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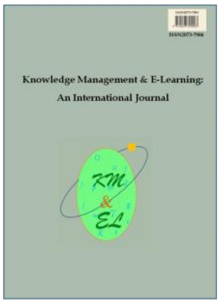

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Using virtual reality technologies in STEM education: ICT pre-service teachers' perceptions

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Abstract: This study aims to investigate the perceptions, expectations, and experiences of information and communication technology (ICT) pre-service teachers regarding the potential of using virtual reality (VR) as a learning and teaching tool in STEM education. The research participants included 44 ICT pre-service teachers. The data were collected through the self-efficacy and pedagogical usage questionnaire. Descriptive statistics, t-tests, and content analyses were used for analysis. The results show that most ICT pre-service teachers did not have the experience of using VR technology, although they stated that using VR technology had a positive impact on STEM education in many ways. They felt that using VR technologies in STEM education can be more useful and effective in the process of exploring inaccessible places. Some participants had some concerns about using VR in the classroom, for example, VR is a costly tool, and it might isolate and distract students from the real world.

Keywords: ICT pre-service teachers; Expectation; Perception; Self-efficacy; STEM; Virtual reality

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1. Introduction

Virtual reality (VR) technologies have recently been actively used in education, teaching, and many different disciplines (Radianti et al., 2020). VR technologies are an important component in the current process called the fourth industrial revolution and many leading companies (such as *Alibaba, Samsung, Google, Facebook, and HP*) invest in these technologies (Hollebeek et al., 2020). In this context, it is predicted that by 2022, VR technologies will grow up to about 209.2 million dollars economically in the world market (Statista, 2020).

These developments in VR technologies undoubtedly have an impact in the field of education because VR technologies are projected as the intended learning tool of the 21st century (Rogers, 2019; Ioannou & Ioannou, 2020; Khan et al., 2022). Besides, many educators and researchers focus on these technologies since these technologies provide the opportunity to best integrate visualization and interaction components (Radianti et al., 2020). VR is expected to be widely used in classrooms and adopted by students, particularly over the next two to three years (Freeman et al., 2017; Zou et al., 2018). In this context, it is obvious that VR technologies will be an important part of our digitized education world in the future.

VR is defined as a computer-based simulation platform that allows users to experience a three-dimensional (3D) environment very realistically using some specialized equipment (Linowes, 2015). Craig et al. (2009, p.11) define VR as environments that perceive the user's position and actions in an interactive environment containing 3D computer simulations, provide synthetic feedback to one or more senses and help them experience the feeling of being immersed. As a result, VR can be considered a computer-aided simulation technology that allows users to experience a sense of reality in a dynamic and interactive environment (Amin & Ikhsan, 2021).

In the VR environment, students are immersed in a realistic environment where they can imitate the real thing, explore, interact and change the objects in the environment through their avatars representing them (Jensen & Konradsen, 2018). Students can feel the presence of objects in the VR environment more like in the real world, receive instant feedback from the instructors, and experience the feeling of presence in a real environment (Monahan et al., 2008). The environments presented on VR platforms can be a representation of real places, or they can be presented to users in the form of environments designed as completely imaginary. For example, entering the nucleus of an atom or walking around the surface of a celestial body such as the sun are actions that cannot be explained or performed by real-life physics. However, the user can interact with objects, move, communicate with other users, create objects, and even play games in the designed VR environment (Zinchenko et al., 2020). Siegle (2019) also draws attention to the similar features of VR. In particular, the researcher states that VR allows users to experience and feel environments where they are not physically present and manipulate objects in the environment. For instance, we can grab an object in a VR environment with the help of virtual hands that look like our hands in the real world, move it, lift it, and drop it by moving it to a different point in the virtual environment. In this context, VR technologies are real-time, interactive, technology that goes beyond textbooks, and allows the development of flexible and appropriate learning strategies (Chung, 2012; Zou et al., 2018).

Designing activities that will enable students to perceive the VR environment as a real experience is necessary to achieve learning activities' goals (Silva et al., 2016). Students feel as if they are a part of the VR environment and participate in activities within the environment through immersion and presence (Passig et al., 2016). Therefore, VR theory is based on immersion and presence components (Jensen & Konradsen, 2018). It is also argued that the level of these components is critical in the interaction process of users in the VR environment (Meyer et al., 2019). Therefore, it is stated that many companies, universities, and organizations that are aware of these components have recently made tremendous investments to increase the level of interaction of users with content and media (Jerald, 2015).

While immersion is defined as the sensitivity level of the sensory features offered by VR systems to users, presence is evaluated as the subjective reactions of the users to the virtual environment psychologically. In other words, presence is expressed by technological features that provide users with a sense of reality by abstracting the richness, resolution, and panoramic image of content information from other physical realities in the environment (Slater, 2018). Eventually, immersion is considered a technological characteristic of VR systems to provide users with a sense of reality (Radianti et al., 2020).

VR technologies offer users three different systems in terms of immersion features (Buttussi & Chittaro, 2018): Desktop-based VR, HMD (head-mounted display) based VR, and CAVE (cave automatic virtual environment) based VR. Desktop-based VR is defined as a VR system in which users can interact with the virtual environment using a keyboard, mouse, game console, or touch screen (Lee & Wong, 2014). HMD-based VR is a VR system that monitors two LCD screens fixed according to the user's eye position, mounted on a device like glasses, and monitors the user's head direction and in some cases the position of the user through these glasses (Sousa Santos et al., 2009). CAVE is a projection-based VR system (Sherman & Craig, 2002). In this system, the user is disconnected from the real outside environment, and his audio-visual perception is completely integrated into the virtual environment, allowing him to experience the virtual environment. In this context, HMD or CAVE-based VR systems have a higher capacity in terms of providing immersion to users. In contrast, it is emphasized that desktop VR systems have a lower capacity (non-immersive) in terms of immersion (Meyer et al., 2019). It is also argued that VR systems with immersion are more advantageous in terms of ensuring the presence of participants than desktop VR systems (Mikropoulos & Natsis, 2011).

Learning institutions tend to integrate and use digital technologies such as VR with education (Riemann et al., 2020; Chang et al., 2020). Discussions continue on how to integrate VR technologies in education disciplines called STEM (Science, Technology, Engineering, Mathematics) education and how to use them in classrooms (Cooper et al., 2019). The general purpose of STEM education is to help solve the problems of students who score low in international assessments such as TIMMS and PISA and want to have a job related to science and technology (Pimthong & Williams, 2020). In addition, government and industry stakeholders in many countries argue that there should be more participation in STEM education and that it would be beneficial to adopt this process (Rahman et al., 2021; Cooper et al., 2019). To this end, many countries are transforming their economies and labor markets into higher-skilled, knowledge and service-based industries. (Barry et al., 2018). Thanks to STEM education, students are expected to acquire reasoning skills, gain the competencies to investigate real-life problems from a scientific point of view, and produce the necessary tools for national development and industrialization (He et al., 2021). Considering that entrepreneurship and innovation activities will significantly contribute to the economic welfare of the relevant country (Eltanahy et al., 2020), STEM education should be considered an important achievement. In addition, it is stated that STEM education will provide the opportunity for today's students to gain 21st-century skills as it integrates group activities, laboratory research, and projects (Bybee, 2010a). Aware of this situation, the United States of America is conducting a national policy to increase the number of graduates with STEM degrees in the country to maintain its competitive position in the global economy (Pimthong & Williams, 2020). As a result, STEM education is very important for governments, industrialists, and educators.

The adoption, use, and integration of VR technologies by students into learning environments and the development of applications related to these technologies in the future are projected to be important achievements in STEM education (Cooper et al., 2019). The role of Information and Communication Technology (ICT) teachers is important in the process of using VR technologies as a learning and teaching tool in STEM education. ICT teachers can have a wide range of functions in the process of providing and supporting technology-based change in schools. While ICT teachers sometimes initiate change and develop new ideas, they sometimes support other teachers' efforts to transform their classrooms with technology directly or indirectly (Sarkar, 2012; Guibao & Vargas, 2021).

In addition, fear of technology and negative perceptions of ICT teachers towards related technology may lead to misuse of ICT in educational environments or prevent its use as an auxiliary tool in educational environments (Alfalah, 2018). In this context, before applying ICT in educational settings, ICT instructors' perceptions of the relevant technology should be examined (Riley & Stacy, 2008). In addition, if ICT teachers are confident in using their technology leadership skills and are confident in using these skills effectively, their motivation toward technology integration in schools can increase and they can successfully fulfil these tasks. Therefore, identifying and developing ICT pre-service teachers' perceptions of ICT is important for them to use ICT such as VR in teaching activities (Alfalah, 2018; Ekici et al., 2012; Hacıfazlıoğlu et al., 2011; Baxter & Hainey, 2019). In addition, teachers' perception of ICT and teachers' thoughts on the use of ICT can be an important parameter in predicting the progress in ICT-assisted learning (Ekici et al., 2012, Hu et al., 2021). In this context, ICT teachers' perceptions, beliefs, and attitudes towards the pedagogical use of digital technologies such as VR should be determined. In this sense, it is argued that if the predictions for the potential of VR technologies are correct, this technology can transform teaching pedagogy in ways that are currently unimaginable (Cooper et al., 2019).

In the literature, there is not much research on the perceptions of ICT pre-service teachers towards VR technologies. Nevertheless, there are some studies on the perception and experience of VR technologies (Ruberg et al., 2011; Zeichner & Zilka, 2016; Uygur et al., 2018; Alfalah, 2018; Huang & Liaw, 2018; Baxter & Hainey, 2019; Zafar et al., 2020; Kerzic et al., 2021). When the results of these studies are examined, it is seen that virtual environments are examined in a general context rather than VR technologies, ICT teacher candidates are mostly not included as a sample, environments such as distance education and virtual environments are compared, technologies such as augmented reality are also included in VR technologies, and they lack qualitative data that examines the reactions of the participants in more depth. is seen. In addition, it is seen that variables such as age and gender are examined in determining the perceptions of higher education students towards IT technologies rather than VR technologies. In this context, it can be said that little is known about the perceptions, expectations, and experiences of ICT pre-service teachers regarding the potential of using VR technologies as a learning and teaching tool in STEM education. Hence, this study is important in terms of filling this critical gap in the literature. Accordingly, research questions are formulated as follows:

- What is the level of pre-service teachers' self-efficacy regarding VR technologies in STEM education, and is there a significant difference between this level and their self-efficacy levels regarding other technologies?
- What are the opinions and experiences of pre-service teachers on whether VR technologies have a positive effect on STEM education?
- In which learning experiences do the pre-service teachers think VR will be more effective in STEM education?
- What are the pre-service teachers' concerns regarding the use of VR in the classroom in STEM education?

2. Method

2.1. Research design

The case study method was used in this study. Case studies allow for a detailed investigation of the data collected on a particular topic (Merriam, 1998). In other words, factors related to a situation (such as environment, individuals, events, and processes) are investigated with a holistic approach, focusing on how they affect the relevant situation and how they are affected by the relevant situation. This approach was deemed appropriate because it is suitable for the context of this research and is related to the analysis of pre-service teachers' perceptions based on their experiences of the VR environment (McMillan & Schumacher, 2010; Creswell & Poth, 2016). Additionally, this research model was used to describe the experiences, perceptions, and expectations of pre-service teachers as a result of using VR technology.

2.2. Participants

44 ICT pre-service teachers, 15 females, and 29 males, ranging in age from 21-to 25, were included in the study. Pre-service teachers are students enrolled in the Computer Education and Instructional Technology Department of Agri Ibrahim Cecen University. Participants were determined using the purposive sampling method (Patton, 2002). This method was chosen because it is suitable for this exploratory research design, it is low cost, and the sampling process takes less time (Malhotra & Birks, 2000). All the participants have not participated in educational activities such as STEM or TPACK before. They also have not had the experience of learning or teaching in an authentic educational setting using technologies such as VR. However, within the scope of the educational technologies course, they took at the undergraduate level, all the participants are knowledgeable about training such as STEM, TPACK, and current technologies such as VR. All the participants took part in the study voluntarily. In addition, the ethical approval for the study was obtained from Agri Ibrahim Cecen University Ethics Committee.

2.3. VR apparatus

In the VR application process, the *HTC Vive VR* glasses set (1 headset, 2 sensors, 2 hand controllers, computer input connections, and LCD interconnection cables), a computer that meets the minimum hardware requirements for VR glasses to operate, an LCD screen, and a room of 5m×5m with an average temperature of 25^{o} centigrade were used. The headset of the glasses weighs 550 grams. The glasses show a 3D environment with two OLED screens (1080 × 1200 pixels per eye, 90 Hertz) with a field of view of 100×110 degrees. Participants controlled the VR environment with a standard handheld *HTC Vive* controller. Images of the activities of the participants were viewed on an LCD television.

2.4. Research procedure

In the study, two different VR environments were designed by the researcher. VR environments were prepared using the *Unity* 3D game engine and *Steam* VR software (Unity, 2019; Steam, 2019). The preparation of the media was completed in about two months. For the first VR learning environment, Africa's *Savanna* region was attempted to be simulated. Seeing and interacting with most creatures such as lions, elephants, crocodiles, rhinos, and wolves in the real world is a very risky and challenging action. However, thanks to VR, users are allowed to touch these creatures in a virtual environment, hear their voices, and watch their movements. In addition, thanks to the teleport component of the *Steam* VR software, users can move in the VR environment and view the environment from different angles using their controllers.

For the second VR environment, the planets in the *Milky Way* galaxy were attempted to be simulated. Seeing and interacting with the atmosphere, surface structure, and physical properties of other planets outside of the world in our real world is a highly risky and almost impossible action. However, using VR, users were allowed to navigate these planets, see their surface shapes, and obtain different experiences. In addition, thanks to the teleport component of the *Steam* VR software, users can move between planets and view the environment from different angles using their controller. In Fig. 1, a pre-service teacher experiencing developed environments is shown.


Fig. 1. An ICT pre-service teacher experiencing VR environment (left), and VR environment (right)

Before experiencing the developed VR environments, the participants tested the VR contents in the Steam VR library for 10-15 minutes after the last lesson of each day for about a week to learn how the VR equipment works. They learned what the buttons on the hand control devices do and how to adjust the headgear according to them in this process. After these practice experiences, the participants individually experienced both environments. Participants decided which VR environment would be experienced first. Each participant experienced VR environments for about 7-10 minutes. A technical staff member in the practice room gave information about how the pre-service teachers should install and use the VR tools. Data were collected from the participants who completed the application process. The data collection process took approximately 25 minutes.

2.5. Data collection tool

As a result of the implementation process, the pre-service teachers filled out the *self-efficacy and pedagogical use* questionnaire (Cooper et al., 2019). The questionnaire consists of three parts. In the first section, demographic information about gender and education level is included. The second section aims to obtain information about the potential use, self-efficacy, and previous experiences of the pre-service teachers in the process of learning digital technologies and VR technologies. In the last section, the potential positive aspects, efficacy, and use of VR technologies as a learning and teaching tool are attempted to be determined. Accordingly, there are questions regarding both quantitative and qualitative data in the questionnaire.

2.6. Data analysis

Descriptive statistics (such as percentage, total, and frequency) and *t*-test analysis were used to analyze quantitative data. Qualitative data were analyzed by the content analysis method. As a result of the analysis of qualitative data, codes, categories, and themes were revealed. In addition, quotations reflecting the experiences of pre-service teachers were used to enrich the obtained categories and themes.

3. Findings

3.1. Pre-service teachers' self-efficacy level regarding VR technologies in STEM education

It was observed that pre-service teachers' self-efficacy perceptions towards using digital technologies ($\bar{x}$ = 6.18; *SD* = .81) as a pedagogical tool in STEM education were found to be lower compared to VR technologies ($\bar{x}$ = 6.25; *SD* = .96). However, as a result of the *t*-test analysis, it was determined that this difference was not significant ($t[43] = .416$; $p = .686$; $p > .00$).

3.2. The opinions and experiences of pre-service teachers on whether VR technologies will have a positive effect on STEM education

When the prospective teachers were asked whether they would use VR technologies in STEM education when given the opportunity, all the candidates (n = 44) answered yes. This has shown a high interest in the use of VR technologies in STEM education. In addition, most of the pre-service teachers (n = 40) suggested that VR technologies would have a positive effect on STEM education. Only four participants stated that VR would not have a positive effect on STEM education. However, they did not explain the reasons for this situation. The simulator sickness they experienced during the process of using VR technology or their prejudices about VR technologies may be a reason for them to say "no". In this context, the code and frequency information about the teachers' positive opinions about VR technologies are shown in Table 1.

Table 1
Pre-service teachers' opinions on whether VR will have a positive effect on STEM education

Category	Coding	*f*
Yes (n = 40)	Presenting the feeling of immersion	11
	Providing permanent learning in complex and abstract subjects	6
	Supporting experiences that are not possible in real life	5
	Providing the opportunity to learn by doing	4
	Allowing facilitating learning	4
	Offering a realistic environment	4
	Helping develop the imagination	3
	Allowing navigating in different places	3
	Being attention-grabbing	3
	Increasing self-confidence	1
	Being motivating	1
	Helping overcome fears (*allowing confronting animals in the savanna area*)	1
	Supporting the presentation of visually rich content	1
	Encouraging class participation	1

When Table 1 is examined, it is seen that the frequency value of the code of "presenting the feeling of immersion" is the highest, in addition, the pre-service teachers emphasized that VR can be effective in teaching complex and abstract subjects, it allows having experiences that are not possible in real life, and it facilitates the learning process in STEM education. Some participants reflected on their opinions and experiences regarding this situation as follows:

> *"In a VR environment, you feel like you are in the real environment, and you try to keep up with the environment. Besides, learning in a VR environment creates positive emotions in people. I recommend these technologies to everyone in the classroom." [PST_F2].*

> *"VR environment is a very realistic environment. It can also provide permanent learning in the teaching of complex and abstract subjects." [PST_M1].*

> *"In virtual environments like VR, students can learn by doing almost anything." [PST_M8].*

The teachers stated that VR technologies allow experiential learning in STEM education, can simplify the learning process, support the transfer of events with a more realistic platform, and help develop students' imaginations.

3.3. Pre-service teachers' opinions regarding which learning experiences VR will be more effective in STEM education

The pre-service teachers stated that VR technologies in STEM education could be more useful and effective in the process of exploring inaccessible places (n = 47.72%). They stated that using VR technologies for communicating with people inside or outside the school would be the least beneficial (n = 47.72%). Fig. 2 shows the teachers' perceptions of usefulness according to the intended use of VR technologies.

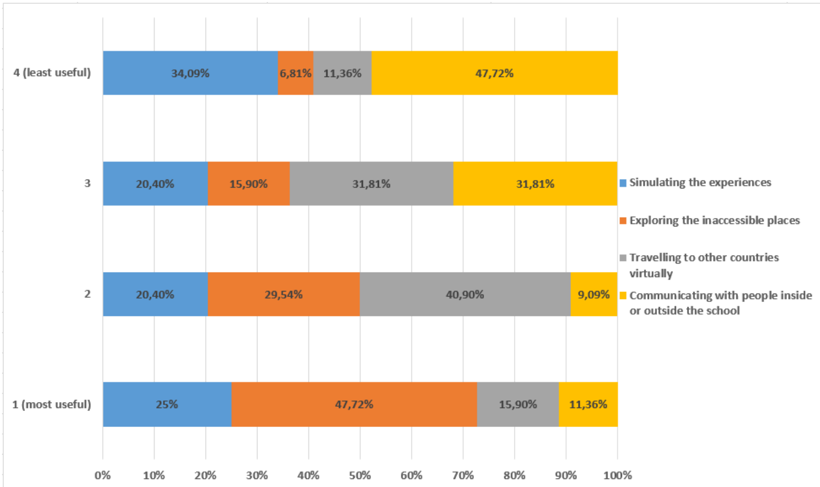

Fig. 2. Pre-service teachers' perceptions of VR usefulness

The pre-service teachers stated that the usefulness of VR technologies could be secondly (n = 40.90%) used to travel to and explore other countries. In addition, the category titled "communicating with people inside or outside the school" was the third most useful one as well as the last category of "traveling to other countries virtually" (n = 31.81%).

3.4. Pre-service teachers' concerns about VR use in the STEM classroom

A great majority of the pre-service teachers (n = 33) stated that they do not have any concerns about the use of VR technologies in STEM education. However, some participants (n = 11) suggested that they have concerns about VR technologies. Code and frequency information regarding this situation are given in Table 2.

Table 2
Participants' concerns about VR technologies

Category	Coding	*f*
Concerns of ICT pre-service teachers	It can be costly	4
	Impact and injury to objects in the real environment may occur	2
	It can create negative situations for people who cannot control their emotions, such as fear and excitement.	2
	It can isolate and distract students from the real world	2
	The repair process can be costly in the event of a breakdown	1

Four pre-service teachers complained that VR technologies are a costly tool. They stated that they were concerned about the supply of these tools to every student because of the cost. Two pre-service teachers argued that during the process of using VR technologies in the classroom, situations such as hitting objects in the real environment and injuries might occur. Besides, two pre-service teachers complained that technologies such as VR could create negative situations for people who cannot control their emotions, such as fear and excitement. The other two pre-service teachers stated that the image is very realistic, students can be isolated from the real world and their attention can be distracted. Finally, a pre-service teacher complained that technical and hardware problems such as breakdown may arise due to the high cost of these devices and that the repair process can be costly.

4. Discussion and Conclusion

This study aims to investigate the perceptions, expectations, and experiences of ICT pre-service teachers regarding the potential of using VR technologies as a learning and teaching tool in STEM education. The study also concluded that the self-efficacy perceptions of pre-service teachers for using digital technologies as a pedagogical tool in STEM education were low compared to VR technologies, but this difference was not significant.

Another result obtained from the study is that all the pre-service teachers stated that they would use VR technologies in STEM education when they start teaching. Besides, they added that VR technology has a positive effect on STEM education in many ways, including presenting the feeling of immersion, providing permanent learning in complex and abstract subjects, supporting experiences that are not possible in real life, providing the opportunity to learn by doing, allowing facilitating learning, offering a realistic environment, helping develop the imagination, allowing navigating in different places, and being attention-grabbing. In the study conducted by Yildirim et al. (2020), it was stated that teachers' use of VR technologies in teaching would provide many benefits to students. These include that these technologies engage students and increase their creativity, allow students to take virtual trips and explore situations that are impossible to explore in the real world, increase students' motivation and interest in the subject, and allow teachers to act as facilitators in the classroom, allow students to discover new technologies, enables teachers to spend more time getting to know the students' learning styles, and allows teachers to do experiments that are difficult to do in the classroom. Studies in the literature support these results (Aoki et al., 2005; Bailenson et al., 2008; Chen et al., 2019; Edwards et al., 2019; Keskin, 2017; Pirker et al., 2019; Tuzun & Ozdinc, 2016). Additionally, it is seen in the literature that the use of educational technologies in the classroom has the potential to be included in STEM classes and increases students' academic achievement (Nersesian et al., 2019; Pellas et al., 2020). In the study by Truchly et al. (2018), students indicated that VR applications are easy to use, where learning is more active and visually enriched.

The pre-service teachers expressed that VR technologies in STEM education can be more useful and effective in the process of exploring inaccessible places. They stated that the use of VR technologies to communicate with people inside or outside the school would be the least useful. In addition, they suggested that VR technologies can be used to travel to and explore other countries as the second usefulness (see Fig. 2). In the literature, it was pointed out that pre-service teachers think that VR technology is a promising way of teaching physics, especially through experiments, and that VR makes learning contents more interesting, fun, and interesting (Pirker et al., 2019). Using VR in

STEM education provides a better understanding of abstract science subjects for students. For example, Manseur (2005) used VR to teach abstract subjects such as molecular systems, galaxies, and astronomy subjects, and in his interview with the teachers, they stated that VR was used in different areas of daily life such as education, health, and art. Likewise, Hite et al. (2019) stated that VR applications could play an essential role in science lessons. In addition, it is thought that VR will benefit STEM education as it allows students to experiment without space or time limitations and can be used all year round, even from home (Bogusevschi et al., 2020; Makransky et al., 2019; Southgate et al., 2019). As the students actively participate in problem-solving and learning by experiencing, VR applications have the potential to significantly support students' motivation to learn and even improve their social, collaborative, and cognitive skills (Martín-Gutiérrez et al., 2017).

While most of the pre-service teachers stated that they do not have any concerns about the use of VR technologies in the classroom in STEM education, some participants underlined that they have concerns. These concerns are that VR technologies are a costly tool, that situations such as hitting and injury to objects in the real environment may occur during classroom use and may create negative situations for people who cannot control their emotions such as fear and excitement, and when technical and hardware problems such as malfunction occur, the repair process can be costly. Similar results were also obtained in the literature (Sharples et al., 2009; Yildirim et al., 2020). Moreover, according to Liou et al. (2017), VR can cause students to isolate themselves from their peers. The study conducted by Truchly et al. (2018) concluded that students' use of VR technology enabled them to be motivated to learn, but some students did not feel comfortable using the VR headset.

Consequently, interaction with VR applications allows students to develop critical thinking, imagination, and creativity skills. In studies examining the use of VR applications in STEM subjects, it was revealed that students were able to develop social skills such as abstract thinking, problem-solving, and group work and to better understand learning materials (Abdullah et al., 2019; Jimeno-Morenilla et al., 2016; Kozhevnikov et al., 2013). In this direction, it can be said that VR is a suitable application for STEM education. VR is a convenient educational tool for students to interact with the physical world in ways not possible before. Using VR as a learning tool provides an understanding of the possible learning opportunities provided by this technology. It also allows visualizing various experiments on subjects such as physics or chemistry when certain facilities and tools are not available (Heradio et al., 2016). As technological developments provide new opportunities in teaching and learning, the use of VR in STEM education must be encouraged. With the wide availability of VR content, students interact more with the world. They can also explore many science topics by being interested in STEM subjects in their learning scenarios (Frydenberg & Andone, 2019). Hence, studies on the use of VR in mathematics education indicated that students' interests and attitudes towards mathematics increased when using VR (Simsek, 2016). True STEM education should increase students' understanding of how things work and improve their use of technologies (Bybee, 2010b). In the coming years, teaching techniques that take advantage of emerging technologies such as VR are likely to become standard components of STEM education (Al-Azawi et al., 2019). In STEM education, real-life problems are primarily defined, and the focus is on the solution of the problem. VR requires students to apply their knowledge and understanding to the identified real-life complex problem by providing an innovative education that allows students to evaluate themselves in solving the problem (Abulrub et al., 2011). In this line, the use of

VR technology in STEM education offers various opportunities to improve learning-related factors.

Author Statement

The authors declare that there is no conflict of interest.

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