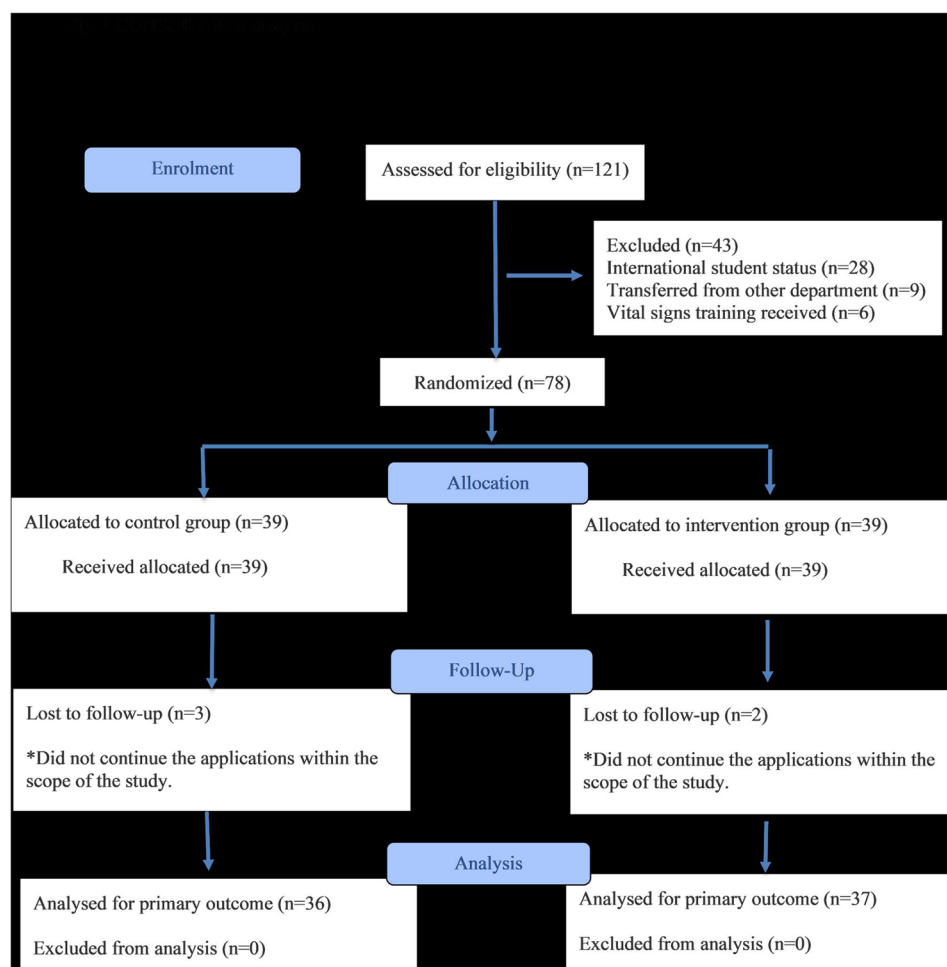


Fig. 1 CONSORT flow diagram

demonstrated acceptable internal consistency with a KR-20 reliability coefficient of 0.77. The average item difficulty index was 0.62, and the average discrimination index was 0.39, indicating that the test comprised moderately difficult and sufficiently discriminative items. Test scores had a mean of 16.19, standard deviation of 4.6, skewness of -0.528 , and kurtosis of 0.045 , supporting normal distribution. These results indicate that the test has satisfactory content validity and reliability, and that it is composed of items that effectively distinguish among students with varying levels of achievement. Each correct response was scored as 1 point and each incorrect response as 0 points, yielding a possible total score range of 0 to 26.

Student satisfaction and Self-Confidence in learning scale

The original scale was developed by Jeffries and Rizzolo (2006) with 13 items, and the total number of items was reduced to 12 during its adaptation to Turkish [36, 37].

It is a 5-point Likert-type scale consisting of two sub-scales: 'Satisfaction with Current Learning' and 'Confidence in Learning'. Satisfaction with current learning sub-item consists of 5 items, confidence in learning sub-item consists of 7 items, and there are no negative items. Cronbach's alpha coefficients were reported as 0.85 for 'Satisfaction with Current Learning', 0.77 for 'Confidence in Learning', and 0.89 for the total scale. Higher total scores indicate greater student satisfaction and confidence in learning. The scale has also been validated in different nursing education contexts. For example, Jawabreh et al. (2025) reported high internal consistency ($\alpha = 0.89$ for the confidence subscale) in a mental health nursing simulation study, supporting the scale's cross-context applicability and reliability.

Implementation of the study

The implementation of this research was carried out in three stages: 'preparation', 'practice' and 'evaluation'.

First stage: Preparation

Designing the website of the game-based simulation application with 3D animation technology

Under the guidance of a software company, a game-based simulation application with 3D animation technology was designed for the skills of measuring vital signs (measuring blood pressure, counting radial artery pulse, taking apical route pulse, measuring body temperature and counting respiratory rate), which is the first stage of the research.

The website for the game-based simulation application was built under the name <https://www.yasambulgarionyun.com/>. The development of the simulation was a collaborative endeavour that spanned a period of approximately three months, undertaken in conjunction with a professional software company. The 3D animation components were created using a combination of Blender, MetaHuman, and pre-model 3D scanned objects. Facial expressions and body movements were captured and digitised using motion capture technology to enhance realism. The integration of these assets, scene creation, character animations, and rendering processes were executed in Unreal Engine 5, which also enabled the use of ray tracing to simulate realistic lighting effects. The website of the project was built on a WordPress infrastructure, incorporating HTML, PHP, and JavaScript. The data were stored in a MySQL database, thus enabling expert access and user-based tracking of responses. This application was also compatible with mobile devices such as smartphones and tablets. The website had an educational module to watch videos created with 3D animation technology and a game module to reinforce what they had learned by playing games. To access the game, students registered using their corporate email accounts (Fig. 2).

Development of training videos using 3D animation technology

In the study, instructional videos were prepared on blood pressure measurement, radial artery pulse assessment, apical artery pulse assessment, body temperature measurement, and respiratory rate measurement. The content of these videos was developed by the researchers in accordance with the literature [1, 8, 10, 38]. Scenarios for each vital sign skill were designed under the guidance of a researcher with expertise in simulation-based education. Each scenario involved two settings: a medication preparation room and a patient room, and two characters: a patient and a nurse.

The scenarios were sent to the animation designer, who produced demo videos for all vital sign skills. These demos were evaluated by a team of three professionals with more than five years of academic and clinical experience. After receiving approval, the final versions of all videos were produced.

The blood pressure measurement video is 5 min 30 s in length, the pulse assessment and respiratory rate measurement video is 2 min 18 s, the body temperature measurement video is 3 min 16 s, and the apical artery pulse assessment video is 3 min. The animation designer integrated these videos into the website, where they can be accessed via mobile phones, tablets, or computers by logging in with a username and password.

Development of game-based simulation with 3D animation technology

At this stage, game videos were developed according to the applications and explanations in the training videos. Each game video was adapted from the corresponding instructional video. For each application, three or four questions were prepared. At designated points in the video, playback was paused, and a multiple-choice question was displayed. Correct answers triggered an applause sound, while incorrect answers generated an error sound and displayed a text-based explanation. Students could continue selecting answers until the correct option was chosen. The interactive features incorporated embedded multiple-choice questions that were dynamically triggered at specific time points within the instructional videos. The questions under consideration were drawn from a predefined question bank and integrated directly into the JavaScript codebase. Upon reaching a designated segment, the video automatically paused and presented a question interface to the student. Correct answers were met with auditory feedback (e.g., applause), while incorrect answers prompted text-based explanations and allowed for repeat attempts until the correct option was selected. Student responses were stored in a MySQL database under each user's profile, enabling subsequent review and expert evaluation. This configuration supported real-time formative assessment and self-paced learning. Each question had four answer options, and when a student selected an incorrect response, a corresponding explanation was displayed to clarify the mistake (Fig. 2).

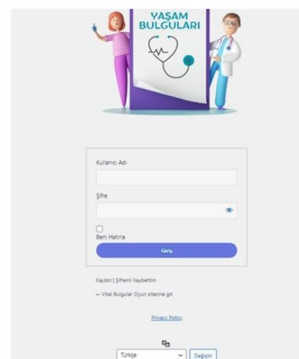
Second stage: practice

All students who participated in the study first received a six-hour theoretical lesson on vital signs measurement, delivered by the same educator. Following this session, they were assigned to either the intervention or control group.

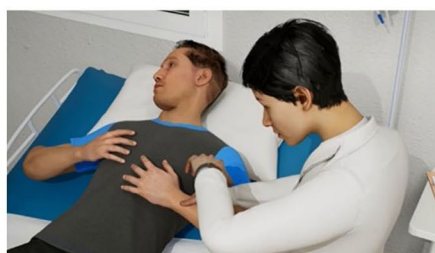
The students in the control group received practical training on vital signs measurement using the demonstration method in the skills laboratory, delivered in a face-to-face format by an instructor. This four-hour session included hands-on demonstrations and supervised practice on blood pressure measurement, apical pulse measurement, radial pulse assessment, body temperature



1. Home Page of the Game-Based Simulation Application Website with 3D Animation Technology



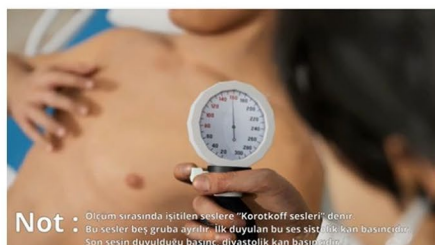
2. Game-based simulation application login screen developed with 3D animation technology



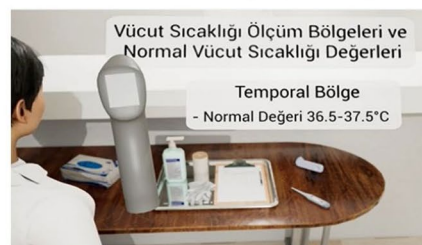
3. Pulse-taking video visualisation



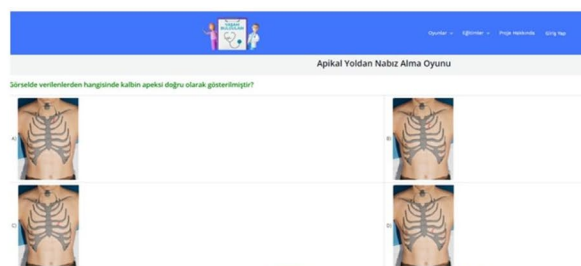
4. Video visualisation of apical pulse-taking



5. Body temperature measurement video image



6. Blood pressure measurement video image



7. Apical pulse-taking application game visualization

Fig. 2 User interface of the interactive game-based learning platform

measurement, and respiratory rate counting. Students observed procedures performed on mannequins and then practiced the skills under supervision.

The students in the intervention group ($n = 37$) learned vital signs through a game-based simulation application conducted in the computer laboratory. Under the supervision of a researcher, each student logged into the platform using their individual username and password, watched all instructional videos in the training section, and then proceeded to complete all game-based

exercises. The simulation design aligns with Kolb's Experiential Learning Theory, as students actively participated in simulated clinical scenarios, reflected on their performance through feedback, conceptualized knowledge via instructional videos, and re-applied it in varied game-based tasks. The simulation intervention lasted six hours, consistent with the findings of Gentry et al. (2019), who reported that simulation-based interventions exceeding four hours significantly improve learning outcomes. To minimize contamination between the intervention and

control groups, training sessions were conducted simultaneously but in separate settings, each supervised by a different researcher. Data were collected via structured questionnaire forms administered in person between April and May 2024.

Third stage: evaluation

In the final stage of the study, the Academic Achievement Test of Vital Signs Measurement Skills and the Student Satisfaction and Self-Confidence in Learning Scale were administered to the students in both groups. All outcome measures were administered immediately after the completion of training sessions for both groups. To minimize bias, the study was conducted as a single-blind design. The educators who delivered both the demonstration and the game-based simulation training were blinded to the scoring process of the academic achievement test to ensure objective assessment. Additionally, the data analysis was performed by a separate researcher who was blinded to group assignments, preventing detection bias during statistical evaluation. The study was reported in accordance with the CONSORT guidelines for randomized controlled trials.

Data analysis

The data obtained from the study were analysed using SPSS version 25. Numbers, percentages and arithmetic means were used to analyse the descriptive characteristics of the students. Independent sample t test and Chi-square test were used to evaluate the homogeneity of the groups in terms of demographic data after randomisation. The Shapiro–Wilk test was applied to examine normality. Results indicated that the academic achievement test scores were normally distributed ($p=0.544$), whereas the Student Satisfaction with

Learning and Self-Confidence scale scores did not follow a normal distribution ($p<0.05$). Accordingly, parametric tests (independent samples t-test) were applied to the academic achievement data, and non-parametric tests (Mann-Whitney U test) were applied to the satisfaction and confidence scores that did not meet the normality assumption.

The independent samples t-test was used to evaluate the difference between the academic achievement test scores of the intervention and control groups. Student satisfaction and confidence in learning scale and its sub-dimensions were evaluated by Mann-Whitney U test in intervention and control groups. A p-value of less than 0.05 was considered statistically significant.

Ethical approvals

Ethical approval for the study was obtained from the Ethics Committee of Sakarya University of Applied Sciences (Approval No: E-26428519-044-65435). Participation was entirely voluntary, and all participants were informed that they could withdraw at any time without any academic consequences, and that their participation would not influence their course grades. Personal data were handled in strict confidentiality and were not disclosed to third parties under any circumstances. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. To prevent interaction between groups, each student was assigned a unique username and password. Students in the control group were informed that they would be granted access to the virtual game simulation after the study concluded.

Results

The mean age of students was 19.00 ± 0.66 years in the intervention group and 19.19 ± 0.88 years in the control group. The mean academic grade of the students was 2.77 ± 0.53 in the intervention group and 2.75 ± 0.64 in the control group. In the intervention group, 78.4% of students were female, compared with 72.2% in the control group. Additionally, 59.5% of the intervention group and 50.0% of the control group reported willingly choosing the nursing department. When the demographic characteristics of the students in the intervention and control groups were evaluated, it was found that there was no significant difference between the groups and the distribution was similar in both groups ($p>0.05$) (Table 1).

In Table 2, the mean academic achievement test scores of the intervention and control groups were found to be 17.86 and 17.80, respectively. As a result of the independent sample t-test, there was no statistically significant difference between these two groups ($p>0.05$).

Student satisfaction results are presented in Table 3. Two sub-dimensions, satisfaction with current learning

Table 1 Demographic characteristics of students in the intervention and control groups

Descriptive characteristics	Intervention group Mean $\pm$ SD	Control group Mean $\pm$ SD	Statistical analysis
Age	19.00 $\pm$ 0.66	19.19 $\pm$ 0.88	$t=-1.055$ $p=0.295$
Academic Grade Point Average	2.77 $\pm$ 0.53	2.75 $\pm$ 0.64	$t=0.149$ $p=0.295$
	n (%)	n (%)	
Gender			
Female	29 (78.4)	26 (72.2)	$\chi^2=0.085$
Male	8 (21.6)	10 (27.8)	$p=0.882$
Nursing Preference			
Willingly	22 (59.5)	18 (50.0)	$\chi^2=1.205$
Not willingly	4 (10.8)	7 (19.4)	$p=0.548$
Partly willing	11 (29.7)	11 (30.6)	
Total	37 (100.0)	36 (100.0)	

SD Standard deviation, t Independent sample t-test; χ^2 Chi-square test

Table 2 Comparison of academic achievement test scores between intervention and control groups

Groups	n	Mean $\pm$ SD	t	p	d
Intervention	37	17.86 $\pm$ 3.08	0.085	0.932	0.02
Control	36	17.80 $\pm$ 2.84			

SD Standard deviation, t Independent sample t test, d Cohen's d (effect size)

Table 3 Descriptive statistics for student satisfaction and Self-Confidence in learning scale in each group

Groups		Satisfaction with current learning	Self-confidence in learning	Total mean score
Intervention (n = 37)	Mean	3.76	3.71	3.73
	SD	0.80	0.68	0.68
	Min	1.40	1.14	1.25
	Max	5.00	4.71	4.67
Control (n = 36)	Mean	4.08	3.89	3.97
	SD	0.52	0.44	0.43
	Min	2.80	3.00	3.00
	Max	5.00	5.00	5.00

SD Standard deviation, Min Minimum, Max Maximum

and confidence in learning, were used to assess student satisfaction. In the study, the intervention group had a total score of 3.73 ± 0.68 for student satisfaction and self-confidence in learning and the control group had a total scale score of 3.97 ± 0.43 . Higher scores on this scale indicate greater satisfaction and self-confidence in learning. In both groups, the descriptive mean scores for satisfaction with current learning and self-confidence were relatively high.

The mean ranks of the Student Satisfaction in Learning and Self-Confidence Scale were compared between the intervention and control groups, as presented in Table 4. A statistically significant difference was identified in the sub-dimension of satisfaction with current learning, with the control group demonstrating higher levels of satisfaction ($p < 0.047$). The effect size for this difference was small ($r = 0.23$), indicating a weak effect. No statistically significant differences were observed between the groups in the sub-dimension of self-confidence in learning ($p = 0.375$), or in the total scale scores ($p = 0.151$). Even though both groups reported relatively high levels of satisfaction and self-confidence in the descriptive results (Table 3), the difference in satisfaction with

current learning was statistically significant, whereas other dimensions showed no meaningful difference.

Discussion

This study evaluated whether the use of a game-based simulation application developed with 3D animation technology is an effective method for teaching vital signs measurement skills in nursing education. For this purpose, first-year nursing students with no prior knowledge or skills in measuring vital signs were assigned to either an intervention group or a control group for comparison.

Comparison of academic achievement between groups

It was determined that academic achievement related to vital signs did not differ between the intervention group and the group receiving traditional instruction. Rather than viewing this as a failure of the intervention, this finding can be seen as evidence that the 3D game-based simulation method is non-inferior. Chao et al. (2021) reported in their study comparing traditional presentation videos with immersive 3D interactive video programmes that there was no significant difference in academic achievement between the two groups [12]. Similarly, in another study conducted at two comparable schools, the use of an animated and sound-supported computer application for teaching vital signs did not result in any change in factual knowledge between the groups [38]. In their study examining the effect of simulation-based teaching methods applied to three different groups in teaching vital signs, Eyikara and Göçmen Baykara (2018) reported that there was no statistically significant difference between the groups' pre-test cognitive knowledge scores; however, their post-test scores increased significantly [1]. Similarly, Hanson et al. (2019) emphasised the supportive effect of this method on academic achievement, stating that there was a significant increase in students' knowledge levels in pharmacology education using 3D visualisation technology [39]. This situation shows that the effectiveness of technology-supported learning methods may vary depending on the content, teaching time, students' prior knowledge, and characteristics of the learning environment. In the study, the fact that both groups received vital signs training from the same instructor for the same duration (6 h) can

Table 4 Comparison of mean ranks on student satisfaction and Self-Confidence in learning scale between groups

Scale	Groups	Mean Rank	U	p	r
Satisfaction with current learning	Intervention (n = 37)	32.24	490.00	0.047*	0.23
	Control (n = 36)	41.89			
Self-confidence in learning	Intervention (n = 37)	34.49	586.00	0.375	-
	Control (n = 36)	39.22			
Student satisfaction and self-confidence in learning	Intervention (n = 37)	33.49	536.00	0.151	-
	Control (n = 36)	40.61			

* $p < 0.05$, U = Mann Whitney U test, r = Effect size

Table 5 Comparison of study findings with previous literature

Study	Participants	Intervention Type	Academic Achievement	Satisfaction	Self-Confidence
This Study	First-year nursing students ($n=73$)	3D animation-based game simulation	No significant difference between groups	Higher in control group (traditional method)	No difference between groups
Eyikara & Göçmen Baykara (2018)	First-year nursing students ($n=90$)	High-fidelity simulation with SimMan®	No difference between groups in the pre-test; significant increase in the post-test	Not specified	Not specified
Kaveevivitchai et al. (2009)	Nursing students ($n=117$)	Multimedia-supported computer training integrated with anatomy and physiology	No significant difference between groups	Not specified	Not specified
Chao et al. (2021)	Nursing students ($n=45$)	Immersive 3D interactive video programme	No significant difference between groups	Higher in the intervention group	No significant difference between groups
Hanson et al. (2019)	Nursing and Midwifery students ($n=187$)	Pharmacology education supported by 3D visualisation	Significant increase in the intervention group	Positive attitudes reported (no quantitative data available)	Not specified
Pence (2022)	Nursing students ($n=28$)	Animation-based vSim application	Not specified	High satisfaction reported	High self-confidence reported
Opsal et al. (2025)	Undergraduate nursing students ($n=54$)	Blended learning-based skills training	Not specified	High satisfaction reported	High self-confidence reported
Widiasih et al. (2022)	Undergraduate nursing students ($n=139$)	VNursLab 3D web-based nursing skills simulator	Significant improvement in nursing skill knowledge	Higher satisfaction in intervention group	Higher self-confidence in intervention group
Toqan et al. (2023)	Nursing students ($n=150$)	High-fidelity simulation	Not specified	Higher in the intervention group	Higher in the intervention group
Gentry et al. (2019)	Health professions students (27 RCTs and 3 cluster RCTs with 3634 participants)	Serious games and gamification	Improved	Positive impact, limited evidence	Positive impact, limited evidence
Jawabreh et al. (2025)	Nursing students ($n=75$)	High-fidelity simulation (Mental Health Nursing)	Not specified	Higher satisfaction in experimental group	Higher self-confidence in experimental group

be considered a possible factor explaining the similarity in their knowledge levels (Table 5).

Student satisfaction and self-confidence in learning

Given that the maximum score that can be obtained from the “Student Satisfaction and Self-Confidence in Learning Scale” used in the study is 5, it was determined that the overall satisfaction and self-confidence scores of students in both groups were considered high. This finding shows that both traditional teaching methods and 3D animation-supported simulation applications can positively affect students’ satisfaction and confidence levels in learning. Pence (2022) reported that the computer-assisted and animation-based vSim application used in nursing education was found to be useful by students and increased their satisfaction levels; however, they noted that learning mainly took place in laboratory or clinical settings [40]. Similarly, Opsal et al. (2025) and Widiasih et al. (2022) emphasised that 3D animation and game-based technologies used in nursing education can be effective in increasing students’ satisfaction and self-confidence levels, but that these technologies cannot fully replace

direct practical experience [41, 42]. In this regard, rather than emphasising the absolute superiority of traditional methods over technology-supported learning methods, it can be said that both approaches are effective in their own contexts and can generate high levels of satisfaction and self-confidence among students (Table 5).

Comparison of student satisfaction and self-confidence in learning between groups

The study found a statistically significant difference between groups only in the sub-dimension of ‘Satisfaction with Current Learning’ ($p=0.047$). This finding shows that students in the control group reported higher levels of satisfaction with traditional teaching methods. However, the fact that the p-value is very close to the significance level suggests that although this difference is statistically significant, its effect is weak. Toqan et al. (2023) stated that nursing students’ satisfaction levels with simulation-based learning methods were higher than with traditional methods [26]. Similarly, Jawabreh et al. (2025) stated that simulation applications with a high degree of realism increased students’ satisfaction

and confidence levels in learning. However, the study also noted that the effect of simulation on satisfaction may vary depending on the content and may be limited, particularly in affective learning areas such as psychiatric nursing ($\eta^2 = 0.12$) [43]. Gentry et al. (2019) reported that serious games and gamification methods in health sciences can increase student satisfaction; however, current evidence is insufficient to fully substantiate this claim [25]. The positive impact of active, experiential learning on student satisfaction and confidence has been demonstrated by research on simulation in nursing education [1, 44, 45]. In this study, the higher learning satisfaction scores observed for traditional teaching methods may be attributed to students' greater familiarity with this approach or to the possibility that the innovative simulation method did not fully meet their expectations. Usability-related factors such as technology fatigue, interface complexity, or limited interactivity may also have negatively affected satisfaction with the 3D simulation application. For instance, requiring students to log in with a username and password while simultaneously presenting video materials and game sections on the same interface may have contributed to a heightened cognitive load. Although traditional methods seem to provide higher satisfaction among students, 3D animation-supported simulation tools can offer significant advantages in terms of increasing the level of interaction, scalability to wider student groups, and supporting long-term knowledge retention. Therefore, integrating such technologies into nursing curricula through blended or supplementary teaching models warrants consideration (Table 5).

Limitations

This study has several limitations. First, the sample consisted exclusively of students from the nursing department of the Faculty of Health Sciences at a state university, which limits the generalisability of the findings.

Another limitation of this study is that the sample size calculation is based on a large effect size (1.03) obtained from a previous study [33]. Although the sample size is appropriate for comparison, it may be limited in determining statistically significant effects. Furthermore, no separate power analysis was performed for these secondary variables, which represents a notable methodological limitation.

The results on student satisfaction indicated higher scores in the control group compared to the intervention group. The novelty effect of 3D game-based simulation may have influenced students' responses in a positive or negative way. There are many factors (learning style, teaching environment, instructor's approach) that affect students' satisfaction. Therefore, the effect of factors other than simulation implementation (e.g., students'

individual learning styles or classroom interaction) on satisfaction can be investigated. The study only evaluated cognitive outcomes and did not include behavioural or application-based performance measures.

Although qualitative student feedback was not collected in the current study, incorporating such data in future research could provide deeper insights into learners' subjective experiences and perceptions of different instructional methods. Open-ended responses or focus group interviews would allow researchers to explore nuances behind satisfaction and confidence scores, offering a richer understanding of how students engage with both traditional and simulation-based learning environments. To strengthen future research, more comprehensive data on learning satisfaction and confidence can be obtained using mixed methods or qualitative approaches.

In addition, the study evaluated short-term learning outcomes, but did not conduct a long-term follow-up to assess knowledge retention. A more in-depth examination of the relationship between training time and interactive learning may yield healthier results. For example, the training period can be extended, or simulation games and laboratory studies can be combined.

Despite all these limitations, the study also has significant strengths. The use of a randomized controlled design increases internal validity, while the application of an innovative teaching method such as 3D game-based simulation contributes to the field of nursing education.

Conclusions

The results of this study indicate that students' satisfaction scores for current learning were higher in the traditional teaching group, with a statistically significant difference between the groups ($p = 0.047$). However, given that this level of significance is limited, the findings should be interpreted with caution. Students trained using both traditional methods and 3D animation-supported game simulation showed similar results in academic achievement and self-confidence, with no statistically significant differences observed in these variables. Although the 3D animation-supported simulation did not demonstrate a clear advantage over traditional teaching methods in terms of satisfaction, self-confidence or academic achievement, it yielded comparable results in these key areas. These findings suggest that technology-enhanced approaches of this kind may serve as effective complementary tools in nursing education. Future research may focus on the long-term effects of these contemporary teaching strategies, particularly their integration into blended learning environments and their applicability to different student groups.

Abbreviations

3D	Three-dimensional
CONSORT	Consolidated Standards of Reporting Trials

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

Fatma Tanrikulu, Handenur Gündoğdu, and Funda Erol provided the conception and design of the study. Data collection was carried out by Fatma Tanrikulu and Handenur Gündoğdu. Funda Erol and Yurdanur Dikmen performed the data analysis and contributed to the interpretation of the results. The first draft of the manuscript was written by Fatma Tanrikulu, Handenur Gündoğdu, and Funda Erol. Yurdanur Dikmen critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to institutional privacy policies but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Ethics Committee of Sakarya University of Applied Sciences (Approval No: E-26428519-044-65435). Before data collection, all participants provided informed consent. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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