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The impact of virtual reality on self-efficacy, self-regulation, motivation, and academic performance in sciences

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ABSTRACT
This study aimed to investigate the impact of using VR technology on the academic self-efficacy, self-regulation, academic motivation and academic performance of Iranian eighth-grade pupils in the field of experimental sciences. The research employed a quasi-experimental model with two experimental groups and a control group. A pre-test and post-test design was administered to both groups. The study population consisted of all male eighth-grade students at the secondary school level in Bam, Iran. The sampling method used was purposive convenience sampling, as conducting the research required specific facilities and equipment, such as VR goggles. In this study, four standard questionnaires were employed as research tools: one for self-efficacy developed by Midgley (2000), one for self-regulation (SRQ) developed by Miller and Brown (1991), one for the academic motivation questionnaire by Harter's scale (1981), and to measure academic performance, a researcher-made test in the field of experimental sciences. The collected data were analysed using SPSS 23 software. The results showed a significant relationship between the use of virtual reality and academic performance, self-efficacy, self-regulation, and motivation. Virtual Reality is a tool that can be used to help school learners and meet the needs of future science teachers.

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Introduction

The ever-evolving world witness the continuous expansion of information and communication technology (ICT). To effectively navigate these shifts, individuals must embody a lifelong learning mindset, innate curiosity, adaptability, and skill development. They require the necessary skills to comprehend, interpret, and process information for continuous education that benefits both the individual and society. Human education and its presentation have continuously evolved. With the emergence of each new technology, education has adapted accordingly. ICT with features such as personalised learning, a multisensory approach, and increased interaction with content can play a significant role in shaping knowledge and skills. In the not-so-distant future, learners may not require a physical presence in classrooms, focusing instead on digital tools such as blackboards or projectors (Zhenbo et al., 2019). By integrating virtual reality (VR) with the e-learning system, a comprehensive virtual learning world has been created for electronic education (Harry & Kha, 2021). Effective learning in the classroom depends on the ability and skill of teachers to instruct and engage learners in discussions and lessons. Among these, VR learning environments encompass innovative methods such as teamwork, creative thinking, meaning-making through social interaction, and learning by doing, which can have a significant impact on learning motivation. Virtual reality-based curriculum often contradicts traditional curriculum. VR technology involves the simultaneous overlay of virtual images, including two-dimensional, three-dimensional, film and animation onto the real world, with an appropriate angle and spatial position designated as an added element to the real world. This sentence doesn't make sense in conventional curricula, there is a greater emphasis on delivering theoretical content (Emmelkamp et al., 2019), while a virtual reality-based curriculum aims to engage and involve learners in learning topics (Riva, 2018), mitigating quality control challenges ??, individual differences among learners, and providing learning feedback in real environments, thus enhancing learners' understanding of subjects and concepts. This jumbled sentence needs revisiting! In a virtual reality-based curriculum, education becomes simulation. A virtual reality-based curriculum utilises computer software and audio-visual equipment to create an artificial environment, simulating real-world scenarios, thereby enabling more effective and realistic learning experiences (Jang & Kim, 2020). One of the primary objectives of educational systems is to enhance the academic performance of learners. Academic performance encompasses all activities and efforts that an individual demonstrates to acquire knowledge and pass various educational levels in educational institutions (Martin et al., 2016). The academic performance of students is the key feature and one of the essential goals (Narad and Abdullah, 2016) of education, which can be defined as the knowledge gained by the learner, which is assessed by marks by a teacher or educational goals set by students and teachers to be achieved over a specific period of time. Academic performance is something of immense significance for anyone concerned with education (Osiki, 2001). In fact, academic performance can be understood as the nucleus around which a whole lot of significant components of the education system revolve, which is why the academic performance of students, specifically belonging to Higher Education Institutions (HEIs), has been the area of interest among researchers, parents, policy framers and planners. Since a sound academic performance is considered a prerequisite for securing good jobs, a better career and subsequently a quality life, the significance of the students' academic performance is immense. Although it may seem to be a simple outcome of education, the impact of students' academic performance in any nation is multifaceted. Narad and Abdullah (2016) mentioned in their research. the success or failure of any academic institution depends mainly upon the academic performance of its students. They also reiterated the general belief that good academic performance signals better career prospects and, therefore, a more secure future.

The academic performance of students is immensely significant, as the economic and social development of any country are both attributable to the academic performance of the students. The better students perform academically, the better the prospects are for developing a pool of quality manpower who will contribute to the nation's economic and social development (Ali et al., 2009). Students performing better than the expectations and norms set by society are mostly expected to contribute to the growth, development, and sustainability of society (Akinleke, 2017). This provides a compelling reason to rephrase for educators, granting the highest priority to the academic performance of their students (Farooq et al., 2011).

One of the influential factors on academic performance is students' self-efficacy (Duff et al., 2015), which is central to Albert Bandura's social cognitive theory. According to Bandura (2001), self-efficacy is an individual's belief in their ability to organise and perform a wide range of activities required to cope with different situations and circumstances. In other words, self-efficacy is the belief in one's ability to succeed in a specific problem. According to Bandura, this belief is a determining factor in individuals' thinking, behaviour, and feelings. Self-efficacy is the ability to organise and coordinate behavioural, emotional, social, and cognitive skills for numerous goals. Individuals with strong self-efficacy perceive challenging issues as problems to overcome, show a deeper interest in activities they are engaged in, feel a greater commitment to their interests and activities, and quickly overcome feelings of despair. In addition to self-efficacy, self-regulation can also impact the personal and academic lives of students. Self-regulation is the ability to set aside interfering emotions and tensions and to think before acting (Garcia & Pintrich, 2016). Self-regulation of behaviour means that individuals recognise appropriate and inappropriate behaviours and choose their actions accordingly (Altun & Erden, 2020). Zimmerman defines self-regulation as systematic efforts that guide thoughts, emotions, and actions toward achieving goals and desires; for this reason, its application in educational and psychological fields has become highly significant. Bandura believes that humans have specific capabilities that are generally examinable in three dimensions: imitation and modelling, self-reflection, and self-behaviour regulation. He considers self-regulation as the third human capability and identifies functions for it, including goal setting, self-observation, self-monitoring, evaluation, and judgment of performance and self-reaction. Thus, individuals consistently strive to determine their own goals and then compare their successes with these goals and standards; thereby, individual criteria can stimulate greater motivation for further effort or behavioural change towards achieving a specific goal or standard (Zelkowitz & Cole, 2016). Nurturing motivated, goal-oriented, and progressive learners is a significant issue in the educational system. Motivation is a force that creates, maintains, and directs behaviour. It is something that compels us to perform our tasks to the best of our abilities. Pintrich (2004) states that the structure of academic motivation in educational environments applies to behaviours associated with learning and progress. Deci and Ryan (2002) define academic motivation as students' inclination to engage in and be involved in educational activities, as well as their continuous effort to complete and finish those activities. There are students who, after consecutive failures in their studies, attribute all their failures to their own incompetence. As a result of this perception, these students refrain from making efforts and conclude that their efforts will be fruitless. Therefore, teachers should interact with students in a manner that indicates their interpretations are incorrect. Teachers' positive views of students reinforce in students the feeling that, in the event of failure in their studies, they can boost their motivation to compensate for that failure and pave the way for their progress. Psychologists emphasise the importance of appreciating motivation in education due to its effective connection with new learning, skills, strategies, and behaviours. Academic motivation is one of the basic constructs they have proposed to explain it (Kavousipour et al., 2015). Students' academic motivation for learning is associated with self-confidence, concentration, hard work, perseverance in complex tasks, a willingness to continue studying after class, and choosing assignments that demand more effort. Students' motivated strategies. For learning is one of the main components affecting successful learning, and if appreciated, a learning environment becomes more attractive and engaging for learners (Amrollahi Beyooki et al., 2020).

In the realm of education, teachers have always sought different solutions to concretise various aspects of knowledge for learners. One of these subjects is experimental sciences, which often causes three learning challenges for pupils. Firstly, the high cognitive aspect of scientific content diminishes their sense of proximity to any given problem. In conventional teaching classes, teachers attempt to explain concepts using diagrams, models, and other tools; however, in this subject, due to its high cognitive aspect, students struggle to visualise the presented scenarios (Tan & Waugh, 2016). Secondly, the inability to interact and engage with phenomena, WHAT phenomena? in science class is an issue. Experimental sciences are a subject that primarily focuses on practical and research skills, requiring pupils to interact with educational equipment and conduct experiments, thereby enhancing their problem-solving skills (Andersen et al., 2018). Thirdly, the high cognitive load in some science topics imposes a significant cognitive burden on students due to their complex and intellectually demanding nature. Leading to learning difficulties. VR is a three-dimensional simulated environment where users can interact as if it were a physical environment. Generally, a VR-based curriculum provides simulated real-life situations, fosters interaction and communication with phenomena, helps reduce cognitive load, and aims to increase proximity to the problem, personal control over problem-solving, and self-confidence in problem-solving for learners. For this reason, some researchers have recommended the use of VR curriculum for science subjects. Many concepts taught in these areas are abstract, making them very complex for pupils to grasp. In such cases, the use of VR technology can aid in the proper understanding of these topics. One of the unique advantages of VR is its ability to visualise abstract concepts or inaccessible or dangerous events. Since learning is always the primary focus of any educational endeavour, and education is meaningful only when accompanied by learners' acquisition of knowledge, it is essential to pay attention to academic motivation. This whole section is disjointed. It needs restructuring, as one of the most important components in successfully addressing educational, occupational, familial and social challenges (Tan & Waugh, 2016).

Literature review indicates that in recent years, research on the use of VR technology in various courses and educational levels has been ongoing. For instance, studies by Liu et al. (2023) and Pogorskiy and Beckmann (2023) have shown that learning self-regulation skills has a positive correlation with desktop-based VR, predicting higher satisfaction and increased motivation among students. (i.e., enjoyment, engagement, focus, and presence), helping learners effectively compensate for deficiencies in self-regulation skills. Additionally, O'Connor and Mahony (2023) concluded that students' cognitive strategies influence their perception and interaction with technology and learning tasks, and that augmented VR has a positive impact on students' academic self-efficacy in higher education. Moreover, in the research by Özeren and Top (2023), the academic progress and motivation of students in the experimental group, using augmented reality applications, significantly exceeded those of the control group students. The results of studies by Cetintav and Yilmaz (2023) and Ozdemir et al (2022) also demonstrate that VR applications are engaging and interesting for students, positively affecting academic progress, self-regulated learning skills, student motivation, and active participation in class.

Hsiao (2021) concluded that experiential education with virtual reality affects self-efficacy and learning motivation. The results of studies by Jiang & Fryer (2024) also demonstrate that students' motivation increased after the VR intervention or was higher than in other pedagogical conditions. Based on these findings, the current research seeks to answer the following four questions:

1. Is there a relationship between the use of virtual reality and students' academic performance in science lessons?
2. Is there a relationship between the use of virtual reality and students' self-efficacy in science lessons?
3. Is there a relationship between the use of virtual reality and students' self-regulation in science lessons?
4. Is there a relationship between the use of virtual reality and students' motivation in science lessons?

Methods

This study aims to investigate the impact of using VR technology on academic self-efficacy, self-regulation, academic motivation, and academic performance of Iranian eighth-grade students in the field of experimental sciences. The present research, in terms of its nature, objectives, background, and the application of its results in the field of education and learning, is considered an applied study, utilising a quasi-experimental method with two experimental groups.

Table 1

Pre-test-post-test with control group

Select type	group	pre-test	dependent variable	post-test
R	experimental	@@	x	@@
R	control	@@	@	@@

Note: The experimental group and the control group, and a pre-test-post-test design have been employed, as illustrated in Table 1.

The population of the study comprised all male eighth-grade students at the secondary school level in Bam city, Iran. The sampling method used was purposive convenience sampling, as conducting the research required specific facilities and equipment, such as VR goggles. Therefore, one of the secondary schools in Bam city equipped with these facilities was selected for sampling. Subsequently, two eighth-grade classes in this school were chosen, and 30 pupils in one class were randomly assigned to the experimental group, while 30 students in another class were assigned to the control group. Both groups underwent a pre-test, followed by the teaching sessions, during which the control group received. Both groups underwent a pre-test before the teaching sessions began. The control group received traditional teaching methods, such as lectures and question-and-answer sessions, without the use of technology to teach science lessons. In this group, science instruction was solely based on the topics covered in the textbook; note earlier comment about use of this phrase, the experimental group received instruction with the assistance of virtual reality (VR). It is important to note that one of the authors of the programme was an experienced science teacher with 15 years of experience in science education and expertise in educational technology. This teacher had a deep understanding of technological tools and science lessons. Therefore, no additional training was required, and the teaching sessions for the experimental group were conducted over a period of 6 months, as indicated in Table 2. It should be mentioned that due to the complexity and detail of specific topics, multiple training sessions were needed. As a result, although the original plan was to have 10 sessions, additional time was allocated to ensure thorough coverage of these topics. Furthermore, since there was only one pair of virtual reality glasses available in the classroom, the training duration was extended to approximately 6 months to provide equal opportunities for all students to work with the glasses. The results of the pre-test were then compared with the post-test assessments for the participants. In this study, four questionnaires were employed as research tools. The standard self-efficacy questionnaire, developed by Midgley (2000), consists of 25 questions that encompass components of personal efficacy. The reliability of this questionnaire was calculated using Cronbach's alpha coefficient as 0.78.

The self-regulation questionnaire (SRQ) was developed by Miller and Brown (1991), comprising 63 questions and seven subscales titled receiving relevant information, evaluating the information and comparing it to norms, triggering change, searching for options, formulating a plan, implementing the plan, and assessing the plan's effectiveness. This questionnaire is measured based on the Likert scale. Its reliability was calculated as 0.89.

The academic motivation questionnaire comprises 33 items aimed at investigating academic motivation among students. This instrument is a modified version of Harter's scale (1981) for measuring academic motivation. Harter's original scale measures academic motivation with bipolar questions, where one pole represents intrinsic motivation, and the other pole represents extrinsic motivation. The respondent's answer to each question can only include one of the intrinsic or extrinsic reasons. Since both intrinsic and extrinsic motivations play a role in many academic subjects, Lepper et al. (2005) transformed the Harter scale into standard scales, where each question considers only one of the intrinsic or extrinsic motivational reasons. This questionnaire is based on the Likert scale (never, 1; rarely, 2; sometimes, 3; often, 4; almost always, 5). Its reliability was calculated as 0.92.

To measure academic performance, a researcher-made test in the field of experimental sciences was utilized. To confirm the validity of the instrument, science teachers from different schools were also employed. These teachers confirmed the relevance, clarity, and comprehensibility of the questions. In this study, the validity of the questionnaire. was also confirmed by several professors and experts. Additionally, its reliability was obtained as 0.87 using Cronbach's alpha coefficient. the researchers also conducted informal observations and interviewed the pupils in the experimental group. The purpose of these assessments was to evaluate the pupils' satisfaction levels when working with virtual reality glasses, as well as to determine the impact this tool had on their science lesson comprehension and motivation.

To conduct the research, various VR goggles were examined, considering the advantages and disadvantages of different models available in the market. Eventually, the "Meta Quest" VR goggles were selected. Another notable point about the Meta Quest is its completely wireless structure. Unlike older models that relied heavily on computers or mobile phones, this model is entirely wireless. This means that the Meta Quest incorporates powerful hardware responsible for processing VR content. Prior to commencing the pupils' training, the experimental group was familiarised with these goggles and how to use them. Given the teaching subject, the Share Care Your software was utilised for instructional purposes. Before the training commenced, pre-tests for self-efficacy, motivation, self-regulation, and academic performance were conducted. Subsequently, the training began, with the control group taught through traditional methods and the experimental group receiving instruction with the assistance of VR goggles. Finally, post-tests were administered, and the collected data were analysed. Then, 75-minute teaching sessions were conducted using VR in the anatomy section of the eighth-grade science textbook, utilising the Sharecare software.

Figure 1

A view of MetaQuest virtual reality glasses

Figure 1 shows a view of MetaQuest virtual reality glasses.

This free VR software, designed for teaching human anatomy, is suitable for both university and high school levels and displays body parts with high quality. Sharecare allows each student to freely explore and investigate the accurate three-dimensional anatomical model of the human body, its organs, and their natural functions. They can visualize the functioning of their own body, explore organs and systems in a fully immersive 3D environment, understand physiology, and simulate diseases. It enables students to personalize the human body as a representation of their own body.

Figure 2

A view of the share care for your software environment.

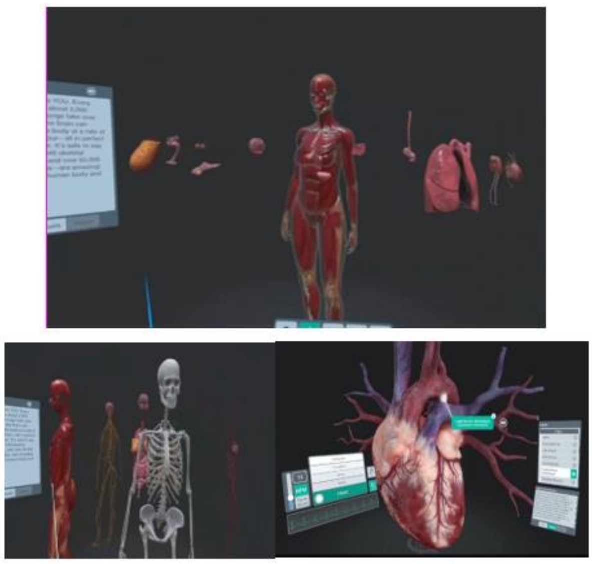


Figure 3

Pictures of research implementation

Note: For data analysis, descriptive statistics (mean and standard deviation) as well as inferential statistics (analysis of covariance) were utilized, and ultimately, the collected data were analysed using SPSS23 software.

Table 2

The topics covered in each session

Session	Activity
First	Pre-test and familiarisation with the functioning of the VR goggles and using VR.
Second	Overview of human anatomy using VR, covering its components such as ligaments, tendons, joints, cartilage, bones, their types, how organs function, and diseases related to them.
Third	Review of spinal anatomy and its components, how it functions, and diseases associated with it.
Fourth	Review of muscle anatomy and the nervous system, their components, how they function, and related diseases.
Fifth	Review of eye anatomy and its components, how it functions, and diseases associated with it.
Sixth	Review of ear anatomy and its components, how it functions, and diseases associated with it.
Seventh	Review of tongue anatomy and its components, how it functions, and diseases associated with it.
Eighth	Review of nose anatomy and its components, how it functions, and diseases associated with it.
Ninth	Review of chest anatomy and its components, how it functions, and diseases associated with it.
Tenth	General review of the presented topics and conducting the post-test.

Findings

Table 3

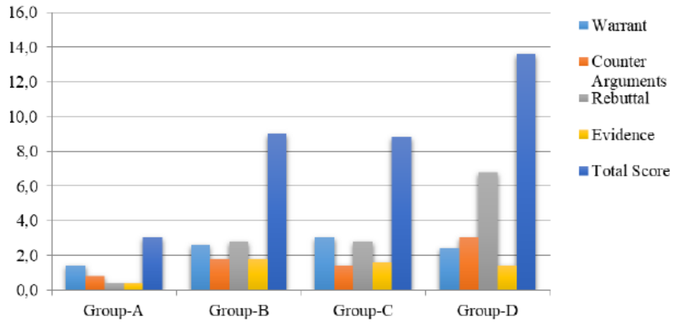
Descriptive statistics of scores in the pre-test and post-test stages in the two groups

Group	Measure	Control		Experimental	
		Mean	SD	Mean	SD
Pre-test	Self-efficacy	66.1	9.79919	80.0667	10.14357
	Self-regulation	199.9667	17.63711	210	15.80921
	Motivation	111.5333	13.5589	110	23.26311
	Academic Performance	4.3	2.11969	4.4667	2.25501
Post-test	Self-efficacy	69.5667	6.20724	76.1333	9.32085
	Self-regulation	188.5	16.96599	204.4667	33.77587
	Motivation	109.0333	13.3274	111.9	16.1829
	Academic Performance	5.7333	7.93914	6.4	2.11073

Note: As seen in Table 3, the mean scores of academic performance, self-efficacy, self-regulation, and motivation of eighth-grade students in the experimental and control groups did not show significant changes between the pre-test and post-test stages. However, in the experimental group, a noticeable change was observed from the pre-test to the post-test stage, indicating the effectiveness of the intervention.

Figure 4

Argumentation skills score of PSTs



Note: As shown in Table 4, the significance level of the Kolmogorov-Smirnov test for all variables is greater than 0.05, indicating the acceptance of the assumption of normality of the data for the variables in both control and experimental groups.

Figure 4 shows the Argumentation skills score of PSTs.

Table 4

Results of the Kolmogorov-Smirnov test to assess the normality of the data before the test

	Control		VR	
Variable	Statistic	Sig	Statistic	Sig
Pretest				
Self-Efficacy	0.137	0.154	0.119	.200e
Self-Regulation	0.1	.200e	0.157	0.056
Motivation	0.123	.200e	0.101	.200e
Academic Performance	0.123	.200e	0.151	0.077
Posttest				
Self-Efficacy	0.172	0.054	0.138	0.15
Self-Regulation	0.168	0.06	0.115	.200e
Motivation	0.139	0.142	0.178	0.016
Academic Performance	0.137	0.151	0.146	0.1

Table 5

The results of the linearity test between pre-test and post-test self-efficacy scores

ANOVA[a]					
	Sum of squares	Df	Sum of mean	f	sig
regression	724.821	1	724.821	15.898	[b]000.
remain	1276.545	28	45.591		
total	2001.367	29			

Coefficients[a]

group	Unstandardized values		standardized values	t	sig
	B	Std. Error	Beta		
Pre-test	465.1	367.	602.	987.3	000.

Note: As can be seen in Table 5, the relationship between pre-test and post-test is linear. (*0 /05]* P-Value ≤ *=15.898* ،F) This linear relationship is also illustrated in Figure 5.

Figure 5

Linear relationship between pre-test and post-test measures of self-efficacy

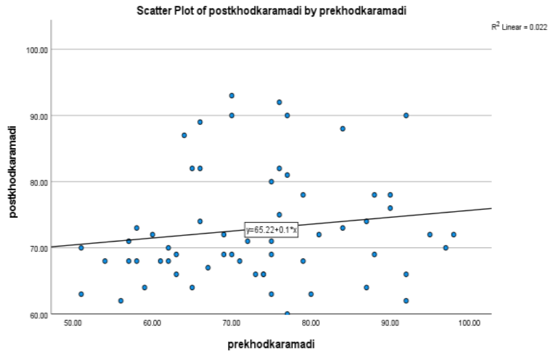


Figure 5 showed the *Linear relationship between pre-test and post-test measures of self-efficacy.*

Table 6

The results of the linearity test between pre-test and post-test self-regulation scores

ANOVA[a]					
	Sum of squares	Df	Sum of mean	f	sig
regression	709.432	1	709.432	25.918	[b]000.
remain	766.434	28	27.373		
total	1475.867	29			

Coefficients[a]

group	Unstandardised values		standardised values	t	sig
	B	Std. Error	Beta		
Pre-test	148.1	225.	693.	091.5	000.

Note: As can be seen in Table 6, the relationship between pre-test and post-test is linear *0 /05]* P-Value ≤ *=25.918* ،F. This linear relationship is also illustrated in Figure 6.

Figure 6

Linear relationship between pre-test and post-test measures of self-regulation

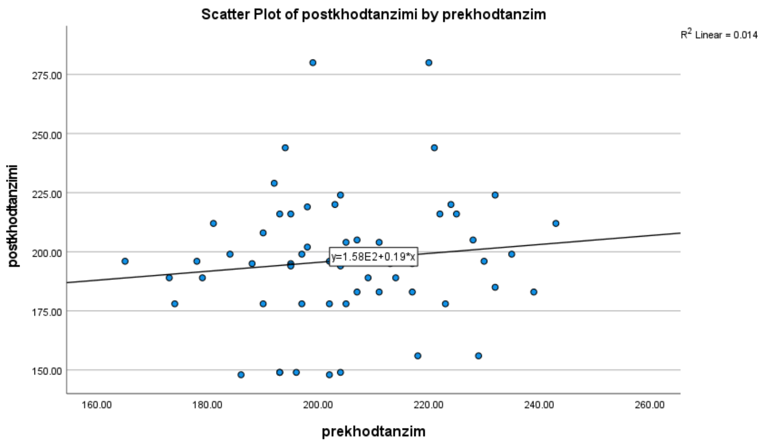


Table 7

The results of the linearity test between pre-test and post-test motivation scores

			ANOVA[a]		
	Sum of square	Df	Sum of mean	f	sig
regression	709.432	1	709.432	23.201	[b]000.
remain	766.434	28	27.373		459.1448
total	1475.867	29			875.8
			1696.967		
group	Unstandardized values		standardized values	t	sig
	B	Std. Error	Beta		
Pre-test	798.	062.	924.	12.755	000.

Note: As can be seen in Table 7, the relationship between pre-test and post-test is linear *0 ⁄05 ⁄05 ⁆* P-Value ≤=*23.201* ،F. ، This linear relationship is also illustrated in Figure 7.

Figure 7

Linear relationship between pre-test and post-test measures of motivation

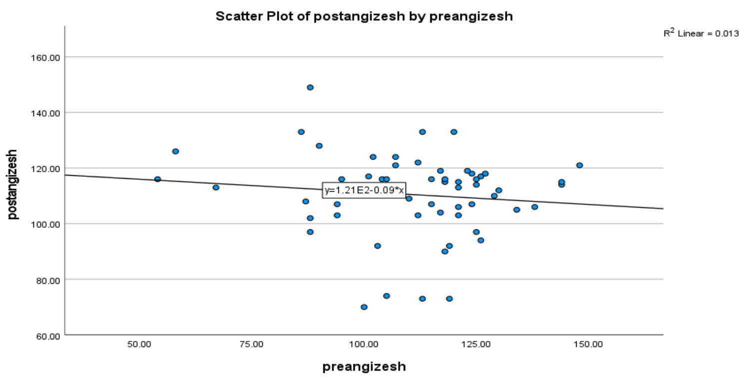


Figure 7 showed a Linear relationship between pre-test and post-test measures of motivation.

Table 8

The results of the linearity test between pre-test and post-test academic performance scores

		ANOVA[a]			
	Sum of square	Df	Sum of mean	f	sig
regression	2782.016	1	2782.016	11.761	[b]040. .
remain	367.850	28	13.138		016.2782
total	3149.867	29			850.367
		3149.867			
group	unstandardized values		standardized values	t	sig
	B	Std. Error	Beta		
Pre- test	998.	069.	940.	552.14	000.

Note: As can be seen in Table 8, the relationship between pre-test and post-test is linear *0/05]* P-Value ≤*=11.761* ،F. This linear relationship is also illustrated in Figure 8.

Figure 8

Linear relationship between pre-test and post-test measures of academic performance

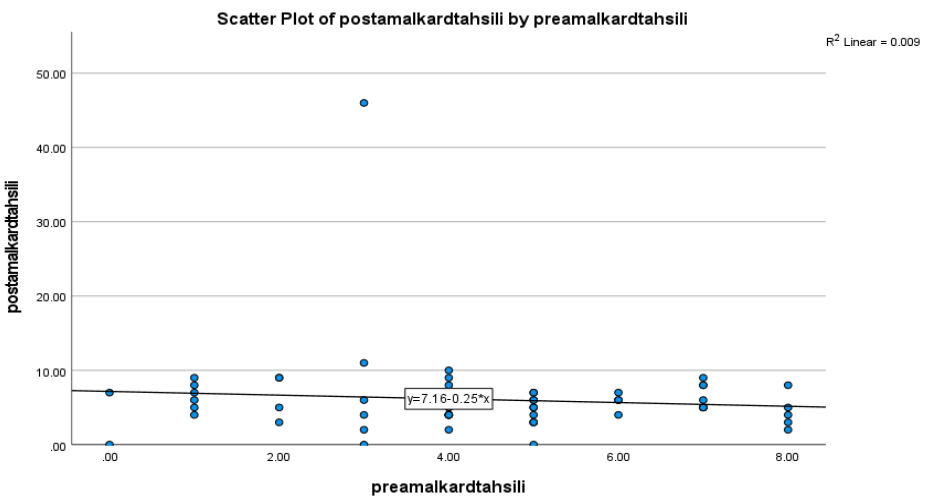


Figure 8 shows a Linear relationship between pre-test and post-test measures of academic performance.

Table 9

Results of the covariance analysis to compare the mean scores of student self-efficacy in the science course

Source	Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared
Pre-test	37.963	1	37.963	0.601	.441	.010
Group	590.007	1	590.007	9.345	.003	.141

Note: As observed in Table 9, the difference between the pre-test and the post-test scores was significant [P-Value ≤ 0.05, F = 0.601]. The F value in the group is reported to be important at a level less than 0.05 [P-Value ≤ 0.003, F = 9.345]. It means that after controlling for the effect of the pre-test, a significant difference exists between the mean scores of the two groups in the post-test. This indicates that there is a relationship between the use of VR and student self-efficacy in the science course. Eta squared was reported as 0.141, indicating the magnitude of this influence.

Table 10

Results of the covariance analysis to compare the mean scores of student self-regulation in the science course

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Pre-test	55.532	1	55.532	2.077	.043	.091
Group	3247.013	1	3247.013	4.473	.039	.103

Note: As observed in Table 10, the difference between the pre-test and the post-test scores was significant [P-Value ≤ 0.05, F = 2.077]. The F value in the group is reported to be significant at a level less than 0.05 [P-Value ≤ 0.039, F = 4.473]. It means that after controlling for the effect of the pre-test, a significant difference exists between the mean scores of the two groups in the post-test. Eta squared was reported as 0.103, indicating the magnitude of this influence.

Table 11

Results of the covariance analysis for comparing the mean scores of student motivation in the science course

Source	Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared
Pre-test	161.994	1	161.994	6.734	.035	.113
Group	111.776	1	111.776	5.506	.028	.109

Note: As shown in Table 11, the difference between the pre-test and the post-test scores was significant [P-Value ≤ 0.05, F = 6.734]. The F value in the group is reported to be significant at a level less than 0.05 [P-Value ≤ 0.028, F = 5.506]. This indicates that, after controlling for the pre-test effect, a significant difference exists between the mean scores of the two groups in the post-test. Eta squared was reported as 0.109, demonstrating the magnitude of this influence.

The level of participation, satisfaction and motivation of the students in the experimental group was assessed through recorded class sessions. Informal observations and interviews were conducted to gauge the pupils' enthusiasm for participating in class discussions and their willingness to use virtual reality glasses to learn the science topics. During many meetings, they reported having a good understanding of the lesson topics and not feeling the need to practice or review outside of class. Many students also reported increased interest in science lessons compared to before. Furthermore, the observations revealed that students developed greater self-efficacy in learning after a few sessions and were able to grasp the topics independently in the virtual reality environment without requiring additional explanations from the teacher. These comments reaffirm the findings of the current research.

Table 12

Results of covariance analysis for comparing the mean academic performance scores of students in the science course

Source	Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared
Pre-test	18.251	1	18.251	6.537	.037	.139
Group	7.537	1	7.537	7.222	.026	.154

Note: As seen in the table 12, the difference between the pre-test and the post-test scores was significant [P-Value ≤ 0.037, F = 6.537]. This means that after controlling for the effect of the pre-test, a significant difference exists between the mean scores of the two groups in the post-test. Therefore, it can be concluded that the use of VR affects students' academic performance in the science course. Eta squared was reported as 0.154, indicating the magnitude of this influence.

Discussion

The results of comparing the mean self-efficacy scores in the two experimental and control groups showed that the mean self-efficacy scores for the experimental group (VR) are higher than those of the control group. That is, after controlling for the pre-test effect, a significant difference exists between the mean scores of the two groups in the post-test, which is consistent with the findings of O'Connor and Mahony (2023) and Hsiao (2021). Self-efficacy is an individual's belief in their ability to organise and execute a wide range of activities required to deal with different situations and circumstances. According to Bandura, this belief is a determining factor in individuals' thinking, behaviour, and emotions. Self-efficacy is the ability to organise and coordinate behavioural, emotional, social, and cognitive skills for achieving goals. Individuals with strong self-efficacy perceive challenging issues as problems to overcome, show a deeper interest in the activities they are involved in, feel a greater commitment to their interests and activities, and quickly overcome feelings of hopelessness.

VR offers several important components for educational environments, including clarifying abstract concepts, enhancing three-dimensional thinking skills, presenting three-dimensional cases, increasing self-efficacy, and providing an interactive environment (Erbas & Demirer, 2019).

Teaching based on VR enables learners to play an active role in the learning process, allowing them to participate more fully in the lesson and experience a greater sense of accomplishment. Since VR-based teaching facilitates active participation throughout the learning process, it positively influences students' beliefs in active involvement and their sense of self-efficacy. Additionally, consistent with prior research (Cetintav & Yilmaz, 2023; Liu et al., 2023; Pogorskiy & Beckmann, 2023; Prahani et al., 2022), comparisons of the groups' mean self-regulation scores indicated that the experimental (VR) group had higher self-regulation than the control group.

Since self-regulation involves regular efforts that guide thoughts, feelings, and actions toward achieving goals and desires, behavioural self-regulation means that individuals recognise appropriate and inappropriate behaviours and choose their actions accordingly (Altun & Erden, 2020). Self-regulation has functions that include goal setting, self-observation and self-monitoring, self-assessment and judgment of performance, and self-reaction. Thus, individuals constantly strive to set their own goals and then compare their successes with these goals and standards, thereby allowing individual criteria to stimulate greater motivation for more effort or behaviour change towards achieving a specific goal or standard (Zelkowitz & Cole, 2016). Therefore, teaching with VR, which combines videos, images, and other elements in the physical world, creates numerous incentives, increases efforts to understand concepts, and produces pleasure that leads to improved performance. Teaching with VR encourages active participation from individuals in various activities. The attractiveness of this type of teaching increases interest in the environment and follows individuals' enthusiasm and interest, which is one of the important stages of learning. Teaching with VR increases students' self-awareness and learning speed and consequently enhances their enthusiasm for learning. The results of comparing the mean motivation scores in the two experimental and control groups showed that the mean motivation scores for the experimental group (VR) are higher than those of the control group. After controlling for pretest scores, results showed a significant difference between the groups' adjusted posttest means, suggesting that the VR-supported instruction had a statistically significant effect on students' motivation in science lessons. This finding is consistent with prior research (Cetintav & Yilmaz, 2023; Jiang & Fryer, 2024; Mufit et al., 2024; Ozdemir et al., 2022; Özeren & Top, 2023).

As noted earlier, academic motivation is the desire or eagerness to achieve success and participate in activities whose success depends on personal effort and ability, and individuals academically succeed. The need for progress and the desire to perform tasks are applied to functions that lead to learning and progress in school. Academic motivation leads to an individual's presence in educational environments and obtaining an academic degree. Academic motivation is one of the prerequisites for learning and is a factor that gives direction, intensity, and sustains the learners' behaviour, gives them energy and directs their activities. Supporters of the socio-cognitive theory believe that background factors such as teaching methods, teacher feedback to students, task difficulty level, self and peer understanding, importance of the presented content, and similar factors affect academic motivation (Tsai et al., 2020). In this regard, the VR-based teaching method acts as a group creativity for general ideas. The use of VR-based teaching in lessons increases learners' motivation because VR-based teaching supports collaboration, facilitates expression of opinions during group work, demands detailed explanations from their teachers during the learning process, and encourages deep learning efforts. Additionally, creating a positive attitude in pupils towards learning new information, existing ideas, and scientific subjects not included in the curriculum is a reason for increasing their motivation (Dorgan, 2016). The VR-based teaching method in science education has led students to show more interest and effort in educational activities, increasing their academic motivation. The results of comparing the mean academic performance in the two experimental and control groups indicated that the mean academic performance scores for the experimental group (VR) were higher than those for the control group. After controlling for pretest scores, a significant difference was found between the groups' posttest means, consistent with previous findings (Arslan et al., 2020; Cetintav & Yilmaz, 2023; Ozdemir et al., 2022; Özeren & Top, 2023).

Conclusion and Implications

Today's learners, often referred to as "digital natives," are fundamentally different from their predecessors. This is primarily due to their constant exposure to technology and media. As a result, their learning goals and teaching approaches need to be adjusted to meet the demands of the 21st century. In an information age and knowledge-based society, the integration and effective use of technology is essential. Technology is no longer a mere option for students and teachers, but a fundamental literacy skill (Mishra & Mehta, 2017). High academic performance occurs when students acquire essential skills, including personal, social, educational, critical thinking, and reasoning skills. In other words, comprehensive success in education refers to achieving mastery in a particular skill or expertise. One of the criteria for the effectiveness of the educational system is the academic performance of students, and the educational system is concerned with it. Generally, society and particularly the educational system are interested in and concerned about students' successful growth and development, expecting them to progress and excel in various aspects, including cognitive dimensions, acquiring skills and abilities, as well as emotional and personality dimensions. Teaching method is an important factor in academic performance. VR-based teaching enhances interaction and engagement with course content, enabling students to actively participate in the learning process and giving them more control over their learning activities. Moreover, VR-based teaching enables students to think more about the subjects. Therefore, as students ask more questions, they can actively participate in class and establish connections between real life and study subjects (Doğan, 2016). Therefore, VR-based teaching has led to an increase in student participation in educational activities, the acquisition of more skills and abilities, and the attainment of higher academic performance. Based on the results obtained, it is suggested that in order to improve academic performance, principles and concepts should first be taught to students, and then VR-based education should be used alongside traditional methods as a complementary approach for practical and applied skills. Empowerment programs for teachers should be held to familiarize them with the foundations, principles, and methods of VR-based teaching so that they can impact student motivation by presenting such innovative teaching methods, and help students develop a positive attitude towards subjects, make progress in school subjects, and achieve better academic performance. Education leaders and administrators face the challenge of creating accessible opportunities that provide necessary support for students in non-traditional classroom settings. When technology is designed with the needs of both teachers and students in mind, and when attention is paid to the learning content, both parties can benefit. The development of emerging technologies, such as virtual reality, must acknowledge the vital role played by teachers as mediators of digital experiences. While there is a wide range of high-quality digital resources available to teachers and students, it is crucial to evaluate these resources based on their alignment with the curriculum and their effectiveness according to best practices (Brenneman, 2010). Technology can contribute to achieving this goal, but it requires significant effort to ensure that widespread access becomes a reality. However, there are limitations and challenges that come with integrating emerging technologies such as VR. These include access and infrastructure, teacher training and professional development, cost and sustainability, curriculum alignment, pedagogical integration, and ethical and privacy considerations. To address these limitations and challenges, collaboration is necessary among educators, policymakers, and technology providers. This collaboration should focus on providing equal access to resources, comprehensive teacher training and support, cost-effective solutions, curriculum and pedagogy alignment, and addressing ethical considerations. By fostering collaboration between policymakers and educators, it becomes possible to effectively address the limitations and challenges associated with integrating emerging technologies into education. This collaboration can lead to the development of supportive policies, provision of resources and training, curriculum alignment, research-based decision-making, and establishment of ethical guidelines, ultimately promoting the successful integration of VR in education. Despite the contributions of this study, there are several limitations that need to be addressed. First, the present study only included students from one city in Iran due to time limitations and lack of sufficient course support. Future research should include students from different cities in Iran to extend the results. Second, the cultural background of the study was another concern. Western education systems dedicate a significant amount of time and responsibility to guide students towards self-determination in their learning, which is different from Eastern education systems. Therefore, future studies should collect samples from different cultural backgrounds and conduct a comparative study to further explore the findings of this study.

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Appendix

lesson plan		
1- Muscle Anatomy **2-** Nervous System **3-** Their Components and They Function, **4-** Related Diseases.	**eighth-grade**	**Chapter 5: Sense and Movement**

general purpose
• While familiarizing with the components of sensory and motor devices, explain how they function and suggest ways to use them correctly, considering their importance. • -Acquiring students' self-regulation, and academic performance- skills and increasing their academic motivation in learning science lesson. • Deep learning of lessons and higher academic performance.

Staged goals
• Get to know the types of sense organs and determine what kind of stimuli each one is stimulated by. • Remind them of the structure of sensory organs. • be able to explain how sensory receptors work in sensory organs. • be able to name the parts of the motor system and write their function. • Identify the most important bones in skeleton mollags. • Familiar with types of muscle tissue and compare them. • Get to know the different types of muscles and be able to recognize them on the moulage. • By knowing the sensorimotor system and its strengths and weaknesses, they should be diligent in maintaining their health.

Behavioural and educational goals

- Students get to know the sensory organs. (cognitive, understanding)
- Have students think about different parts of the body. (cognitive, understanding)
- Students get to know the movement of the body. (cognitive, understanding)
- Have students think about how to hear, how to smell and taste. (cognitive, knowledge)
- Students get to know the bones of the body. (cognitive, composition)
- Students can do semester tests. (cognitive, understanding)
- Students will learn about joints and cartilage. (cognitive, understanding)
- Students answer the activities and questions related to the lesson. (cognitive, understanding)
- Students can tell the general result of the lesson. (cognitive, understanding)

Teaching Method and Class Model

Lectures, questions and answers, solving problems individually or in groups of two, using virtual reality glasses.
The model and structure of the class is U-shaped, and all students are in front and around the table, while they are also in charge of the board.

Educational Technology and Media

Virtual reality goggles, share care you Anatomy software, Video projector, laptop, smart boards, digital image, speaker, printer, scanner

Initial Evaluation

- By designing questions in the context of the discussion, by drawing attention to the images in the text, by using context-oriented questions, we provide a suitable context to start teaching.
- What is the main factor of movement?
- How does cartilage turn into bone?
- Name the sense organs?

Lesson Presentation

Teacher activity:

In this lesson, students first get to know how sensory organs work. Here, the emphasis is on the types of sensory receptors and how the effect of environmental stimuli is transformed into nerve messages and in which parts of the body the understanding of sensory messages takes place. After that, we explain the components of the movement system, which consists of two parts, the skeleton and the muscles. In the skeleton section, we describe the types of bones and joints and mention the structure of bones and cartilage. In the muscle section, the types of muscle tissue are compared, with an emphasis on the structure of skeletal muscles and how they function in creating movement, and then the most important muscles of the body are introduced in the form of know more.

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- Using virtual reality glasses and share care you Anatomy software in connection with the lesson: sensory organs
- Write questions on the board. Like the following question:
- What are the sensory organs?
- Allow students to come up with the appropriate answer through class discussion. Write the important and interesting points of the students' conversation as answers on the class board and ask them to write it down in their notebooks. (The summation of students' opinions is the answer to the questions.)

Student activity:

- Show appropriate reactions when working with virtual reality glasses
- Expressing your opinions after working with the software
- Answering the questions raised by participating and accompanying the group
- Concurrence and consultation with group members
- Finding appropriate and correct answers
- Answering questions in turn and respecting the rights of others