ORIGINAL ARTICLE

The Views of Students Regarding the Use of Virtual Reality Applications in Elementary Science Classes¶

Osman Urhan, Ercan Akpinar

Dokuz Eylul University, Izmir, Turkey

Abstract*: Recently, Virtual reality (VR) technologies have started to be used increasingly in the field of education, as in many other fields. With the widespread use of virtual reality applications, there is a need to investigate the effects of virtual reality applications in the field of education. The results obtained from these researches can contribute to the creation of effective and efficient virtual reality-supported learning environments. VR applications, one of the technology-supported learning environments, come to the forefront to help students learn concepts more easily and permanently. Since VR is very new and not a common practice in classrooms yet, it is necessary and important to investigate how VR can be used in science lessons and students' views on these practices. The main goals of this study were to develop the Virtual Reality Solar System Model (VRSSM) for the unit "Sun System and Eclipses" for the 6th grade students and to find out what the students think about using virtual reality applications in science classes. This is a qualitative study and 16 students participated in this study and used the VRSSM. The semi-structured interview form was used as a data collection tool. The data was analyzed using content and descriptive analysis. The results of this research revealed that the students want VR to be used not only in science lessons but also in other lessons, they think that the knowledge they have gained is permanent and that they believe that this application can increase their science achievement. Additionally, students think that the application increases their interest in science lessons and affects their learning positively. Therefore, it is expected that the results of this research will lead to the creation and implementation of three-dimensional virtual reality learning environments related to various subjects and levels of science teaching.*

Science Insights Education Frontiers 2024; 21(1):3329-3348.
DOI: 10.15354/sief.24.or550

How to Cite: Urhan,O., & Akpinar, E. (2024). The views of students regarding the use of virtual reality applications in elementary science classes. Science Insights Education Frontiers, 21(1):3329-3348.

Keywords: *Virtual Reality, Solar System, Science Teaching, Virtual Learning Environment, 3D*

***About the Authors**: Osman Urhan, MCs, The Institute of Educational Sciences, Dokuz Eylul University, Izmir, Turkey, E-mail: osmanurhn@gmail.com*

Ercan Akpinar, Professor, Department of Computer Education and Instructional Technology, Faculty of Education, Dokuz Eylul University, Izmir, Turkey, E-mail: ercan.akpinar@deu.edu.tr, ORCID: https://orcid.org/0000-0002-2128-3308

***Correspondence to**: Prof. Ercan Akpinar at Dokuz Eylul University of Turkey.*

***Conflict of Interests**: None*

***Funding**: This study was supported by the Dokuz Eylül University under the grant number 201769.*

¶: This study was produced from the master's thesis conducted under the supervision of Professor Ercan AKPINAR in The Institute of Educational Sciences at Dokuz Eylül University

Introduction

PEOPLE'S habits of using technology change quickly due to the rapid advancement of technology, such as virtual reality (VR) and augmented reality (AR), and this development necessitates differentiation and change of learning environment. Virtual reality is a computer-generated environment that allows users to interact by activating their senses, creating the illusion that they are immersed in the created world (Okul & Şimşek, 2020).According to Tanrıkulu and Karagöl (2021), virtual reality is a growing field of study that is being investigated in both academic and business fields. In addition, the mobile technology and entertainment industries have made significant investments in virtual reality systems. Furthermore, major mobile device and phone manufacturers include virtual reality hardware in their products, and virtual reality glasses and hardware are increasingly being integrated into game consoles. Sezgin (2016) discusses Facebook's investment in virtual reality, foreseeing significant societal attention in the future. He highlights Facebook's pivotal role in this technology, suggesting it will become a major focus in the evolving landscape. There have been significant developments in the field of metaverse recently, and this field is now open to many sectors including education. Virtual reality systems, which are widely accepted and allow students to experience phenomena and concepts that are difficult to learn in a traditional educational setting, are also expected to bring new perspectives and benefits to educational processes. These systems, which were previously difficult to access due to their high cost and hardware shortcomings, are now developing rapidly in a variety of industries, most notably entertainment and medicine and these deficiencies are eliminated to a certain extent (Bayraktar & Kaleli, 2007). Gürsoy (2020) stated in his research that in business sectors with difficult and dangerous conditions, such as mining, virtual reality technology can be used to simulate very close to real-world conditions, while training can be conducted safely and without causing harm to the learners or their environment.

The importance of taking advantage of these opportunities in numerous disciplines grows with time, and it is critical to research issues that are difficult to learn or do in normal classrooms. At the same time, these systems are extremely effective at concretizing abstract concepts due to the much visual materials they have, integrating them into the education environment is essential (Aktamış & Arıcı, 2013). According to Kandemir and Demir (2020), virtual reality improves concept learning by providing learners with rich experiences that connect and varied feedback, correlating easily with real-world situations, allowing learners to engage with the virtual world, and amusing them as they study. Since the structure of the primary school science curriculum currently in practice in Turkey is based on constructivist learning theory and inquiry-based approach (Ministry of National Education, 2018), creating learning environments that allow students to actively participate in the learning process and enriching it with technology becomes even more important. In this context, learning environments enhanced with technology such as virtual reality, augmented reality, educational digital games, and gamification are thought to play an important role in ensuring active participation of students in lessons and inquiry-based learning. Virtual reality applications can improve and enhance the educational environment and other fields (Häfner et al., 2018). One of virtual reality's most significant contributions to education, according to Hamilton et al. (2021), is that it allows students to practice difficult and complex tasks repeatedly in a safe environment. In their study, Us and Aytıs (2009) define virtual reality as a system created in a computer environment that offers the user with a feeling of realism. Kuruüzümcü (2010) emphasizes how virtual reality helps the design of environments favorable to interdisciplinary learning employing multimedia technologies, as well as the investigation of concepts with actual accuracy and order. According to Aktamış and Arıcı (2013), using music, light, and interaction components in virtual reality settings engages all the students' sensory organs. The use of virtual reality in education has transformed it into an engaging and attractive framework (Öztürk & Sondaş (2020). Moreover, Heyselaar, Hagoort, and Segaert (2017) stated that the interactions with virtual avatars, are strikingly comparable to interactions with actual people. Moreover, the result of the study made by Liou, Yang, Chen and Tarng (2017) provides evidence that both AR and VR systems can improve students' knowledge structuring. In other words, both AR and VR systems are useful for knowledge construction. VR technology has been extensively presented in recent years as an innovative technology capable of creating extremely realistic, immersive, and interactive three-dimensional learning environments (Sarıtaş, 2015).

Because science courses cover a wide range of scientific concepts and principles, it is possible to visually present this knowledge to the students by utilizing computer-assisted teaching software. Many of the subjects or concepts mentioned in the science lesson are abstract. The difficulties that primary and secondary school students have in acquiring these abstract topics are frequently attempted to be solved via lectures delivered through the presentation. However, in some cases, learning through the presentation in this way may not be sufficient. For example, it has been determined that students have misconceptions or alternative concepts regarding the unit of solar system and eclipses, which is the subject of this study (Ekiz & Akbaş, 2005; Öztürk & Uçar, 2012). As a result, concretizing abstract events and concepts thanks to new technologies like VR can help students learn science concepts more easily and meaningfully (Dağdalan, 2019). In addition, when challenges and some learning problems arise, using computer simulations can help to solve this learning problems or offer new solutions especially when the subject involves three dimensions provide more attractive learning environment (Çekbaş et al., 2003). Today, virtual reality applications may be demonstrated as one of the most effective methods of benefiting from these simulations. So virtual reality applications are intended to improve learning settings, make students more involved in the learning process, and increase their interest in the subjects (Dağdalan, 2019; Öztürk & Sondaş, 2020). Furthermore, it is expected to contribute to the development of new possibilities and learning materials to make the same concepts more scientifically meaningful. In this context, it is thought that virtual reality learning environment would be effective in teaching abstract concepts or events that are difficult to learn and understand in science education such as solar systems which are the subject of this research, as well as in other concepts in order to make them easier and more understandable (Arıcı, 2013; Dağdalan, 2019; Liou et al., 2017).

In addition to the effect of virtual reality on the effective learning of concepts, it also enables an understanding and experience beyond the existing limits, as impossible phenomena can be fictionalized in the physical world (Kuruüzümcü, 2010). Because students have not yet had the opportunity to experience the "Solar System and Eclipses" unit of the 6th-grade science course in person or the classroom, the concepts in the "Solar System and Eclipses" unit remain abstract for them. Moreover, astronomy generally includes abstract scientific concepts and presents a significant cognitive learning challenge for primary school students (Liou et al., 2017). Moreover, elementary school students often find it challenging to grasp abstract astronomical concepts related to the relative positions and movements of the sun, moon, and earth (Sun et al., 2010). In addition, there is a need for innovative teaching methods that facilitate access to processes and structures that cannot be directly observed, such as atoms and the solar system. For this reason, instructors and teachers should use this technology to build virtual learning settings in which students engage with virtual real-like items connected to scientific concepts that can't be studied or observed at a macro or tangible level (Sarıtaş, 2015; Sun et al., 2010). Students can explore and interact with these concepts and phenomena on-site thanks to the tools and components created within the virtual reality opportunities. The review of the literature indicated that virtual reality applications for a wide range of disciplines in general, and scientific education in particular, are very limited, indicating the need for further research on the subject. Furtermore, as a result of their research study on Virtual Reality regarding Solar System, Eryanto and Prestiliano (2017) suggested to develop the materials by designing other animations (such as: comets, the planets' orbit) and improve the graphic quality of the planets and the space to make them more realistic. In spite of the fact that in learning science subject and concepts, especially the solar system, an interactive and interesting learning media is highly needed for the students

(Arıcı, 2013; Eryanto & Prestiliano, 2017; İneç, 2020), the using of the virtual reality in educaton has not been systematically studied yet (Lee, Park, Kim & Lee, 2005). At the same time, virtual reality technology needs to be studied on different topics, with different samples, at different grade levels (Dağdalan, 2019; Sarioglu & Girgin, 2020). Moreover, there is no doubt that investigating the reflections of VR-assisted science education practices is not only crucial for learners but also for educators who need to learn how to use new technologies effectively in their science classrooms (Artun et al., 2020). Considering all these factors, in this study, a virtual reality application was created for the "Solar System and Eclipses" unit in accordance with the science curriculum with the aim of allowing students to observe and learn the subjects and concepts interactively and visually. In this way, Virtual Reality about the Solar System can be effectively delivered knowledge in terms of the solar system lesson based on current curriculum (Eryanto & Prestiliano, 2017).

When the existing studies in the literature are examined in general, it has been concluded that only 23% of the existing applications are done in the field of education (Şimşek and Tuncer, 2019). The majority of studies which utilized ready-made applications conducted within the scope of virtual reality and investigated their effects on some discipline such as mathematics, medicine, languages and science education (Akaslan et al., 2018; Aktamış & Arıcı, 2013; Heyselaar, Hagoort & Segaert, 2017; Öztürk & Sondaş, 2020; Shih, 2015; Terzioğlu, et al., 2012; Şimşek & Tuncer, 2019). However, the number of studies regarding science education is very limited (Gündoğdu & Dikmen, 2017; Liou & Chang, 2018; Mintz et al., 2001) and some of these reseachers stated that the effects of virtual reality applications on different variables in learning environments should be studied by conducting new studies in this area (Aktamış & Arıcı, 2013; Dağdalan, 2019; Eryanto & Prestiliano, 2017; Lee et al., 2005; Sarıçam, 2019).

As stated above, the immersive virtual reality (IVRS) system offers many opportunities such as active participation and being there, as well as a new visual learning experience that has not been systematically studied yet and what's more ın previous studies on the solar system, which is the subject of this study, ready-made and publicly available virtual reality software which does not directly address the learning outcomes in the science curriculum was used on the computer screen or as a presentation tool, and its effect on the achievement of 6thgrade students was investigated (Aktamış & Arıcı,2013).

As previously stated, the immersive virtual reality (IVRS) system provides many opportunities such as active participation and being there, as well as a new visual learning experience that has not been systematically studied yet. Furthermore, in previous studies on the solar system, which is the subject of this study, ready-made and publicly available virtual reality software that does not directly address the learning outcomes in the science curriculum was used on the computer. The purpose of this study is to create virtual reality applications for "Sun System and Eclipses subjects" by taking into account learning outcomes in science curriculum, instructional design principles, and constructivist approaches, which are based on students learning and constructing their own knowledge through doing-living and active participation in the learning environment, as well as to determine students' views on the virtual reality application (VRSSM)).

The Main Problem of This Study

What are the students' views on virtual reality applications?

Methodology of Research

The methodology of this study consists of two stages. In the first stage, a virtual reality application was developed in accordance with the learning outcomes of the unit topic in this study. During the development of the application, the opinions of subject matter experts and science teachers were sought. In the second stage, voluntary 6th-grade students utilized this virtual reality application, and their feedback regarding the application was collected. At the commencement of the second stage, a science teacher was briefed on how to conduct the application by one of the authors of this study. In a school laboratory, 16 students were taught the topic by using virtual reality applications. Before each lesson, 5 virtual reality systems were prepared, and students were given preliminary information on how to use the application before being allowed to use the application (VRSSM) with the teacher's instructions. The one author of this study interviewed the teacher every week before the course and informed her about the use of the applications if needed.

Data Collection Tools and Analysis

Semi-Structured Interview Form for Virtual Reality Application

The Semi-Structured Interview Form was prepared by the researchers (the authors of this article) by taking the opinions of two experts experienced in virtual reality application and a science educator in order to determine the students' views about the VRSM developed in this study. The students participated voluntarily in this study, and also their parents' permission was obtained. The interview approach has significant characteristics in terms of being ideal for measuring features, offering the possibility to gather in-depth information, and being continually monitored (Teddlie & Tashakkori, 2009). The researcher conducted the interviews face to face and recorded them, giving each student a nickname such as Student A, B, C. The researcher has the opportunity to listen to the video recordings more than once while transcribing the interviews because the interviews were recorded. In additionally, to avoid any misunderstandings, a pilot research was conducted. The data obtained from the interview were analyzed as content and descriptive (Yıldırım & Şimşek, 2011). In the content analysis, first of all, codes, categories and themes were determined by two researchers (encoder) in this study by examining the interview texts. The researcher independently read and generated coding categories for each of the themes they encountered. After reviewing the results, the researchers recorded the data. Afterwards, an external expert's opinion was taken again regarding the determined codes and categories. Finally, the differences in category and coding were discussed and reached a consensus by the researchers together. The encoder reliability of the study was calculated as 89 %. Calculations of reliability greater than 70% are considered reliable for research (Miles & Huberman, 1994). In addition, the content analysis was supported by quoting the views of the students.

The virtual Reality: Design, Development, Application Process

In this study, the virtual reality environment and almost all the visual elements used in the application were designed and created by the researchers by considering learning outcomes in the science curriculum, instructional design principles, and constructivist approaches, which are based on students learning and constructing their own knowledge through doing-living and active participation in the learning environment. Furthermore, the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), which is one of the best-known examples of instructional design models (Dick & Carey, 2000) was utilized to design the virtual reality environment for the Solar System and eclipse unit in this study. During the development process of VR, the opinion of three science education experts, two science teachers, and two ICT experts about the VRA were obtained, and the VRA was updated in line with the experts' feedback. The main field of application for the planned three-dimensional education environment is virtual reality glasses and control devices. The preferred virtual reality (VR) device is computer-assisted hardware. The sensors in this hardware detect the location of the user and transfer the physical actions such as location and direction change into the application in real-time. In this way, the movement of the user, for example, who makes walking or bending movements in the real world, instantly finds a response within the VR application. Similarly, control devices enable users to see their hands as avatars in the VR program and interact with it by moving their hands. In addition to this hardware, the LEAP MOTION tool, which permits interaction with only one's hands without the use of a control device, was chosen to provide an alternative and a different experience. In addition to these features, the program has been designed to be suited for usage in a computer environment, allowing for the broader field. Furthermore, the way the application works can be carried out simultaneously on virtual reality equipment and computers. In this way, the application has been designed in such a way that it can be used interactively from the computer that is connected at the same time and can be observed from the outside via the computer screen or external monitors to which the image will be transferred. Moreover, it is designed to work with Android-based mobile devices that require additional hardware and software.

Virtual Reality Solar System Model (VRSSM)

The students started their journey at a cabin in the virtual reality environment in Virtual Reality Solar System Model (VRSSM). They can use a telescope to investigate the moon and space at the observatory located area. Then, they can travel into space by boarding a spacecraft in the area. Moving into space, they find themselves in a space station orbiting the Earth and can observe the Earth from Space and begin to examine miniature versions of objects such as the Moon, inner and outer planets in the solar system (**Figure 1**). Both verbal and written information about the characteristics of the objects is also given. Following that, students are expected to classify the inner and outer planets in an interactive way in the VRSSM. In this stage, the student moves the inner and outer planets to the appropriate areas by using the laser stick in his/her hand (**Figure 2**). So they can learn these planets' orders in the Solar System.

In the next steps, the students are expected to visit all planets in order to examine some information about the planets through multimedia support (audio, visual, and written forms). After this section, students return to the space station for learning the subject of eclipses. When the course on all subjects is completed, they are expected to travel to the Earth, Sun, and Moon positions by teleporting with the spacecraft and making observations from each position during the eclipse (**Figure 3**).

Software used in Application Development Phase

Despite the fact that the application mostly displays visual parameters, different software was utilized in the development phase and in the program's background. Adobe Photoshop software was used in the editing of the im-

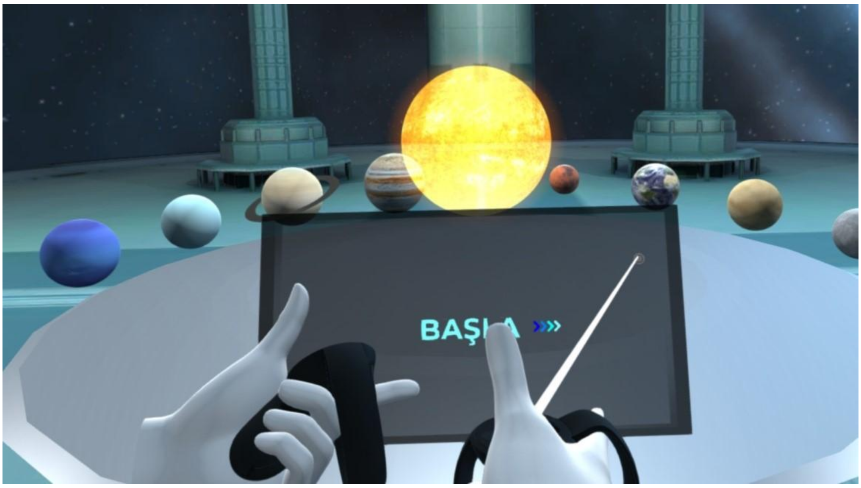

Figure 1. A Sample Image of Starting (BAŞLA in Turkish) Scene from Inside the Space.

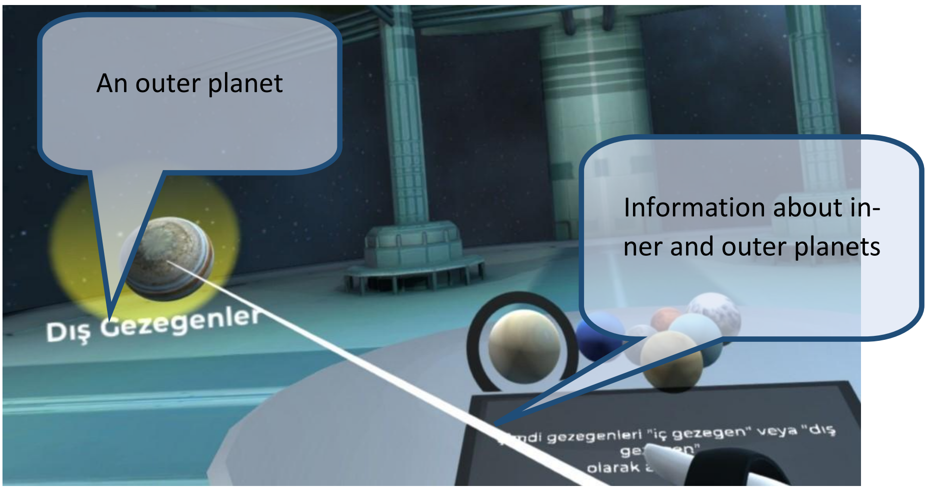

Figure 2. An Example Image from the Inner and Outer Planets Classification Application.

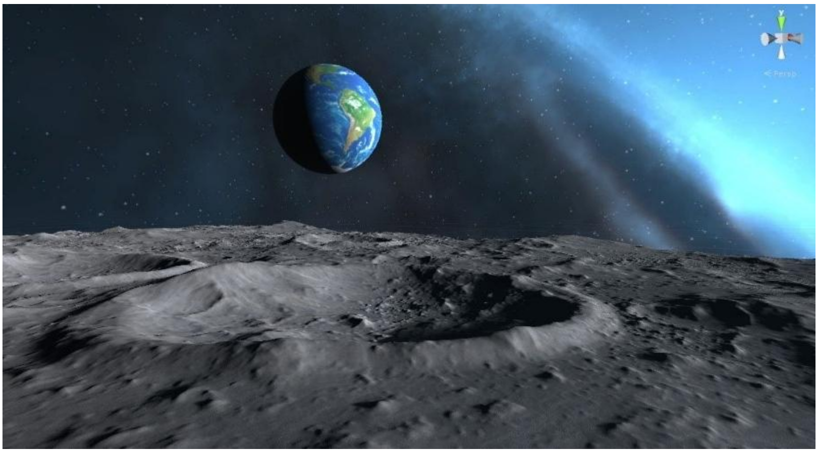

Figure 3. A Scene of the Virtual Solar System Model.

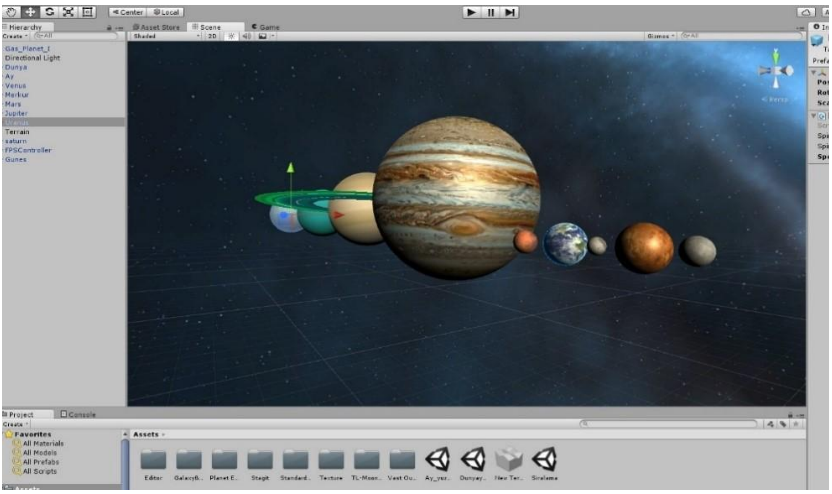

Figure 4. A Scene from the Developing Phase of the Application.

Figure 5. Sample Images from the Implementation Process.

ages after taking expert opinions, and Adobe Illustrator software was used in the design processes. The three-dimensional objects used throughout the program were created in Autodesk 3DS Max and combined with the edited visuals in this software. The process of making the created objects interactive was carried out in the Unity 3D software (**Figure 4**), which is the main software in the design of the application. While creating the interaction of objects, be-sides the use of CSHARP and Java programming languages on Unity 3D software, Microsoft Visual Studio was also preferred when needed. Leap Motion Controller software was used to provide interaction without an external device. Adobe After Effect and Premiere software were used in the design part of the application that needs to be edited in animations. The final version of the application was implemented with students in a classroom environment (**Figure 5**).

Findings

After the application, the students were asked the following question: “What do you think about whether the application affected your learning of the unit or not? If it did, how did this affect it?” The responses regarding the effect of virtual reality applications obtained from the interviews with students were classified under the themes “with effect” (13 students) and “without effect” (3 students) and three categories (funny, feeling reality, and no effect) within these themes, and these findings have been supported by sample quotations from students' responses here. First, almost all of the students who participated in the interview, except for three, think that the application is effective and funny. Moreover, some of the students thought that the VRA was very funny, while others stated that they experienced a sense of reality and felt as if they were walking in space. Some sample quotes from the students' opinions are given here: "*Yes, it (VRA) affected my learning .... If it wasn't for the virtual reality application, I wouldn't be able to understand anything about it....*(Student A)". Similarly, student B expressed her opinion as follows: "*Yes, it affected me, it made me feel like I was really next to the objects, I liked it very much*". Student G stated his opinion as follows: "*Yes, it did, I learned it while having fun.*" Student F stated as follows: "*Yes, it was impressive; it was like I was playing a game; I liked it very much*" and Student K stated that "*It was very fun; I was very impressed.*" Student J stated that he thought there was no difference between the two applications (VR and normal instruction) by saying, "*It didn't affect me much; I could understand the subject (in) anyway….*". These findings show that the virtual reality application has a positive effect on the emotion of students in general.

After the application, the students were asked, "*Did the virtual reality application affect your interest in the lesson in general? If so, did it affect it positively or negatively? Can you explain?*". During the interview, most of students stated that the virtual reality application positively affected their interest in the course, and three students said that "*we were already interested in science lessons*". For example, Student A expresses his views on the effect of virtual reality application on interest in the course as "It affected positively, it was memorable." Student F said "It affected my interest positively, it was a very good experience…". Student C stated that "*…. I already loved science, but I also saw the fun side of science again*". Student E stated that "*It affected me positively and increased my interest in the lesson*." On the other hand, student H expressed an opinion about virtual reality, as "*It did not affect my interest.*" ,"*Because there was not many thing that would affect my interest in the course*."

The third research question is, "Do you think that the virtual reality application makes the subject or concepts you have learned more permanent?", "Can you explain why?" With this question, it is aimed to reveal whether the virtual reality application provides the permanence of the knowledge (Due to the data limitations of this study, this finding reflects students' perceptions on the relevant subject). According to the content analysis of this question, three themes (e.g., interaction, memorableness, and exciting) and 25 codes (e.g., memorable, not forgettable, funny, interactively) within the themes have been reached in the coding of the responses that were collected through interviews. Thanks to this application, the student's knowledge becomes concrete, and they learn by doing and living in the virtual reality environment as if in a real one. All but one of the students stated that the virtual reality application was effective in ensuring the permanence of knowledge. For example, student A stated that "*yes, it was such a funny,… and beautiful application that I cannot forget the subject." Similarly, student E expressed his views as follows: "Yes, because we did it interactively, it was more memorable…." Student C stated that "it was much better to see with visuals such as life, and it was catchy." Student L said that "Yes, now when I take an exam,… I think that virtual reality helps me to remember what I learn so I will always be able to remember it…*"

During the interview, we asked the students, "Did you encounter any problems while using the application? Were there places you couldn't understand? If so, how did you fix these problems?" and then student responses were analyzed in a descriptive way. *While half of the students stated that they did not encounter any problems, others had some problems and needed the help of the teacher or the researcher. In terms of how the applications were used, student A stated, "No, I did not experience any difficulty, and there was no point that I did not understand." Student C explained, "No, it didn't happen, but I did get help from the teachers when I got a problem." Regarding the usage of the virtual reality application, student D said that, "No, I did not have any problems with the application, and there was no point that I could not understand." Another student stated as follows: "Sometimes it happened. In the button, there was a contact failure. I pressed a button, and the system was no longer able to function. I needed the teacher's help to solve it*."

The last research question is, "*Would you like to learn other lessons and topics with virtual reality applications? For which course or for which unit would you like to learn thanks to this application?*" With this question, it is aimed to reveal whether the student likes to use the application for other lessons or subjects. According to the content analysis of this question, one theme, "willingness" with four categories (e.g., all lessons, science, math), and 13 codes (e.g., all lessons, every lesson, all subjects, science, math, mathematics, sense organs, computer) have been reached in the coding of the responses that were collected through interviews. Most of the students who participated in the interview wanted the Virtual Reality Application to be used in all disciplines, two of them only in science lessons, two of them only in mathematics lessons, and three of them in other lessons. Some quotes from the students' responses are given below.

Student D said, "*I would like virtual reality applications to be used in all lessons and all subjects*." Student E expressed that "*Yes, I would like it to be used in math class*." Similar to Student D' views, Student F also stated that "*I would like it for every lesson and every unit because the virtual reality app was so much fun*". Student J stated that "*I would like to have this application in the sense organs (science) unit as well.*" Student K expressed that "*yes, I would like it to be used in math class*".

Conclusion, Discussion and Recommendations

The opinions of sixth-grade students about the virtual reality application were collected using a semi-structured interview form in this study. When the virtual reality application was used in the science course, the students thought that the virtual reality learning environment attracted their attention and interest and made the science lessons funnier and more interesting than normal teaching. This result was consistent with the findings of previous studies (Kandemir & Demir, 2020; İneç, 2020). For instance, Gedik (2020) took the students' thoughts on the virtual reality application and concluded that the students' interest, engagement, and motivation for climate lessons taught by using virtual reality technology increased. As mentioned above, similar results were found in this study. The following quotes from the students in this study show that they found the application effective and funny.

"Yes, it (VRA) affected my learning." "If it wasn't for the virtual reality application, I wouldn't be able to understand anything about it." "Yes, it affected me; it made me feel like I was really next to the objects, I liked it very much." "It affected my interest positively; it was a very good experience." "I already loved science, but I also saw the funny side of science again."

Interests are direct or indirect determiners of all essential components of science education, as they are in all fields of education (Kuhns, 1977), and help knowledge be retained for a much longer period of time. So, the fact that this virtual reality application has increased students' interest and helps them learns the lesson more easily. Similar to the results of this study, Dağdalan (2019) revealed in his research that the students found the virtual reality application interesting and that they learned while having fun thanks to this application. It was also observed that the students in the virtual reality experimental group had positive attitudes toward this technology. According to the results of the study by Kaleci et al. (2017), virtual reality environments are interesting, impressive, and intriguing, and provide a unique experience for users. In another study, it was concluded that virtual reality increased students' interests more than other materials (Lee, Park, Kim & Lee, 2005). Considering the results of both the current study on the solar system and eclipse and the above studies, it can be said that virtual reality applications positively affect students' interest in the course. Since the increase in students' interest in the lesson will allow them to listen and learn the lesson more carefully, virtual reality applications should be created for mostly all subjects in science lessons, and the effects of these applications on students' attitudes should be investigated. In this manner, understanding students' attitudes and views toward digital technology looks to be crucial in efforts to properly integrate them into instruction (Tsivitanidou et al., 2021).

Another result of this study's qualitative finding is that students believe the information they learn through virtual reality is more permanent. All but one of the students stated that the virtual reality application was effective in ensuring the permanence of knowledge. According to İneç (2020), the knowledge gained in a virtual reality environment is permanent because it contains multimedia and gives the impression of being there. These findings are supported by previous research (Gedik, 2020; Öztürk & Sondaş, 2020). In addition, thanks to this application, the students' knowledge becomes more concrete and memorable because they learn by doing and by living in the virtual reality environment as if in real one. This result should be tested in future studies since it was obtained based on interviews with students in the current study.

Regarding the problem faced by the students while performing the virtual reality application, half of the students stated that they did not encounter any problems, while some of them stated that they had some problems and needed the help of the researcher or the teacher. This may be due to the fact that they use virtual reality glasses for the first time, and it is also a new technology. Taking this conclusion into account in future studies can ensure the successful, healthful, and efficient use of virtual reality applications.

According to the results obtained from the research, the majority of the students who participated in the interview wanted the Virtual Reality Application to be used in all disciplines, while two of them wanted it to be used only in science courses, the other two wanted it to be used in mathematics courses, and three of them wanted it to be used in other courses. In the research conducted by Dağdalan (2019) on virtual reality, it was revealed that students want the use of virtual reality applications to continue in classes at the highest rate. Similar to this result, a study conducted by Dağdalan (2019) on Virtual Reality Applications revealed that students want such applications to be used in higher grades as well.

In this study, the data revealing the effect of VR application on students' achievement has not been analyzed yet. However, many studies have been done on this subject. The application of virtual reality technologies in the lessons helps to improve students' academic achievement significantly. In the literature review, it is seen that this study shows similar results to the studies carried out on virtual reality (Aktamış & Arıcı 2013; Chung, 2012; Dağdalan, 2019; Eryanto & Prestiliano, 2017; ; Gedik, 2020; Hwang & Hu, 2013; İneç, 2020; Liou & Chang, 2018; Jou & Liu, 2012; Lee & Wong, 2014; Sarıçam, 2019; Sun, Lin & Wang, 2010; Tüzün et al., 2009). For example, according to the experimental research on virtual reality that was conducted by Sarıçam (2019), the students who used VRA believe that their imaginations developed during the virtual reality application process, and that they were constantly active throughout the process, resulting in more permanent knowledge.

Another study's results on virtual reality indicated that many students had positive opinions on Virtual Solar System (VSS) for using it in their class; and they thought this kind of teaching activities contributed their understanding more effectively (Lee et al. (2005). Avcı et al. (2019) have concluded as a result of their meta-analysis that virtual reality applications at the primary, secondary, high school, and undergraduate levels have a moderate effect on students' academic achievement. Due to the fact that virtual reality applications produced for the public or general use cannot fully satisfy the needs of students, it is critical to create learning environments that are specific to the subject to be taught and designed to the students' levels. So, in future studies, a virtual reality learning environment should be accompanied by appropriate pedagogical approaches on each subject and should include orientation and navigation tools in order to empower learners' perceptual and cognitive systems (Lee et al., 2005). In order to generalize the results of these studies and current study, it is thought that it is necessary to make new studies regarding VR on more and different student groups and also discipline in future studies. Similar suggestions have been expressed by other researchers (Liou & Chang, 2018; Sarioglu & Girgin, 2020).

References

Akaslan, D., Ernst, F. B., Sarıışık, G., & Erdoğan, S. (2018). Research and training opportunities for virtual reality application [Sanal Gerçeklik Uygulamaları İçin Araştırma ve Eğitim Olanakları]. *Electronic Turkish Studies*, 13(21):1-21. DOI: https://doi.org/10.7827/TurkishStudies.13914

Aktamış, H., & Arıcı, V. A. (2013). The Effects of using virtual reality software in teaching astronomy subjects on academic achievement and retention [Sanal gerçeklik programlarının astronomi konularının öğretiminde kullanılmasının akademik başarı ve kalıcılığa etkisi]. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, 9(2):58-70.

Arıcı, V. A. (2013). Fen eğitiminde sanal gerçeklik programları üzerine bir çalışma: "Güneş Sistemi ve Ötesi: Uzay Bilmecesi" ünitesi örneği. MSc. Diss., Adnan Menderes University, Turkey.

Artun, H., Durukan, A., & Temur, A. (2020). Effects of virtual reality enriched science laboratory activities on pre-service science teachers' science process skills. *Education and Information Technologies*, 25:5477-5498. DOI: https://doi.org/10.1007/s10639-020-10220-5

Avcı, Ş. K., & Çoklar, A. N., İstanbullu, A. (2019). The Effect of three dimensional virtual environments and augmented reality applications on the learning achievement: a meta-analysis study. *Education and Science*, 44(198):149-182.

Bayraktar, E., & Kaleli, F. (2007). Sanal gerçeklik ve uygulama alanları. Akademik Bilişim Konferansı, Kütahya.

Chung, L. Y. (2012). Incorporating 3D-virtual reality into language learning. *International Journal of Digital Content Technology and its Applications*, 6(6):249-255. DOI: https://doi.org/10.4156/jdcta.vol6.issue6.29

Çekbaş, Y., Yakar, H., Yıldırım, B., Savran, A. (2003). Bilgisayar destekli eğitimin öğrenciler üzerine etkisi. *The Turkish Online Journal of Educational Technology*, 2(4):76-78.

Dağdalan, G. (2019). Sanal Gerçeklik uygulaması destekli fen bilimleri öğretiminin öğrencilerin bilişsel düzeylerine, üst bilişsel farkındalıklarına ve sanal gerçeklik uygulamalarına ilişkin tutumlarına etkisi. Master's thesis, Ordu University Institute of Science, Ordu, Turkey.

Dick, W., & Carey, L. (2000). The systematic design of instruction (5th ed.). New York: AddisonWesley.

Ekiz, D., & Akbaş, Y. (2005). İlköğretim 6. Sınıf öğrencilerinin astronomi ile ilgili kavramları anlama düzeyi ve kavram yanılgıları. *Milli Eğitim Dergisi*, 165:61-78.

Emre, İ. E., Selçuk, M., Budak, V. Ö., Bütün, & M., Şimşek, İ. (2019). Eğitim amaçlı sanal gerçeklik uygulamalarında kullanılan cihazların daldırma açısından incelenmesi. *Bilişim Teknolojileri Dergisi*, 12(2):119-129. DOI: https://doi.org/10.17671/gazibtd.453381

Eryanto, D. R. D., & Prestiliano, J. (2017). Design of learning media for the solar system lesson using animation and virtual reality. *Open Science Journal*, 2(1):1-13. DOI: https://doi.org/10.23954/osj.v2i1.790

Gedik, R. (2020). Sanal gerçeklik teknolojisinin ortaokul sosyal bilgiler dersi iklimler konusunda kullanılması üzerine öğrenci görüşleri [Students' views on the use of virtual reality technology in climate topic in middle school social studies course]. *Journal of Innovative Research in Social Studies*, 3(1):33-53.

Gündoğdu, H., & Dikmen, Y. (2017). Hemşirelik eğitiminde simülasyon: Sanal gerçeklik ve haptik sistemler. *Journal of Human Rhythm*, 3(4):173-176.

Gürsoy, M. (2020). Yeraltı madenciliği eğitiminde bazı sanal gerçeklik uygulamaları. Master's thesis, Afyon Kocatepe University Institute of Science, Afyon, Turkey.

Häfner, P., Dücker, J., Schlatt, C., & Ovtcharova, J. (2018). Decision support method for using virtual reality in education based on a cost-benefit-analysis. Paper presented at 4th International Conference of the Virtual and Augmented Reality in Education (VARE 2018), Budapest, September 18-19.

Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education*, 8(1):1-32. DOI: https://doi.org/10.1007/s40692-020-00169-2

Heyselaar, E., Hagoort, P., & Segaert, K. (2017). In dialogue with an avatar, language behavior is identical to dialogue with a human partner. *Behavior Research Methods*, 49(1):46-60. DOI: https://doi.org/10.3758/s13428-015-0688-7

Hwang, W. Y., &Hu, S. S. (2013). Analysis of peer learning behaviors using multiple representations in virtual reality and their impacts on geometry problem solving. *Computers & Education*, 62:308-319. https://doi.org/10.1016/j.compedu.2012.10.005

İneç, Z. F. (2020) Sanal gerçeklik teknolojisi ile sosyal bilgiler öğretiminde kültür aktarımı. *Atatürk Üniversitesi Kazım Karabekir Eğitim Fakültesi Dergisi*, (41):180-203. DOI: https://doi.org/10.33418/ataunikkefd.793821

Jou, M., & Liu, C. C. (2012). Application of semantic approaches and interactive virtual technology to improve teaching effectiveness. *Interactive Learning Environments*, 20(5):441-449. DOI: https://doi.org/10.1080/10494820.2010.509632

Kaleci, D., Tepe, T., & Tüzün, H. (2017). Üç boyutlu sanal gerçeklik ortamlarındaki deneyimlere ilişkin kullanıcı görüşleri. *Türkiye Sosyal Araştırmalar Dergisi*, 21(3):669-689.

Kandemir, C., & Demir, B. A. (2020). Eğitimde sanal gerçeklik uygulamaları üzerine: "Sınıfta Ben De Varım" Projesi. *The*

Turkish Online Journal of Design Art and Communication, 10(4):339-354. DOI: https://doi.org/10.7456/11004100/002

Kuhns, L. J. (1977). Teaching for permanent learning. *NACTA Journal*, 14-16.

Kuruüzümcü, R. (2010). Virtual reality as a digital environment and art form [Bir dijital ortam ve sanat formu olarak sanal gerçeklik]. *Sanat Dergisi*, 2010(12):93-96.

Lee, E. A. L., & Wong, K. W. (2014). Learning with desktop virtual reality: Low spatial ability learners are more positively affected. *Computers & Education*, 79:49-58. DOI: https://doi.org/10.1016/j.compedu.2014.07.010

Lee, H., Park, S. T., Kim, H. S., & Lee, H. (2005). Students' understanding of astronomical concepts enhanced by an immersive Virtual Reality system (IVRS). In 3rd International Conference on Multimedia and Information and Communication Technologies in Education.

Liou, W. K., & Chang, C. Y. (2018, February). Virtual reality classroom applied to science education. In 2018 23rd International Scientific-Professional Conference on Information Technology (IT) (pp. 1-4). IEEE. DOI: https://doi.org/10.1109/SPIT.2018.8350861

Liou, H.-H., Yang, S. J. H., Chen, S. Y., & Tarng, W. (2017). The Influences of the 2D image-based augmented reality and virtual reality on student learning. *Educational Technology & Society*, 20(3):110-121.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis: An expanded sourcebook. California: Sage Publication, Inc.

Milli Eğitim Bakanlığı (2018). Fen Bilimleri Dersi Öğretim Programı ve Kılavuzu (İlkokul ve Ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar). Ankara: MEB Yayınları.

Mintz, R., Litvak, S., & Yair, Y. (2001). 3D-virtual reality in science education: An implication for astronomy teaching. *Journal of Computers in Mathematics and Science Teaching*, 20(3):293-305.

Okul, T., & Şimşek, G. (2020). Sanal gerçeklik uygulamalarının turizm rehberliği bölüm derslerinde kullanımına yönelik bir öneri. *Turist Rehberliği Nitel Araştırmalar Dergisi*, 1(1):31-51.

Öztürk, D., & Uçar, S. (2012). İlköğretim öğrencilerinin Ay'ın evreleri konusunda kavram değişimlerinin iş birliğine dayalı ortamda incelenmesi. *Türk Fen Eğitimi Dergisi*, 9(2):98-112.

Öztürk, E. O., & Sondaş, A. (2020) Sanal sağlık: Sağlıkta sanal gerçekliğe genel bakış. *Kocaeli Üniversitesi Fen Bilimleri Dergisi*, 3(2):164-169.

Sarıtaş, M. T. (2015). Chemistry Teacher Candidates' Acceptance and Opinions about Virtual Reality Technology for Molecular Geometry. *Educational Research and Reviews*, 10(20):2745-2757. DOI: https://doi.org/10.5897/ERR2015.2525

Sarıçam, S. (2019). Fen bilimleri dersinde sanal gerçeklik uygulamalarının dolaşım Sistemi kavramlarının öğretimi üzerine etkisinin incelenmesi. Ph.D. diss., Marmara University Institute of Science, İstanbul, Turkey.

Sarioglu, S., & Girgin, S. (2020). The effect of using virtual reality in 6th grade science course the cell topic on students' academic achievements and attitudes towards the course. *Journal of Turkish Science Education*, 17(1):109-125. DOI: https://doi.org/10.36681/tused.2020.16

Sezgin, S. (2016). Eğitimde giyilebilir teknolojiler: Fırsatlar ve eğilimler. *Mehmet Akif Ersoy University Journal of Education Faculty*, 1(40):405-418. DOI: https://doi.org/10.21764/efd.72734

Shih, Y. C. (2015). A virtual walkthrough London: Culture learning through a cultural immersion experience. *Computer Assisted Language Learning*, 28(5):407-428. DOI: https://doi.org/10.1080/09588221.2013.851703

Sun, K. T., Lin, C. L., & Wang, S. M. (2010). A 3-D virtual reality model of the sun and the moon for elearning at elementary schools. *International Journal of Science and Mathematics Education*, 8(4):689-710. DOI: https://doi.org/10.1007/s10763-009-9181-z

Şimşek, İ., & Tuncer, C. A. N. (2019). Examination of virtual reality usage in higher education in terms of different variables [Yüksek öğretimde sanal gerçeklik kullanımı ile ilgili yapılan araştırmalara yönelik içerik analizi]. *Folklor/Edebiyat*, 25(97):77-90.

Tanrıkulu, B., & Karagöl, A. (2021). Virtual reality applications in the museum: Turtle trainer as a case study [Müzede sanal gerçeklik uygulamaları: Bir örnek çalışma olarak kaplumbağa terbiyecisi]. *Yeni Medya Elektronik Dergisi*, 5(2):95-111. DOI: https://doi.org/10.17932/IAU.EJNM.25480200.2021/ejnm_v5i2001

Teddlie, C., &Tashakkori, A. (2009). Foundations of mixed methods research: integrating quantitative and qualitative approaches in the social and behavioral sciences. Sage, London.

Terzioğlu, F., Kapucu S., Özdemir, L., Boztepe, H., Duygulu, S., Tuna A. Z., & Akdemir, N. (2012). Nursing students' opinions about simulation method [Simülasyon yöntemine ilişkin hemşirelik öğrencilerinin görüşleri]. *Journal of Hacettepe University Faculty of Nursing*, 19(1):16-23.

Tüzün, H., Yılmaz-Soylu, M., Karakuş, T., İnal, Y., & Kızılkaya, G. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers & Education*, 52(1):68-77. DOI: https://doi.org/10.1016/j.compedu.2008.06.008

Tsivitanidou, O.E., Georgiou, Y., & Ioannou, A. (2021). A learning experience in inquiry-based physics with immersive virtual reality: Student perceptions and an interaction effect between conceptual gains and attitudinal profiles. *Journal of Science Education and Technology*, 30(1):841–861. DOI: https://doi.org/10.1007/s10956-021-09924-1

Us, F., Aytıs, S. (2009). Importance of perceptor movement in representation of architectural space [Mimari mekanın aktarımında algılayıcı hareketinin önemi]. *Tasarım+Kuram*, 5(7):82-98.DOI: https://doi.org/10.23835/tasarimkuram.240755

Yıldırım, A., & Şimşek, H. (2011). Sosyal bilimlerde nitel araştırma yöntemleri (8. baskı). Ankara: Seçkin Yayıncılık.

Received: 5 December 2023
Revised: 18 December 2023
Accepted: 16 January 2024