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The Effect of Virtual Reality-Based Teaching (VRBT) on Nursing Students' Learning Performance and Engagement in Anatomy

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Abstract

Background: This research aimed to assess the effectiveness of virtual reality-based teaching (VRBT) in enhancing the learning performance and engagement of nursing students in anatomy courses.

Methods: A quasi-experimental study with a pretest-posttest design was conducted. Due to the limited number of students enrolled in the course, convenience sampling was employed. Students were randomly assigned to one of two groups: (1) Traditional learning (TL) group and (2) VRBT group. Academic achievement tests were administered to assess learning performance, while a questionnaire on self-reported perceptions of engagement was used to evaluate student engagement. Data were analyzed using *t*-tests and covariance analysis.

Results: The study population comprised 62 fourth-year nursing students enrolled in anatomy courses. The findings revealed that students in the VRBT group demonstrated significantly better learning performance compared to those in the TL group. However, no significant difference in engagement was observed between the VRBT and TL groups. Additionally, students in the VRBT group were more likely to report positive utilization of VR technology in the classroom.

Conclusions: This study provides valuable insights into how virtual reality (VR) can improve anatomy learning outcomes for nursing students. The use of VR in anatomy education is strongly recommended.

Keywords: Virtual Reality, Teaching, Performance, Anatomy

1. Background

Anatomy, as a visual discipline, is considered a vital foundation for the study of medical sciences (1, 2). In anatomy learning, students gain an understanding of structures and their visual interconnections (3). However, nursing students often face challenges in fully grasping 3D anatomical images, such as those presented in academic textbooks and other visual materials (4-6). Despite employing various teaching methods, many students report that their knowledge of anatomy remains insufficient (7-11). Nursing students must not only familiarize themselves with the appearance and functions of human anatomical structures but also understand the spatial relationships among hidden structures within the body (12-14). This presents a significant challenge in traditional classrooms, where students primarily rely on 2D images in textbooks and articles as learning references (15-19).

In recent years, the use of 3D computer models for teaching anatomy has increased. Virtual reality (VR) is an immersive technology that allows users to explore, navigate, and interact with objects in real or computer-generated 3D multimedia environments (15, 17). The VR-based anatomy education offers a 3D representation of the human body, enabling students to view anatomical systems from multiple angles and perspectives, thereby strengthening their understanding of spatial relationships between body tissues. Moreover, VR allows students to manipulate 3D models and perform virtual dissections, leading to improved learning outcomes and greater satisfaction with the educational experience (20, 21).

3D anatomy software and applications, virtual dissection, augmented reality, online learning

platforms, 3D printing, and peer-to-peer learning are innovative methods increasingly utilized in anatomy education. While VR significantly enhances anatomy education by offering interactive and engaging learning experiences, its limitations compared to traditional methods highlight the importance of adopting a hybrid approach (17, 18). The VR also influences learner engagement, which is considered a multidimensional psychological construct describing an individual's active participation in learning processes and activities (22-24). Engagement encompasses the behavioral, emotional, and cognitive dimensions of student involvement in the learning process (25).

Previous research underscores the critical role of student engagement in the learning process, revealing a strong correlation between engagement and academic achievement (24-29). A notable challenge in current anatomy education is the limited availability of cadaver samples, which many universities struggle to provide. Virtual reality may help bridge this gap by offering alternative, immersive learning experiences.

2. Objectives

This research focuses on how the actions and reactions within a VR learning environment enhance the learning process and contribute to increased levels of learner engagement (1, 2, 12, 27, 30). Based on these considerations, the present study aims to evaluate the effectiveness of virtual reality-based teaching (VRBT) on the learning performance and engagement of nursing students in anatomy.

3. Methods

3.1. Research Design

A quasi-experimental design with a pretest-posttest approach was employed to evaluate the effectiveness of the intervention method (Table 1). One class was assigned to the VRBT group, while another class was designated as the traditional learning (TL) group.

3.2. Sample Size

Among the courses offered at Razi Medical School in Kermanshah, Iran, the anatomy course was selected for this intervention. The study participants included 70 students enrolled in the anatomy course, from which a sample of 62 students was chosen based on Krejcie and Morgan's table.

3.3. Procedure

The VRBT group utilized VR applications installed on mobile phones (Tables 2 and 3). As shown in Table 1, the study spanned eight weeks, with seven 60-minute sessions conducted each week, beginning on September 1, 2021. During the first week of the intervention, both participant groups completed the pre-tests (academic achievement test and self-reported perceptions of engagement). Subsequently, we evaluated the VR equipment and instructional materials to ensure optimal outcomes for VRBT. The VRBT group also familiarized themselves with the VR tools and classroom setup, minimizing the potential impact of the new technology on their education.

From the second week to the seventh week, the professor delivered anatomy lessons to the VRBT group. Each week, the professor introduced the lesson content and requirements during a 10-minute session. Students were then instructed to perform specific activities designed to help them understand scientific concepts and immerse themselves in VR scenarios. Due to a limited number of VR devices, the students were divided into 10 random subgroups of three individuals each. These subgroups used the headset VR Box 105 during their learning activities. The mobile phones were placed into the VR Box 105, and wired headphones were connected for audio. Students operated the VR applications (Table 4) using a remote control provided with the VR Box 105.

During the VR experience, students viewed images and listened to audio through the wired headphones, with each student experiencing approximately 7 to 8 minutes of virtual scenarios. After completing the VR activities, each subgroup participated in in-person classroom tasks. These tasks involved completing and reviewing printed educational exercises listed on a checklist (Table 3).

The TL group, on the other hand, received instruction using a traditional teaching approach.

The students in this group also utilized the Moodle Cloud platform and online educational resources. These students were randomly divided into six smaller groups, each consisting of five students. They were taught the same material using traditional in-person teaching methods, combined with the Moodle Cloud, within a standard classroom setting. During each session, the teacher used PowerPoint presentations and videos to deliver the lesson content. Following this, each

Table 1. Research Design

Week	TL	VRBT
First week	Academic achievement test; self-reported perceptions of engagement	
Second to seventh week	Class lectures	
	Using face-to-face teaching methods along with the moodle in the regular classroom.	Access learning contents via mobile devices using VR apps
Eighth week	Academic achievement test; self-reported perceptions of engagement	
		Interview; attitude toward VRBT

Abbreviations: VR, virtual reality; TL, traditional learning group; VRBT, virtual reality-based teaching group.

Table 2. Applications Used to Teach Content in the Virtual Reality-Based Teaching Group

Sessions	Subject of Education	Application Used
1	General body anatomy	Anatomy learning-3D anatomy
2	Anatomy and physiology of the heart (1)	Living heart for cardboard VR
3	Anatomy and physiology of the heart (2)	Living heart for cardboard VR
4	Respiratory physiology (1)	Respiratory system anatomy Pro
5	Respiratory physiology (2)	Respiratory system anatomy Pro
6	Brain anatomy (1)	Brain anatomy Pro VR
7	Brain anatomy (2)	Brain anatomy Pro VR

Abbreviations: VR, virtual reality.

Table 3. Procedure

Group	VRBT	TL
Activates	(1) Testing VR devices; (2) introducing the content and prerequisites of the lesson; (3) dividing randomly students into 10 subgroups of three people; (4) using headset VR Box 105; (5) performing face-to-face classroom activities by each subgroup	(1) Introducing the content and prerequisites of the lesson; (2) learning the material through the Moodle cloud and anatomy textbooks; (3) doing learning activities and assignments together; (4) students' discussion; (5) summarizing the answers by teacher

Abbreviations: VRBT, virtual reality-based teaching group; TL, traditional learning group; VR, virtual reality.

subgroup gained additional knowledge through the Moodle Cloud platform and anatomy textbooks, completing learning tasks and exercises collaboratively.

In the Moodle Cloud, students accessed a video, a PDF document, and an assignment during every session. After the students engaged in discussions, the teacher summarized their responses and provided feedback (Table 3). To ensure that both the VRBT and TL groups received identical educational content, two anatomy professors not involved in the study reviewed the application programs listed in Table 2. Based on this, they developed the educational materials for the TL group and taught the same content to that group.

Additionally, to address potential variables affecting the TL group, Moodle Cloud was used solely as an internet-based platform for organizing educational resources, rather than as a standalone method that could influence the TL group's outcomes. Consequently, this platform did not introduce confusion, and both groups (TL and VRBT) were equally familiar with the Moodle Cloud environment.

In the eighth week, both groups of students completed the post-tests. Students in the VRBT group were also interviewed by the researchers and completed the attitude toward VRBT Questionnaire.

3.4. Measurement Tools

3.4.1. Academic Achievement Test

Two anatomy professors contributed to the development of a test, which included both a pre-test and a post-test, to evaluate student performance. The content of the pre-test and post-test was designed to

Table 4. Age and Gender Distribution of Students in Traditional Learning and Virtual Reality-Based Teaching Groups [a]

Variables	TL	VRBT	Difference	
Age (y)				
20 - 21	15 (48)	17 (55)	2	
21 - 22	16 (52)	14 (45)	2	
Gender				
Female	18 (58)	15 (48)	3	
Male	13 (42)	16 (52)	3	
GPA; Group	**Mean**	**Difference of Means**	***t***	**P-Value**
VRBT	17.56	0.56	0.78	0.81
TL	18.12			

Abbreviations: VRBT, virtual reality-based teaching; TL, traditional learning.

[a] Values are expressed as No. (%) unless otherwise indicated.

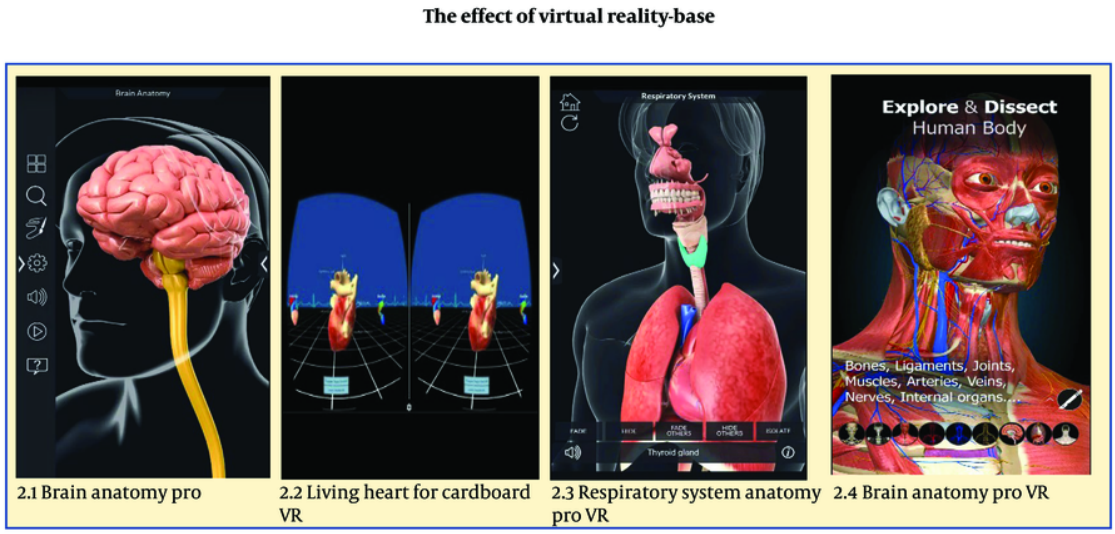

Figure 1. Applications used to teach content in the virtual reality-based teaching (VRBT) group

minimize the potential influence of test similarity on the learners.

The pre-test comprised 25 questions aimed at assessing whether students possessed the same level of pre-existing anatomy knowledge before participation. This included 10 true-or-false items and 15 multiple-choice items, with a total score of 40.

The post-test consisted of 24 items designed to evaluate anatomy knowledge and student progress in the learning modules. This included eight multiple-choice questions, eight true-or-false questions, five fill-in-the-blank items, and three short-response items.

- Cronbach's alpha was employed to measure the reliability of both the pre-test and post-test for multiple-choice items, with values exceeding 0.80, indicating acceptable internal consistency.

- The Kuder-Richardson Formula 21 (KR-21) was applied for other types of questions, with all items achieving reliability scores above 0.80. A panel of experts, including three educators, confirmed the content validity of the test. To ensure that the academic

achievement tests adequately addressed all course objectives, the most recent pre-test and post-test were reviewed by anatomy professors and a panel of experts.

Every effort was made to eliminate barriers and ensure strong validity and reliability. Both the intervention and control groups took identical pre-tests and post-tests, which were administered in Persian.

3.4.2. Self-reported Perceptions of Engagement

To evaluate student engagement, the researchers developed a survey titled "Self-Reported Perceptions of Engagement", based on Reeve et al.'s (24) study. Data from 50 undergraduate students were collected to create the draft questionnaire. Following an analysis of the collected data, the researchers designed a preliminary survey comprising 45 questions.

Based on feedback from experts at multiple universities, items deemed irrelevant or repetitive were removed from the initial version. The revised version consisted of 37 questions. A 5-point Likert scale was used for scoring, with responses categorized as follows: Completely agree (5), agree (4), partially agree (3), disagree (2), and completely disagree (1).

- Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests.

- A KMO value of 0.94 was achieved, indicating a highly satisfactory measure of sampling adequacy.

- Bartlett's test yielded a significant result (χ^2 = 8530.19; $P < 0.000$), confirming the appropriateness of the data for factor analysis.

- Internal consistency .

- The reliability coefficient, calculated using Cronbach's alpha, was 0.950, indicating excellent internal consistency.

- A secondary analysis confirmed a KMO value of 0.93 as excellent, with a significant result from Bartlett's test ($\chi^2 = 7719.09$; $P < 0.000$).

The final survey included four components that collectively accounted for 51.11% of the total variance. Each component demonstrated a high degree of internal consistency:

- Behavioral engagement: 13 items, Cronbach's alpha = 0.863

- Emotional engagement: 10 items, Cronbach's alpha = 0.834

- Cognitive engagement: 7 items, Cronbach's alpha = 0.825

- Agency (student initiative): 6 items, Cronbach's alpha = 0.711

3.4.3. Attitude Toward Virtual Reality-Based Teaching Questionnaire

A modified attitude questionnaire was developed based on the attitude scale utilized in the study by Li et al. (23). This five-point Likert scale survey assessed the treatment group's attitudes toward VRBT, ranging from completely agree (5) to completely disagree (0). The survey included ten items that addressed system operations and educational tasks in VRBT. The KR20 reliability score for the attitude survey exceeded the acceptable threshold of 0.7, achieving a value of 0.81, indicating strong reliability.

3.4.4. Interview

Semi-structured interviews were conducted to examine participants' satisfaction with the use of VR in an educational setting. Eleven students were randomly selected from the VRBT group to participate. The interviews consisted of 11 open-ended questions and were brief, ensuring participants could share their thoughts comfortably. Data from the interviews were collected and analyzed by two researchers independently. The researchers identified the most relevant statements from the responses and highlighted overlapping opinions to ensure accuracy and consistency in the analysis.

The questions included in the interview were as follows:

1. Are you familiar with VR software?

2. What were your thoughts on using VR goggles during the class?

3. Which method helps you learn more: This one or the traditional method?

4. How did this teaching method differ from the classes you had previously?

5. Do you believe that you will acquire more knowledge by using this software?

6. Did any technical issues arise while using the software?

7. What distinguishes this type of training from standard training?

8. Does using this software increase your motivation to learn?

9. Would you like to use this software in additional

classes?

10. Have you experienced fatigue after using VR goggles multiple times?

11. Would you recommend this approach for other courses and various students?

3.5. Statistical Analysis

An independent *t*-test was used to compare the averages of independent groups in this study. Analysis of covariance (ANCOVA) was employed to examine the effect of VR and compare it with the standard teaching approach. Numerical data, including means and variances of both groups, were analyzed using SPSS 25 software.

3.6. Ethics Statement

Students participated in the study voluntarily and agreed to use the VR tools. They provided consent with the understanding that their personal information would remain anonymous. Each participant submitted written informed consent before being included in the study.

4. Results

4.1. Demographic Status of Research Participants

The TL group consisted of 31 students, including 13 males and 18 females, with an average age of 21.11 ± 1.19 years. Similarly, the VRBT group included 31 students, with 16 males and 15 females, and an average age of 20.11 ± 0.67 years (Table 4).

4.2. The Effect of Virtual Reality-Based Teaching on Academic Achievement

Students were assessed on their prior knowledge of anatomy through a pre-test conducted before the learning sessions. As shown in Table 3, the results of the independent *t*-test (VRBT and TL groups: $t = 0.67$, $P = 0.82 > 0.05$) indicated no significant difference in academic performance in the pre-test. This suggests that the prior knowledge levels in both groups were likely similar. Additionally, the results of the independent *t*-test (VRBT and TL groups: $t = 2.27$, $P = 0.05$) revealed a significant difference between the two groups in the post-test, with students in the VRBT group achieving higher scores than those in the TL group (Table 5 and Figure 2).

Furthermore, according to Table 5 and paired *t*-tests, there was a significant difference in academic performance between the pre-test and post-test for the VRBT group, but no significant change was observed for the TL group.

An ANCOVA test was conducted after the learning activities. The homogeneity test results indicated no significant difference in the post-test scores between the groups ($P = 0.73 > 0.05$), allowing for the use of the ANCOVA test. The results of the ANCOVA post-test, presented in Table 6, revealed a significant difference between the VRBT and TL groups ($P = 0.01 < 0.05$), showing that students in the VRBT group achieved significantly higher academic scores than those in the TL group.

4.3. The Effect of Virtual Reality-Based Teaching on Student Engagement

Table 7 shows that the independent *t*-tests did not reveal any significant differences in the post-test engagement factors between the groups. Students in the VRBT group did not score higher in engagement factors compared to those in the TL group (Figure 2 and Table 5).

Table 8 shows that the VRBT and traditional groups did not exhibit significant differences in terms of engagement levels (behavioral: $F = 1.52$, $P = 0.12 > 0.05$; emotional: $F = 1.29$, $P = 0.19 > 0.05$; cognitive: $F = 1.25$, $P = 0.21 > 0.05$; agentic: $F = 1.23$, $P = 0.24 > 0.05$). This suggests that students in VRBT anatomy courses did not show higher engagement compared to those in traditional courses.

4.4. Attitude Toward Virtual Reality-Based Teaching

The findings revealed that more than 66% of the participants expressed interest in using VRBT for learning, recommended it to fellow students, and viewed VR technology as an effective approach for nursing education (Figure 3).

4.5. Students' Views Toward Virtual Reality-Based Teaching

Thematic analysis was used to analyze the data. The students expressed excitement, happiness, and a sense of being valued upon learning about the integration of VR into the course. Two students voiced some hesitation due to their lack of previous classroom experience with VR technology. However, interviews revealed that the students' motivation had increased.

Student 1: "I felt happy when I heard about it for the first time. I am a little unsure, though. We encountered tasks that we were unsure how to complete".

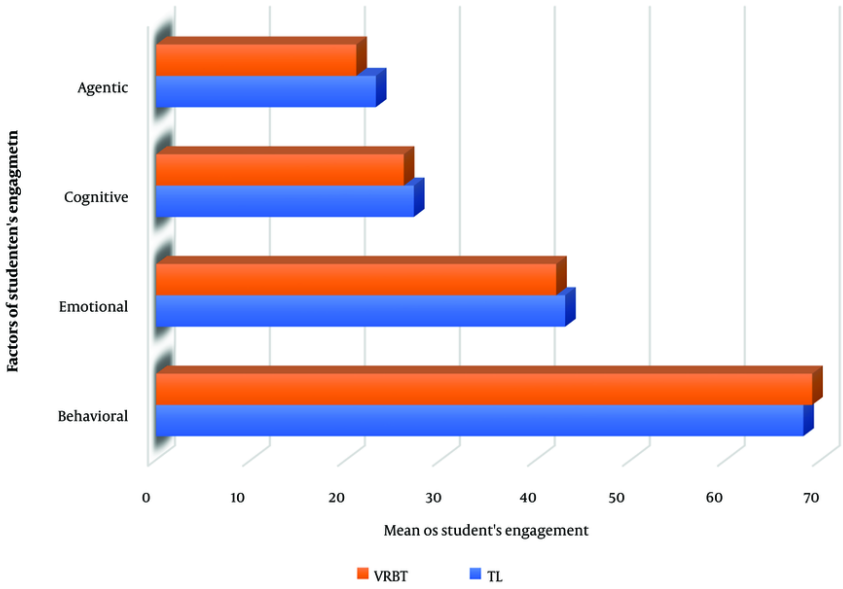

Figure 2. Effect of virtual reality-based teaching (VRBT) on student engagement in the post-test

Table 5. *t*-test Results of Pre-test and Post-test Scores in Academic Achievement (N = 62, Traditional Learning Group = 31, Virtual Reality-Based Teaching Group = 31)

Groups	Tests	Mean ± SD	Difference of Means	*t*	Significant
TL	Pre	22.13 ± 1.25	0.76	0.67	0.82
	Post	22.89 ± 1.21			
VRBT	Pre	21.08 ± 1.35	2.99	3.22	0.05[a]
	Post	24.07 ± 1.20			
TL	Pre	22.13 ± 1.25	1.05	0.67	0.82
VRBT	Pre	21.08 ± 1.21			
TL	Post	22.89 ± 1.35	1.81	2.27	0.05[a]
VRBT	Post	24.07 ± 1.20			

Abbreviations: TL, traditional learning group; VRBT, virtual reality-based teaching group.

[a] P < 0.05 was considered statistically significant.

Table 6. Analysis of Covariance of the Posttest Results for Academic Achievement (N = 62, Traditional Learning Group = 31, Virtual Reality-Based Teaching = 31)

Groups	Test	Mean	F	Significant
TL	Post	22.89	5.23	0.01 [a]
VRBT	Post	24.07		

Abbreviations: TL, traditional learning; VRBT, virtual reality-based teaching.

[a] P-value less than 0.5 is statistically significant.

Student 3: "I had positive emotions. I felt thrilled and joyful. I felt valued in this class".

Student 4: "Being able to access resources and samples anytime was a motivating factor for me".

Table 7. *t*-test Results of Pre-test and Post-test Scores in Student Engagement (N = 62, Traditional Learning = 31, Virtual Reality-Based Teaching = 31)

Factor	Groups	Test	Mean ± SD	Difference of Means	*t*	Sig.
Behavioral	TL	Post	68.14 ± 1.35	0.93	0.87	0.74
	VRBT	Post	69.07 ± 1.20			
Emotional	TL	Post	43.06 ± 0.74	0.94	0.89	0.76
	VRBT	Post	42.12 ± 1.11			
Cognitive	TL	Post	27.13 ± 1.74	1.06	1.01	0.55
	VRBT	Post	26.07 ± 0.34			
Agentic	TL	Post	23.13 ± 1.11	-0.86	0.67	0.83
	VRBT	Post	21.99 ± 0.29			

Abbreviations: TL, traditional learning; VRBT, virtual reality-based teaching.

Table 8. Analysis of Covariance of the Post-test Results for Student Engagement (N = 62, Traditional Learning = 31, Virtual Reality-Based Teaching = 31)

Factors and Groups	Tests	Mean	F	Sig.
Behavioral			1.52	0.12
TL	Post	68.14		
VRBT	Post	69.07		
Emotional			1.29	0.19
TL	Post	43.06		
VRBT	Post	42.12		
Cognitive			1.25	0.21
TL	Post	27.13		
VRBT	Post	26.07		
Agentic			1.23	0.24
TL	Post	23.13		
VRBT	Post	21.99		

Abbreviations: TL, traditional learning group; VRBT, virtual reality-based teaching group.

Student 5: "I really appreciated it. I was always moving around with my mobile device".

Student 7: "Reported that VR positively impacted their learning and also influenced their motivation".

Student 2: "The anatomical structures were easy to understand and clearly visible when using the VR device".

Student 6: "My interest in anatomy lessons grew significantly after the VRBT experience".

Student 7: "I supplemented materials when I was confused during my coursework and tried to resolve the problems".

Students encountered technical difficulties related to internet connectivity, tablets, apps, and other technical issues. Despite these challenges, they believed that VR could be applied to other subjects by eliminating such obstacles. Students also provided suggestions for utilizing VR in the classroom:

Student 2: "The information I came across, both relevant and irrelevant, caused some confusion. I believe persistence levels will increase when VR is applied in hands-on courses".

Student 3: "I aim to access the course materials toward the conclusion of the course".

Student 8: "I sometimes felt confused due to the abundance of photos and information on various topics".

Student 11: "I experienced fatigue after using the VR glasses multiple times".

5. Discussion

In this research, we employed mobile VR technology for teaching anatomy. An experiment was conducted on medical school students across four anatomy course units to assess the effectiveness of the intervention method. The findings indicated that academic

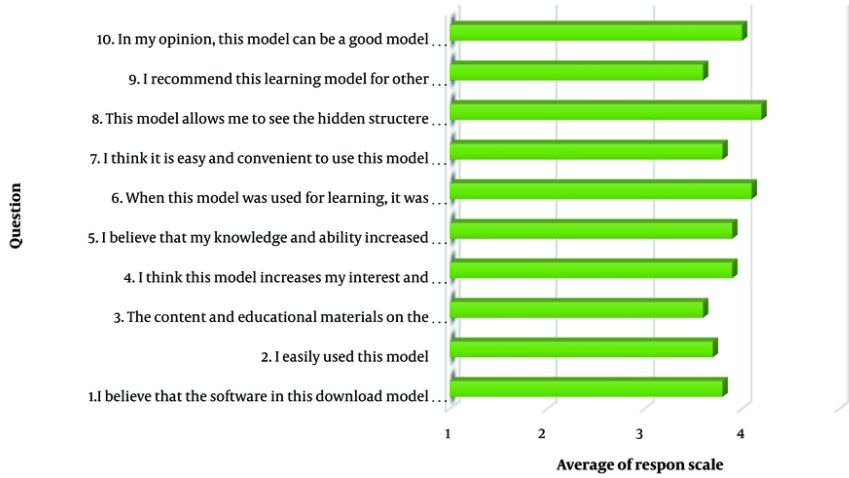

Figure 3. Attitude toward virtual reality-based teaching (VRBT)

Table 9. Attitude Toward Virtual Reality-Based Teaching

Question No.	Response Scale [a, b]					Average Percentage
	5	4	3	2	1	
1	11 (35)	10 (32)	5 (17)	4 (13)	1 (3)	3.8
2	9 (30)	12 (38)	4 (13)	6 (20)	0 (0)	3.7
3	8 (26)	11 (35)	7 (22)	2 (6)	3 (10)	3.6
4	12 (38)	10 (32)	6 (20)	2 (6)	1 (3)	3.9
5	13 (42)	8 (26)	5 (15)	4 (12)	1 (3)	3.9
6	14 (45)	10 (32)	4 (13)	3 (10)	0 (0)	4.1
7	11 (35)	11 (35)	3 (10)	5 (17)	1 (3)	3.8
8	15 (49)	10 (32)	4 (13)	2 (6)	0	4.2
9	9 (30)	11 (35)	5 (17)	4 (13)	2 (6)	3.6
10	14 (45)	9 (30)	3 (10)	5 (16)	0	4

[a] Values are expressed as No. (%).

[b] 5: Completely agree; 4: Agree; 3: Neutrals; 2: Disagree; 1: Completely disagree.

performance was significantly better in students taught in the VRBT group compared to those taught using the TL format. These results align with previous research demonstrating that VR significantly enhances learning (1, 3, 5, 7, 8, 24, 27-29). This study highlights three specific reasons that demonstrate the advantages of VR. The higher success of the VRBT group could be attributed to the positive attributes of VR. Moreover, face-to-face training with VR is more effective in addressing complex issues and fostering understanding, whereas computer environments are better suited for linking ideas and interpretations (4-6). Engaging in collaborative learning tasks within a VR setting can therefore provide a profound and immersive learning experience (4-6). Furthermore, VR could enhance the understanding of anatomy by providing visual depictions of hidden structures and offering prompt feedback to learners within a simulated environment (8-10, 29, 30).

The findings also revealed that students who received VRBT instruction did not exhibit increased engagement compared to those taught using TL methods. Previous studies have shown that learning with VR is effective for increasing engagement in anatomy learning, which

contrasts with these results (12, 13, 22). Additional research is needed in this area. Furthermore, it is recommended to allow a seven-week gap between the intervention and the conflict assessment to reevaluate validity and compare the results with those of a longer time interval to test reliability. To assess engagement with the instructional approach, there should be a specified time frame between the trial and evaluation periods. Researchers suggest waiting six months for reliable outcomes to be obtained (12). In this study, a time frame of eight weeks was used instead of six months due to the participants' intense study program, which resulted in the research being completed in two months. Additionally, the course duration lasted for a total of eight weeks, and due to this factor, the assessment was conducted at the conclusion of the unit.

Additionally, the findings indicated that students in the VRBT group exhibited a positive inclination toward utilizing VR in educational settings. This suggests that VRBT provided a great user interface and enhanced interest in learning. This finding is consistent with earlier research showing that incorporating VR into anatomy lessons can positively impact learners' attitudes (28-30). Furthermore, the interviews revealed that learners found VRBT lessons more engaging and expressed a desire to continue learning through HMD rather than traditional classroom methods.

5.1. Conclusions

The VR model increased students' motivation, learning, and sense of inclusion by fostering an inclusive atmosphere, prompting them to reflect on the material and engage in educational activities. The VR model enhanced students' motivation, learning, and participation through this inclusive environment. The findings of this study provide concrete evidence supporting the use of VR in anatomy education.

5.2. Limitations

Several limitations were identified in this research. First, the findings indicated that the impact of VR on the education of fourth-year nursing students is positive, which suggests that it may not be applicable to students at different stages or ages. When developing or incorporating VR for teaching anatomy in the classroom, it is important to consider additional factors such as students' learning preferences, ability to visualize mentally, and level of interest in learning. Furthermore, VR capabilities, such as direct control, should be taken into account when designing VR-based learning environments. Additionally, while the current study demonstrated that VR can offer instant feedback for student learning, it remains unclear whether this specific VR design with feedback features is as impactful as other virtual learning environments or TL settings. Therefore, VR feedback components must be carefully crafted using both educational and technological advancements to enhance the understanding of anatomy. Furthermore, since students only had limited time to use the HMD in class, it is recommended that future research provide students with the HMD beforehand and observe their interactions in the VR setting. Long-term research is needed to assess the effectiveness of utilizing VR in anatomy classes.

5.3. Highlights

- Enhancing students' learning performance: This study emphasizes that the use of VR increases students' performance and can enhance their learning by providing an immersive 3D environment.

- Improving students' interest in the course: Virtual reality, by involving students in a three-dimensional and engaging space, can increase their participation in the learning process. This participation can improve their interest in and attitude toward using VR in anatomy lessons.

5.4. Lay Summary

This study examined how VRBT improves the learning performance and engagement of nursing students studying anatomy. Sixty-two fourth-year nursing students participated in an experimental design for seven weeks. The findings indicated that students in the VRBT group performed better in learning compared to students in the TL group. Additionally, the results showed that students in the VRBT group were more likely to utilize VR in the classroom. The study suggests that the use of VR increases students' performance and improves their interest in the anatomy course.

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Footnotes

Authors' Contribution: B. R. contributed to idea development and research design and managed the program. B. R. oversaw the program and contributed to the manuscript, analysis, and interpretation of data, as well as drafting and final approval of the manuscript. B. R. contributed to the data collection process and wrote the final draft together. All authors read and approved the final manuscript.

Conflict of Interests Statement: The authors declare no conflicts of interest.

Data Availability: Data sets presented in the study are available upon request from the corresponding author during submission or after publication. The data is not publicly available due to the request of the research participants.

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Informed Consent: Written informed consent was obtained from each participant prior to their inclusion in the study.

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