The Effect of Virtual Reality Applications in Mathematics Classes on Student Attitudes

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***Abstract*—This study aimed to assess students' attitudes toward virtual reality following its integration into mathematics education. The research was designed using the survey model, a commonly employed quantitative research method. The sample consisted of 285 students studying in 9 different schools in Almaty and Kokshetau, during the 2022–2023 academic year. These students participated in a four-week mathematics education program that utilized virtual reality technology. After the training, research data was collected with the virtual reality attitude scale. The scale was developed by researchers. Research data were evaluated with current statistical software. As a result of the research, it was determined that students' virtual reality attitudes were high. A significant difference was observed in the attitudes of students toward virtual reality based on gender. Male students demonstrated significantly more positive attitudes toward virtual reality. It was determined that there was no significant difference in the students' virtual reality attitudes according to the variable of the class they were studying in, and their level of interest in the mathematics course. Based on the findings of this study, it is deemed necessary to implement in-class activities aimed at enhancing the attitudes of female students toward virtual reality. Additionally, it is recommended to incorporate virtual reality applications into teacher training programs and to organize supportive in-service training for teachers.**

***Keywords*—education, mathematics, mathematics student attitudes, survey model, virtual reality**

I. Introduction

The use of technology in education, as in all areas of the world, dates back many years. The development of computers and the internet has significantly accelerated the development of information technologies [1]. Although information technologies are used in many areas, they have created an advantage in education by appealing to many sensory organs of students and increasing their learning skills, learning levels, and permanence [2, 3]. In this way, it allowed students to develop their learning skills and problem-solving skills.

Virtual reality is generally defined as artificially recreating a virtual object, a simulation, a real-life space, or a situation in a computer-generated virtual environment [4, 5]. Virtual reality technology, on the other hand, creates a completely different environment for the user with objects modeled in the computer environment through software [6, 7]. This allows users to interact with these objects.

By using applicatons supported by these technologies in education, the process has been reshaped by ensuring that students' educational activities continue in out-of-school environments [8–10]. Virtual reality is classified into two different types. These are non-interactive and interactive virtual reality [11]. While virtual reality without interaction is a computer simulation of the real world [12], interactive virtual reality replaces the real world by adding dimensions of interaction and user participation to the computer simulation and completely separates the user from the real environment by taking the user into the simulated environment with a head-mounted device [13, 14].

Virtual reality, as one of the technologies increasingly utilized in recent years, aims to achieve learning objectives more efficiently by integrating three-dimensional teaching materials into course content [15]. The use of virtual reality in education offers significant advantages [16–18]. In traditional educational environments, various issues, such as overcrowded classrooms and inadequate physical conditions, often hinder student participation in the learning process [19]. Virtual reality provides an alternative solution to these challenges, enabling students to engage with topics that are difficult to explain using conventional methods [20]. This technology allows students to interact with the learning environment, spend time in virtual settings, have fun, receive feedback, and learn in a manner that closely simulates reality [21]. One of the key reasons for incorporating virtual reality into education is its capacity to offer immersive, interactive, and realistic experiences [22, 23]. These features contribute to making learning more effective and meaningful. Recent studies evaluating student performance across various subject areas have increasingly focused on the new platforms that have emerged with the integration of virtual reality in education and training [24–28].

These studies suggest that virtual reality positively impacts students' learning processes within educational settings. However, despite its growing use in education, there remains a limited number of studies investigating its effects on student attitudes, particularly in mathematics, concerning demographic variables such as gender and grade level. Therefore, this study emphasizes the importance of investigating the integration of mathematics education with virtual reality and evaluating the contributions of students within this combination.

Kaufmann and Meyer [29] developed an immersive virtual reality application to make physics education more effective. In the virtual reality application, they developed to accurately

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simulate physical experiments, students can actively design and examine their experiments. In the study, an exemplary application was presented on how to combine new technologies in physics education in a quality way. Reid [30] studied the effect of virtual reality on game-playing skills by working with a group of children with special needs. Children were observed in 12 different play environments in total. The results indicated that virtual reality applications encourage gaming in children with learning disabilities.

Diwakar *et al*. [31] conducted a comparative analysis of virtual learning components such as animations, simulations, and real-time remote-controlled experiments in their research. According to the data obtained, students and teachers stated that simulation-based laboratories were preferred in developing teaching and learning strategies compared to graphic-based animations and remote-controlled experiments. In their research, Markowitz–Laha *et al*. [32] aimed to raise awareness about the consequences of climate change, especially ocean acidification, with virtual reality applications. As a result of the research, it was determined that individuals' attitudes towards the environment changed positively.

Zantua [33], taught 6th grade secondary school students about the 7 wonders of the world. As a result of the research, it was concluded that teaching using virtual reality technology is more effective. Santos *et al*. [34] aimed to teach university students English words with different senses with virtual reality applications. It was determined that, through the application, students were able to learn vocabulary more easily and were more readily motivated.

Chen [35] examined the effects of mobile augmented reality technology on learning performance, motivation, and mathematics anxiety in mathematics courses. The results indicated that the use of augmented reality increases students' learning performance and reduces mathematics anxiety. Cai *et al*. [36] investigated the effects of augmented reality-based probability learning on students' learning outcomes and attitudes; the study revealed that the use of augmented reality positively affected students' academic achievement and attitudes toward the course. Gargrish *et al*. [37] measured the effectiveness of an augmented reality-based geometry learning assistant on students' memory retention abilities in 3D geometry. The results show that the use of augmented reality improves students' ability to recall information.

The aforementioned studies indicate that virtual and augmented reality technologies significantly impact educational processes across various disciplines, offering a wide array of benefits. However, these studies exhibit certain limitations. In some instances, students' attitudes toward virtual reality applications were not examined in sufficient depth, while in others, demographic variables were not adequately considered. Existing research predominantly focuses on specific age groups or educational levels, such as secondary school or university students. However, the effects of these technologies on students' attitudes across diverse age groups remain underexplored, particularly in subjects that require abstract reasoning, such as mathematics. Consequently, this study seeks to make a substantial contribution to the existing literature by addressing the often-overlooked dimension of "attitude toward virtual reality" within the specific context of mathematics education. Furthermore, it aims to provide valuable insights into the post-implementation effects of virtual reality-based educational interventions.

A. *Purpose of Study*

The purpose of this research was to assess students' attitudes toward virtual reality following the integration of virtual reality into mathematics education. To achieve this, the study sought to address the following research questions.

1) What are the attitudes of students toward virtual reality following mathematics instruction facilitated through virtual reality technology?
2) Do students' attitudes toward virtual reality differ based on gender after participating in mathematics education delivered through virtual reality?
3) Do students' attitudes toward virtual reality differ based on their grade level after receiving mathematics education through virtual reality?
4) Do students' attitudes toward virtual reality differ based on their level of interest in mathematics?

II. Materials and Methods

This section outlines the research method, sample group, data collection tools, data collection process, and data analysis stages.

A. *Research Method*

This study employed the screening model, a widely recognized quantitative research method. Quantitative research is characterized by its reliance on the collection, analysis, and interpretation of numerical data. This approach enables researchers to examine a specific issue using objective criteria, thereby generating generalizable results [38]. Typically, quantitative research aims to test hypotheses and explore the relationships between variables. The screening model specifically seeks to provide a detailed description of the current state of an event, individual, or object. In this model, data are gathered and analyzed in their natural form without any manipulation or intervention [39]. Following the implementation of virtual reality-based mathematics education, students' attitudes toward virtual reality were assessed using the screening model, a method within the framework of quantitative research.

B. *Participants*

The sample consisted of 285 students studying in 9 different schools in Almaty and Kokshetau, during the 2022–2023 academic year. The sample group was created using the simple random sampling method. Simple random sampling is one of the probability sampling methods, in which each individual has an equal probability of being selected for sampling. In this method, each unit in the population has an equal chance of being selected and the selections are made independently of each other. In this way, the probability of the sample representing the population is increased and bias is minimized. Singh [40] defines simple random sampling as "the simplest and most common sampling method in which each unit has an equal probability of being selected in each draw". The main advantage of this method is that it ensures that the sample is a true representative of the population. The characteristics of the students are given in Table 1.

Table 1. Demographic information of students

Variables	F	%
Gender		
Female	152	53.3
Male	133	46.7
Total	285	100
Class		
8th grade	92	32.3
9th grade	105	36.8
10th grade	88	30.9
Total	285	100
Mathematics interest level		
High	82	28.8
Middle	112	39.3
Low	91	31.9
Total	285	100

Table 1 shows students' gender, grade, and mathematics interest levels. 53.3% of the students are girls and 46.7% are boys. 32.3% of the students are in the 8th grade, 36.8% are in the 9th grade and 30.9% are in the 10th grade. 28.8% of the students have a high level of interest in mathematics, 39.3% have a moderate interest in mathematics, and 31.9% have a low level of interest in mathematics.

C. Data Collection Tools

Research data was collected with the virtual reality attitude scale. Before the data collection tool was applied to the students, mathematics education was given with virtual reality.

1) Virtual reality attitude scale

The scale was developed by researchers. During the scale development phase, items were created by scanning the literature. The item pool, consisting of 48 items, was examined by 4 experts to evaluate the suitability of the items to the content of the research. As a result of their examinations, experts identified the items from the item pool that they found most suitable for the research content. Items determined by experts were selected to be used in the scale. For the scale consisting of a total of 26 items, 3 demographic questions were created and turned into an application form. Demographic questions were created to determine the students' gender, the grade they are studying in, and their level of interest in mathematics. 256 students studying in various schools formed the pilot application sample group of the research. 114 of the students are girls and 142 are boys. 96 of the students are in the 8th grade, 90 in the 9th grade, and 70 in the 10th grade.

While 102 of the students in the pilot application sample group had a high level of interest in mathematics, 106 had a medium level of interest and 48 had a low level of interest. After the application, Kaiser-Meyer-Olkin (KMO) and Bartlett Sphericity tests were performed to determine the suitability of the data set for factor analysis. KMO coefficient was calculated as 0.82 and $p < 0.05$ for Bartlett's sphericity test. These results indicate the suitability of the data for factor analysis. Exploratory factor analysis (EFA) was conducted with the SPSS 25.0 program. At this stage, the eigenvalues of the items in the scale were examined.

Two factors with eigenvalues greater than 1 were identified in the scale. The first factor is called "motivation" and the second factor is called "success". There are 14 items in the first factor and 12 items in the second factor. After EFA, the first-factor item loadings ranged between 0.56 and 0.71. Second-factor item loadings vary between 0.70 and 0.88.

The total variance explained by these two factors is 74.27%. EFA was followed by confirmatory factor analysis (CFA) with the LISREL program. The goodness of fit indices was based on the adequacy indicator determined by Schermelleh-Engel *et al*. [41]. Accordingly; Goodness of Fit Index (GFI), Normed Fit Index (NFI), Relative Fit Index (RFI), Comparative Fit Index (CFI), and Incremental Fit Index (IFI) values greater than 0.90 indicate a sufficient level of fit. Standardized root mean Square Residuals (SRMR) and Root mean Square If the Error of Approximation (RMSEA) is less than 0.05, it indicates a good fit, and if it is below 0.10, it indicates an acceptable fit. It is accepted that the ratio of the chi-square value to degrees of freedom below 5 indicates a good fit.

As a result of CFA, it was found that the ratio of chi-square value to degrees of freedom was at a sufficient level below 5. Fit index values were found to be RMSEA = 0.02, SRMR = 0.03, GFI = 0.94, NFI = 0.95, RFI = 0.96, CFI = 0.92 and IFI = 0.99. As a result of CFA, it was determined that the model had a good fit.

Table 2 shows the Virtual Reality Attitude Scale, its items, item-total correlations, and Cronbach Alpha values of the sub-dimensions and the overall scale.

Table 2. Virtual reality attitude scale

Factor	Identifiers	Item Total Correlation	Cronbach's Alpha
Motivation	Virtual reality applications increase my interest in lessons.	0.655	0.811
	Working with virtual reality makes my learning process more fun.	0.664	
	Virtual reality environments allow me to be more active in classes.	0.672	
	Virtual reality technology encourages me to participate in the learning process.	0.701	
	Using virtual reality helps me focus more on my studies.	0.669	
	Working in virtual reality environments pushes me to be more creative.	0.713	
	Virtual reality applications help me understand course topics better.	0.642	
	I look forward to using virtual reality technology in my classes.	0.569	
	Using virtual reality tools increases my enthusiasm for learning.	0.658	
	Virtual reality environments prevent me from getting bored in class.	0.629	
	Working with virtual reality causes me to waste my time.	0.579	
	Virtual reality applications reduce my motivation during the learning process.	0.583	
	Working in virtual reality environments distances me from the learning process.	0.611	
	Virtual reality technology is decreasing my interest in lessons	0.590	
Success	Virtual reality technology contributes positively to my academic success.	0.739	0.863
	Thanks to virtual reality applications, my performance in classes is improving.	0.709	
	I remember the information I learned in virtual reality environments more easily.	0.880	

	Virtual reality applications help me achieve better results in lessons.	0.861	
	Using virtual reality helps me grasp the subjects I learn faster.	0.764	
	Virtual reality environments improve problem-solving skills.	0.723	
	Virtual reality technology helps me achieve my learning goals.	0.833	
	I get better grades with practice in virtual reality environments.	0.790	
	Virtual reality applications negatively affect my academic performance.	0.749	
	Working in virtual reality environments makes it harder for me to achieve success.	0.795	
	Using virtual reality reduces my performance in classes.	0.850	
	Virtual reality technology makes it difficult for me to retain the information I learn.	0.811	
Cronbach's Alpha for Entire Scale			0.844

Table 2 shows the Virtual Reality Attitude Scale items. Cronbach's alpha calculation was made to determine the reliability of the two-factor scale. The alpha value for the "Motivation" factor was found to be 0.81, and the alpha value for the "Success" factor was 0.86. Cronbach's alpha value for the overall virtual reality attitude scale was found to be 0.84. These values indicate that the scale is reliable. The scale was prepared as a 5-point Likert type. On the scale, "very high attitude" is 5 points (4.20–5.00), "high-level attitude" is 4 points (3.40–4.19), "moderate-level attitude" is 3 points (2.60–3.39), "low-level attitude" is 2 points (1.80). −2.59) and "very low-level attitude" was determined as 1 point (1.00–1.79).

2) Mathematics education with virtual reality

A virtual reality-based mathematics education program was developed for the students involved in the research. The training was designed for a duration of four weeks, with four hours of instruction each week, totaling 16 hours. Cardboard virtual reality headsets, smartphones, and headphones were utilized for the delivery of the training. Efforts were made to ensure that the smartphones used were compatible with the virtual reality headsets. Cardboard headsets were chosen for their portability and ease of use. The C# programming language was selected due to its resource-rich capabilities, while the Google VR SDK for Unity was employed for the development of the virtual reality content. Three-dimensional objects were incorporated into the virtual environment created by the application. Royalty-free resources were used to source ambient sounds and music, ensuring their relevance to the thematic content. Virtual reality content focused on geometric objects was developed and tailored to the appropriate grade levels. Collaboration with mathematics teachers occurred during the content analysis phase, where the topics to be addressed were determined. Models, voice-overs, and animations planned for the activities were created and prepared in alignment with the weekly lesson hours. During the implementation phase, mathematics teachers and game developers worked together to ensure the successful integration of virtual reality into the educational process. All students were provided with regular participation in the virtual reality-based mathematics education program.

During the virtual reality sessions, topics aligned with the mathematics curriculum were taught to 8th, 9th, and 10th grade students. In the 8th grade, subjects such as geometric shapes and objects, linear equations, angles, and polygons were addressed. Students explored volumes and surface areas of objects from multiple perspectives in a virtual environment, created graphical representations of linear equations, and measured angles of polygons. In the 9th grade, topics including functions, square roots, and triangles were covered. Function graphs were generated in a virtual setting, square root measurements were taken, and the Pythagorean theorem and trigonometric ratios were explored within a three-dimensional environment. In the 10th grade, content on trigonometry, transformations, and quadratic equations was introduced. Students examined the graphs of sine, cosine, and tangent functions on the unit circle, learned geometric transformations through interactive tasks, and analyzed parabolic graphs. Throughout this process, various instructional strategies such as interactive learning, gamification, audio-visual support, problem-solving, and self-assessment were employed to help students grasp abstract mathematical concepts in a concrete, three-dimensional context. For instance, applications such as constructing a bridge using the Pythagorean theorem or determining the trajectory of an object through function graphs were linked to real-life scenarios to enhance the learning experience. After each session, students' progress was assessed, and their achievements were visualized through feedback and evaluation questions. Throughout this process, mathematics educators and game developers collaborated to facilitate active and engaging learning experiences, allowing students to interact with mathematics in a dynamic and enjoyable virtual reality environment.

D. Data Collection Process

The research data was collected online, following the online training given to the students. Mathematics education with virtual reality lasted 4 weeks. It took 1 week for the students to apply the virtual reality attitude scale developed by the researchers. All students in the sample group participated in the virtual reality-based mathematics education and completed the virtual reality attitude scale. The completion time of the virtual reality attitude scale was measured as approximately 15–20 minutes. It took approximately 5–6 weeks to collect data.

E. Compliance with Ethics

The necessary permissions were obtained from the schools attended by the students for both the development and implementation stages of the data collection tool and the virtual reality-based mathematics education process. The entire research process was thoroughly explained to the students, and their participation was entirely voluntary. The students who comprised both the pilot study group and the sample group were selected based on their suitability for the research process from those who voluntarily agreed to participate. Ethical principles were adhered to at all stages of the research.

F. Data Analysis

Research data were analyzed with the SPSS 25.0 program. Since the data had a normal distribution, parametric tests were applied. At this stage, the weighted average and standard deviation were calculated for the overall scale and its sub-dimensions. Independent variables t-test was applied to determine the relationship between students' gender and their attitudes towards mathematics education provided with virtual reality. One-way analysis of variance (ANOVA) was calculated to determine the relationship between students' attitudes towards mathematics education provided with virtual reality, the class they were studying in, and their level of interest in the mathematics course.

III. Results

Table 3 shows the weighted averages and standard deviations of the virtual reality attitude scale and its sub-dimensions of the students.

Table 3. Virtual reality attitude scale weighted means and standard deviations

Scale	*M*	SD
Motivation	3,98	0,681
Success	3,90	0,655
Virtual reality attitude scale	3,95	0,669

In Table 3, the motivation sub-dimension (M = 3.98, SD = 0.681), achievement sub-dimension (M = 3.90, SD = 0.655), and virtual reality attitude scale (M = 3.95, SD = 0.669) are weighted. Means and standard deviations are given. These results show that students have a high degree of attitude in the motivation and success sub-dimensions of the virtual reality attitude scale and the scale in general.

A. Gender Variable

Table 4 shows the t-test results of the independent variables according to the gender variable of the students.

Table 4. Independent variables t-test results

Gender	N	*M*	SD	F	P
Female	152	3.73	0.692	16.227	0.000
Male	133	4.21	0.803		

In Table 4, the virtual reality attitudes of the students are discussed according to the gender variable. As a result of the T-test, a significant difference was found in the virtual reality attitudes of the students according to the gender variable (F = 16.227, P < 0.0.5). It was determined that male students' virtual reality attitudes were higher than female students.

B. Class Variable

Table 5 shows the students according to the class variable in which they study. A one-way analysis of variance ANOVA results is given.

Table 5. One-way analysis of variance ANOVA results according to the class variable

Class	N	*M*	SD	F	P
8th grade	92	3.99	0.756	4.580	0.233
9th grade	105	3.91	0.734		
10th grade	88	3.96	0.750		

In Table 5, the virtual reality attitudes of the students were evaluated according to the variable of the class in which they studied. As a result of the ANOVA test, it was seen that the students' virtual reality attitudes did not make a significant difference according to the class variable in which they studied (F = 4.580, P > 0.5).

C. Mathematics Course Interest Level Variable

Table 6 shows the results of a one-way analysis of variance ANOVA according to the variable of interest levels of the students in the mathematics course.

Table 6. One-way analysis of variance ANOVA results according to mathematics course interest level variable

Mathematics interest level	N	*M*	SD	F	P
High	82	3.90	0.640	6.411	0.205
Middle	112	3.98	0.691		
Low	91	3.95	0.665		

In Table 6, the virtual reality attitudes of the students were evaluated according to their interest level in mathematics courses. The results of the ANOVA test indicated that there was no significant difference in students' attitudes toward virtual reality based on their level of interest in mathematics courses (F = 6.411, p > 0.05).

IV. Discussions

The students exhibited positive attitudes in the motivation and success sub-dimensions of the virtual reality attitude scale and the scale in general. The findings obtained from the research are parallel to the results of some studies conducted in the field. Some studies have shown that teaching in a virtual reality environment has a positive effect on students' success and motivation [42, 43]. In a study conducted by Gedik [44], it was reported that the integration of virtual reality technology in the secondary school social studies curriculum enhanced students' interest and participation in lessons, resulting in positive effects on motivation and academic success. The findings from this study, along with results from other research in the field, suggest that virtual reality technologies can serve as an effective tool in educational settings and play a significant role in boosting student motivation.

A significant difference was observed in students' attitudes toward virtual reality based on the gender variable. Male students demonstrated higher attitudes toward virtual reality compared to female students. Foti and Ring [45] also investigated the effect of simulations on learning in their research. The study found that while simulations facilitate learning, male students were more likely to benefit from simulations in their learning process. Similarly, a study conducted by Buchner and Weißenböck [46] indicated that attitudes towards the use of augmented and virtual reality technologies in education differed according to gender and age. In this study, it was determined that males had more positive attitudes towards virtual reality technologies. This finding supports the widespread belief that male students have a higher interest in technology. In this context, the reasons behind male students exhibiting more positive attitudes toward virtual reality technologies can be explored. One possible explanation is that male students generally demonstrate a greater interest in technology and are more frequently exposed to technological tools such as video games and simulations. However, these findings also indicate that the impact of the gender variable on attitudes toward virtual reality may be influenced by cultural and individual factors. The research findings reveal that male students tend to have more favorable attitudes toward virtual reality technologies compared to female students. This observation can be interpreted within the framework of Constructivist Learning Theory. According to Constructivist theory, learning is a process of constructing meaning by actively linking new information to an individual's prior knowledge and experiences. In this process, personal interests and prior experiences play a crucial role in shaping an individual's motivation and attitudes toward learning [47]. Male students' greater interest in technology and greater interaction with tools such as games and simulations may cause them to develop more positive attitudes toward virtual reality applications. This is consistent with the basic principle of constructivist learning theory, which emphasizes the effect of individuals' previous experiences on new learning processes.

There was no significant difference in the virtual reality attitudes of the students depending on the class variable in which they studied. This result shows that students at different education levels exhibit similar virtual reality attitudes. Yılmaz *et al*. [48] also concluded in their study that the classes in which students studied did not have any effect on their knowledge of virtual reality. This finding is also consistent with the study by Yıldırım and Arıcıoğulları [49], in which the overall effect of augmented reality applications on students' attitudes was examined. However, no significant difference in attitudes was observed based on grade level. These results suggest that the use of virtual and augmented reality technologies in education produces similar effects across different grade levels. Students' interest in technology and their ability to adapt may be influenced more by individual differences and prior exposure to technology than by their grade level. Therefore, when planning the integration of virtual reality applications into education, it is crucial to develop strategies that are inclusive of all students, regardless of their grade level.

There was no significant difference in the virtual reality attitudes of the students depending on their level of interest in mathematics courses. This result shows that whether students' mathematics interest levels are low, medium, or high does not make any difference in their virtual reality attitudes. Studies conducted in the field have examined students' attitudes toward virtual reality and have concluded that it has a positive effect on their levels of interest in various courses [50–52]. However, studies conducted in the field, which support the findings of this research, have indicated that students' interest in a particular subject does not significantly affect their attitudes toward virtual reality. For instance, in the study by Madden *et al*. [53], the phases of the Moon were taught using virtual reality, desktop simulations, and traditional methods, yet no significant difference was found in the learning outcomes. The study further noted that students' levels of interest in the course did not have a substantial impact on their attitudes toward virtual reality. These findings reinforce the assumption that students' attitudes toward virtual reality may be independent of their personal interest in a subject. This can be explained by the fact that virtual reality technology, as a general learning tool, appeals to students at a similar level, regardless of their specific interest in the course content. In other words, the immersive visual and auditory elements of virtual reality can influence students' attitudes, regardless of whether they are particularly engaged with the subject matter.

V. Conclusion

The relentless progression of technology since its introduction has enabled the integration of technological innovations into the field of education. Virtual reality applications, which are among these innovations, have continued to exist in recent years to increase the interests, skills, and achievements of students at all levels of education. Therefore, this research aimed to evaluate the efficiency of mathematics education provided with virtual reality for students. As a result of the research, it was determined that students' virtual reality attitudes were high. There was a significant difference in the virtual reality attitudes of the students according to the gender variable, and a significant difference was found in favor of male students. It was determined that there was no significant difference in the students' virtual reality attitudes according to the variable of the class they were studying in and their level of interest in the mathematics course.

These findings suggest that gender differences have a discernible impact on the use of virtual reality applications in education. The higher attitudes toward virtual reality observed among male students indicate that this technology, in its current form, is more engaging and appealing to male students. In contrast, the lower attitudes toward virtual reality observed among female students suggest that the content and interactive features of the applications may not equally engage both gender groups. The absence of significant differences in students' grade levels and interest in mathematics implies that virtual reality applications generally offer equitable learning potential for all students. However, this potential cannot be fully realized equally due to varying perceptions influenced by gender. This highlights that the impact of technology in education is shaped by perceptual differences between student groups and that current applications may be insufficient in addressing these disparities. Furthermore, these findings underscore the need for gender-sensitive approaches in the design and implementation of virtual reality applications within educational settings.

VI. Recommendations

Teachers can enhance the content of courses taken through virtual reality applications by considering gender-based differences in interest and perception and planning activities that cater to individual differences. To increase female students' engagement with virtual reality technology, content that is motivating, engaging, and easily accessible can be developed to improve their attitudes toward the technology. Furthermore, it is recommended that teachers engage in continuous professional development programs to deepen their knowledge and skills in gender-sensitive approaches and to utilize virtual reality applications effectively. For students, both individual and group activities that encourage female students to build self-confidence in using technology and foster a sense of achievement can be organized.

Additionally, it is essential to present gamified and visually appealing content that captures the attention of both genders. Learning environments should incorporate interactive and inclusive designs, with themes that appeal to diverse student profiles. Moreover, the ergonomic features of virtual reality devices should be carefully selected to ensure that all students can use them comfortably, and environments should be designed to minimize distractions.

Comprehensive training modules on the effective use of virtual reality applications and gender-sensitive approaches should be integrated into teacher training programs. These modules should inform teacher candidates about the pedagogical foundations of virtual reality technologies, classroom implementation methods, and strategies for designing and utilizing these technologies to meet the needs of various student groups. In addition, practical workshops should be organized, allowing teacher candidates to experience these technologies firsthand. Such initiatives will play a critical role in ensuring that teachers are equipped to use virtual reality technologies effectively and inclusively in future educational settings.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Writing—original draft preparation and analysis of the data, USK; Methodology, review, KGB; Editing, Conceptualization, review KSN; formal analysis, BK; Editing, formal analysis, ONB; Review, editing, KAZ. All authors had approved the final version.

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