PAKAR Pendidikan
p-ISSN: 1693-2226 ; e-ISSN: 2303-2219
Vol. 22, No. 1, January 2024
Hlm. 144-155
http://pakar.pkm.unp.ac.id/

Earth and Solar System Learning Innovation through Virtual Reality (VR) at CoSpace Edu

Inovasi Pembelajaran Bumi dan Tata Surya melalui *Virtual Reality* (VR) di *CoSpace Edu*

https://doi.org/10.24036/pakar.v22i1.525

Muhammad Arif Rahman[1*], Iwan Permana Suwarna[1], Dzikri Rahmat Romadhon[1]
[1] Universitas Islam Negeri Syarif Hidayatullah Jakarta, Jakarta, Indonesia
[*]E-mail: muhammad.arifkun19@mhs.uinjkt.ac.id

Abstract

This research aims to improve junior high school student's understanding of the earth and solar system concept through virtual reality (VR) in CoSpace Edu through a Research and Development (RnD) approach with the 4D model (Define, Design, Develop, Disseminate), the research was conducted in several junior high schools in Depok, involving physics teachers and students in grades 8 and 9. The need for interactive media that can visualize the concept of the solar system and the eclipse phenomenon was observed through preliminary studies in the form of observations and interviews. The development of this VR media begins with a needs analysis, followed by design, product development, and deployment. Data collection instruments include observation, interviews, questionnaires, and tests. Data analysis is based on expert, teacher, and student questionnaires and media effectiveness tests using N-Gain calculations. Based on the N-gain calculation, a score of 0.624 was obtained in the small group and 0.505 in the field test. The results showed that using VR media effectively improves the understanding of the concept of the earth and solar system, contributing to understanding the concept of the earth and solar system.

Keywords: *Virtual Reality*, *CoSpace Edu*, *Earth and Solar System*, *4D.*

Abstrak

Penelitian ini bertujuan meningkatkan pemahaman konsep bumi dan tata surya bagi siswa SMP melalui penggunaan *Virtual Reality* (VR) di *CoSpace Edu*. Metode penelitian *Research and Development* (RnD) dengan model 4D (*Define*, *Design*, *Develop*, *Disseminate*), penelitian dilakukan di beberapa SMP di Depok, melibatkan guru fisika dan siswa kelas 8 dan 9. Kebutuhan akan media interaktif yang dapat memvisualisasikan konsep tata surya dan fenomena gerhana diamati melalui studi pendahuluan berupa observasi dan wawancara. Pengembangan media VR ini dimulai dengan analisis kebutuhan, diikuti oleh perancangan, pengembangan produk, dan penyebarannya. Instrumen pengumpulan data berupa: wawancara, observasi, tes, dan angket. Analisis data didasarkan pada angket penilaian dari ahli, guru, dan siswa, serta uji keefektifan media menggunakan perhitungan N-Gain. Berdasarkan perhitungan N-gain, diperoleh skor 0,624 pada kelompok kecil dan 0,505 pada uji lapangan. Hasil penelitian menunjukkan bahwa penggunaan media VR ini efektif dalam meningkatkan pemahaman konsep bumi dan tata surya, memberikan kontribusi pada pemahaman konsep bumi dan tata surya

Kata Kunci: *Virtual Reality*, *CoSpace Edu*, Bumi dan Tata Surya, 4D

1. Introduction

In the era of modern education, the importance of technology in teaching and learning is becoming increasingly crucial, especially in science learning, which often requires understanding complex and abstract concepts (Emsa & Suherman, 2022). According to Susilawati, the material of the earth and solar system is an abstract subject because in learning it, students must understand the celestial bodies in the solar system whose direct form is not present, thus reducing student involvement (Susilawati et al., 2021). According to Budiman, the impact of these problems causes low motivation to learn and understanding of students to be underachieving in learning. This study focuses on the development of Virtual Reality (VR) as an innovative learning medium for junior high school students on earth and solar system materials. Particularly in some junior high schools in Depok, the lack of interactive learning media for this topic has been identified as a barrier to student understanding.

Based on field studies in several junior high schools in Depok, digital media such as images and videos do not fully visualize phenomena in the solar system's celestial bodies. Interaction between media and users does not exist. Previous research has shown that integrating digital technology in education, namely VR, significantly improves learning (Hendajani et al., 2019; Chandra et al., 2021). According to Susilawati and Darojat, VR can make learning easier. According to Susilawati and Darojat, VR can visualize 3D animations that can be viewed at 360° and interactively when presented with celestial objects. These studies emphasize the importance of innovating learning methods that are more interactive and interesting, which can include the use of innovative digital media, namely VR (Darojat et al., 2022; Susilawati et al., 2021).

Although previous research has shown the effectiveness of using VR earth and solar system, there is still a need for further research on more detailed visualization, dubbing tailored to those using VR, visualization of solar eclipses lunar eclipses, and practice questions in learning earth and solar system material. This research aims to fill the void through the development and evaluation of VR learning media specifically designed for this material. Thus, this research contributes new knowledge in educational technology, especially in using VR for science materials at the junior high school level.

This research is essential because it provides insight into how VR technology can be specifically adapted to enhance the learning of earth and solar system materials. By understanding the impact of this technology on education, we can enrich teaching methods that improve student learning outcomes. In line with Tang's findings (Tang et al., 2020), this research emphasizes the importance of innovation in education and how technologies such as VR can be leveraged to improve traditional learning approaches.

2. Literatur Review

Maritsa conducted the first research on this topic, "The Influence of Technology in Education." This research results in the importance of technological innovation in daily learning activities to attract students' attention. Maritsa found that students tend to be more enthusiastic and engaged when the material is presented through innovative digital media (Maritsa, 2021).

Mulyani conducted the second research on this topic titled "Analysis of the Development of Science and Technology (IPTEK) in Education." The results of her research show that advances in science and technology, especially in education, significantly impact the interaction between teachers and students. Mulyani found that using technology such as VR can make the learning process more exciting and effective (Mulyani, 2021).

P-ISSN: 1693 - 2226
E-ISSN: 2303 - 2219

Darojat conducted the third research on this topic titled "Development of Virtual Reality as a Solar System Learning Media." The results of his research are in the form of learning media products for the earth and solar system, which received a positive response. The disadvantages of this media are dubbing sounds not by VR users, many parts that have nothing to do with the material, and lack of detailed visualization displayed (Darojat et al., 2022).

Susilawati conducted the fourth research on this topic titled "Designing a Virtual Reality (VR) Application of the Solar System as a Science Learning Media." The research results are in the form of VR utilization that attracts student interest and visualizes the material. The disadvantages of this media are that there is no visualization of solar eclipses and lunar eclipses, and there are practice questions for users (Susilawati et al., 2021).

The real difference with the researcher's research is that this research focuses on developing VR learning media for earth and solar system material at the junior high school level. In contrast, the research of Maritsa, Mulyani, Darojat, and Sulilawati is not specific to developing the earth and solar system learning media in junior high school. This shows how this research uniquely contributes to developing interactive and visual learning media designed explicitly for earth and solar system material at the junior high school level.

3. Research Methods

This research adopts the development method using the 4-D model, which consists of four stages: first defining, second designing, third developing, and fourth disseminating (Sutarti & Irawan, 2017). The R&D method was chosen because it allows the development of innovative learning products relevant to students' interests (Sugiyono, 2012). The 4-D model ensures that every aspect of VR learning media development is carried out systematically, from needs identification to product dissemination.

The research was conducted at SMPN 10 Depok, SMPN 14 Depok, and SMP Muhammadiyah Sawangan. The research subjects were science teachers and junior high school students in grades VIII and IX. The research was conducted for 112 days. The instruments used were data collection, including observation, interviews, questionnaires, and test instruments. Observations and interviews were conducted to understand the needs of students. At the same time, questionnaires and tests were used to collect data on the effectiveness of the VR media developed. Data collection instruments are needed to measure the data collected. These research instruments are observation, interviews, questionnaires, and test instruments (Hamzah, 2019). Data were analyzed using equations from validator questionnaires, student questionnaires, teacher questionnaires, and test questions. The questionnaire results were processed with the equation:

$$TCR = \frac{\sum \quad skor\ responden}{\sum \quad skor\ maksimal} \times 100\%$$

The category of respondents' achievement levels from the expert assessment questionnaire can be seen in Table 1.

Table. 1. Categories of Respondent Achievement Rate (TCR) (Sugiyono, 2012).

No	Percentage	Category
1	81,26%-100%	Very good
2	62,51%-81,25%	Good
3	43,76%-62,50%	Fairly Good
4	25,01%-43-75%	Not Good

P-ISSN : 1693-2226
E-ISSN : 2303-2219

The Normalized Gain instrument is used to measure the effectiveness of VR media in improving students' concept mastery. N-Gain is the difference between the initial test score and the final test. The post-test results show increased students' concept mastery after using VR media compared to the pre-test results (Hake, 1998). The N-Gain value can be calculated using the formula:

$$N - GAIN = \frac{skor\ post\ test - skor\ pre\ test}{skor\ ideal - skor\ pre\ test}$$

The calculation of the N-Gain value shows whether there is an increase in student learning outcomes after using the developed media. The N-gain criteria used refer to the criteria described by Hake.

Table. 2. N-Gain Criteria

N- Gain	Criteria
$g \geq 0{,}7$	High
$0{,}7 > g \geq 0{,}3$	Medium
$g < 0{,}3$	Low

4. Results and Discussion

4.1. Research Results

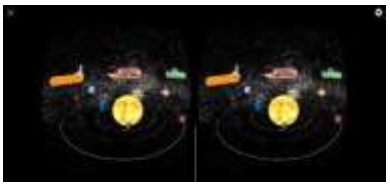
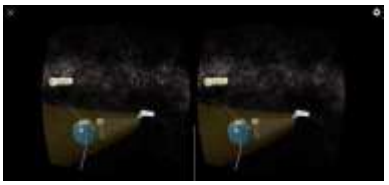
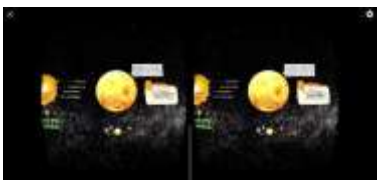
Researchers have developed virtual reality learning media for the earth and solar systems. In the first defining stage, an activity commonly called needs analysis is defined and established. This activity is carried out to analyze development needs for products that meet user needs. Preliminary or literature studies can be used to conduct the analysis. A preliminary study was conducted: observations and interviews at Depok Junior High School. After conducting a preliminary study, it was found that the lack of interactive media that visualize the material of the earth and solar system has an impact on the majority of students not understanding the concept of the solar system, the phenomenon of eclipses or not lunar and solar eclipses. The literature study in Febriyana's research shows that the concept of seventh-grade students is still low; namely, 50% of students have a low level of understanding (Febriyana, 2021).

In the second design stage, a development product is designed to solve the problems found in the defining stage. It involves making a product design that the researcher will develop. Thiagarajan explains that the steps consist of four stages, including, first, designing a test that refers to the benchmark (Constructing criterion-referenced test), selecting media (Media selection) at this stage researchers use the CoSpace Edu application, the third stage of format selection (Format selection) to select the media to be used in organizing formative tests including layout design, This stage simulates the presentation of a media that has been designed and then expert validation in order to test the feasibility of the media developed by researchers (Thiagarajan, 1974).

Figure. 1. Initial Design

The third stage of development aims to improve the virtual reality media before it becomes a usable product. At this stage, data on responses or comments from product users are collected, and the results are used to improve the product. According to Thiagarajan, there are two stages of development: expert appraisal and product testing (Development testing) (Thiagarajan, 1974).

Table. 2. Revision of Media and Material Experts

Revision	Before Revision	After Revision
Addition of instructions for using the media		
Addition of visualization when there is no lunar eclipse		
Equalize rotation and revolution with real ones but with a scale in VR		
Adding narration apart from visuals and audio that is listened to		

Validation of media experts, materials, and teacher response questionnaires are reviewed from several aspects. The analysis results are shown as follows:

P-ISSN : 1693-2226
E-ISSN : 2303-2219

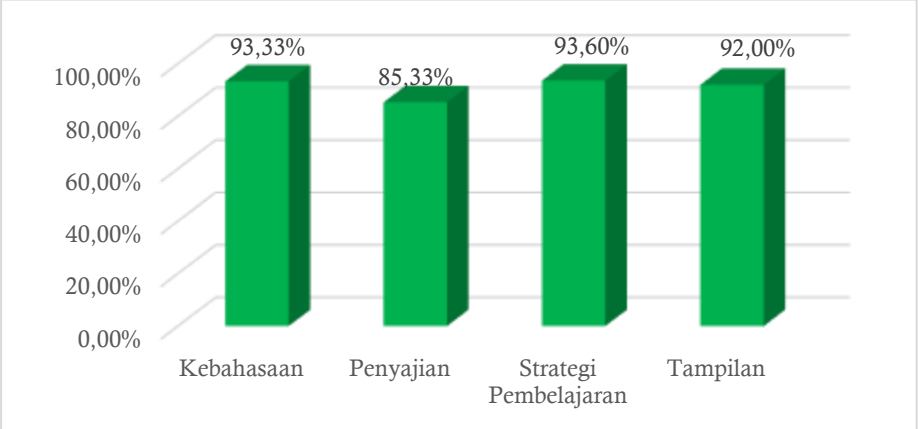


Figure. 2. Graph of Media Expert Validation Results

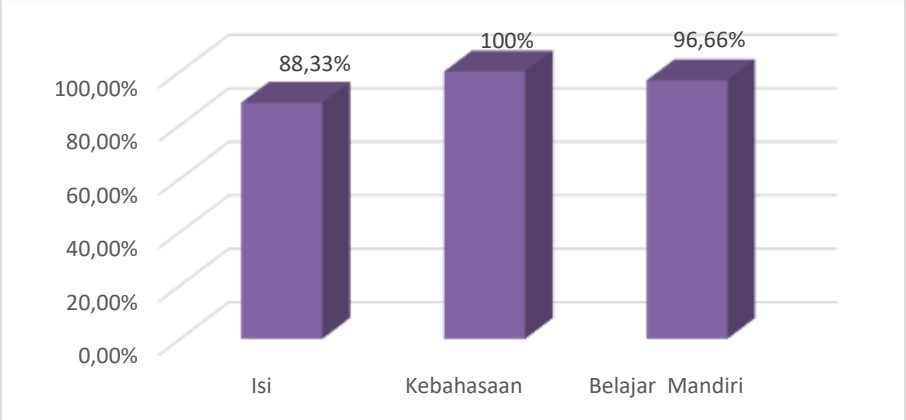


Figure. 3. Graph of Material Expert Validation Results

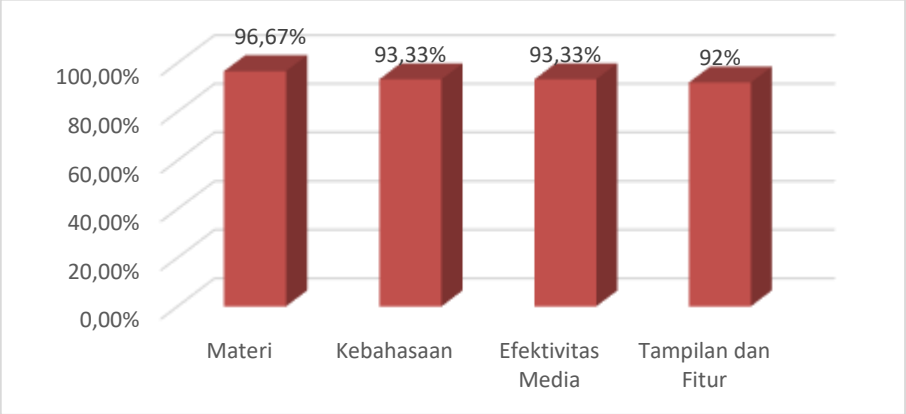


Figure. 4. Graph of Teacher Response Results

Based on the data above, the feasibility and effectiveness of virtual reality-based learning media in the category is very good using a rating scale, as in the following explanation.

Table. 3. Description of Media Expert Validation Results

No	Assessment Criteria Language	Classification			
		Total	Max Value	TCR (%)	Category
1	Presentation	140	150	93.33	Very good
2	Learning Strategy	64	75	85,33	Very good
3	Display	117	125	93.6	Very good
4	Assessment Criteria	207	225	92	Very good
	Total	**528**	**575**	**91.82**	**Very Good**

Table. 4. Description of Material Expert Validation Results

No	Assessment Criteria	Classification			
		Total	Max Value	TCR (%)	Category
1	Content	53	60	88.33	Very good
2	Language	45	45	100	Very good
3	Self-Study	58	60	96.66	Very good
	Total	**156**	**165**	**94.54**	**Very Good**

Table. 5. Description of Teacher Response Results

No	Criteria Assessment	Classification			
		Total	Max Value	TCR (%)	Category
1	Material	29	30	96.67	Very good
2	Language	28	30	93.33	Very good
3	Media Effectiveness	42	45	93.33	Very good
4	Display and Features	69	75	92	Very good
	Total	**168**	**180**	**93.33**	**Very Good**

Then, the product was on junior high school students from three different schools. Where the first trial, namely the one-on-one test, was conducted at SMPN 10 Depok with three respondents, then a small group test stage at SMP Muhammadiyah Sawangan with 12 respondents, then testing in the final stage, namely the field test conducted at SMPN 14 Depok using a student response questionnaire so that the following analysis results were obtained.

P-ISSN : 1693-2226
E-ISSN : 2303-2219

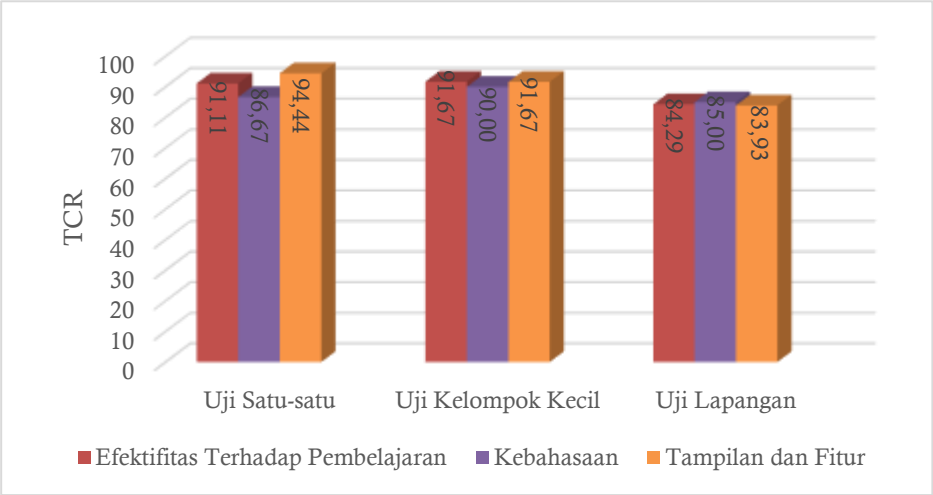


Figure. 5. Graph of Student Response Results

The results of the product testing are as follows.

Table. 6. Description of One-on-One Test Results

No	Criteria Assessment	Classification			
		Total	Max Value	TCR (%)	Category
1	Appearance and Features	85	90	94,44	Very good
2	Language	13	15	86.67	Very good
3	Media Effectiveness for Learning	41	45	91.11	Very good
Total		**125**	**135**	**92.59**	**Very Good**

Table. 7. Description of Small Group Test Results

No	Criteria Assessment	Classification			
		Total	Max Value	TCR (%)	Category
1	Appearance and Features	330	360	91,67	Very good
2	Language	54	60	90	Very good
3	Media Effectiveness for Learning	165	180	91.67	Very good
Total		**490**	**540**	**90.74**	**Very good**

Table 8. Description of Field Test Results

No	Criteria Assessment Appearance and Features	Classification			
		Total	**Max Value**	**TCR** (%)	Category
1	Language	705	840	83,93	Very good
2	Media Effectiveness for Learning	119	140	85	Very good
3	Criteria Assessment	354	420	84,28	Very good
	Total	**1051**	**1260**	**83,41**	**Very Good**

Furthermore, for more clarity, measuring student learning outcomes to determine mastery of the earth and solar system through the results before (pre-test) and after (post-test), pay attention to the analysis of the results in the graph and table.

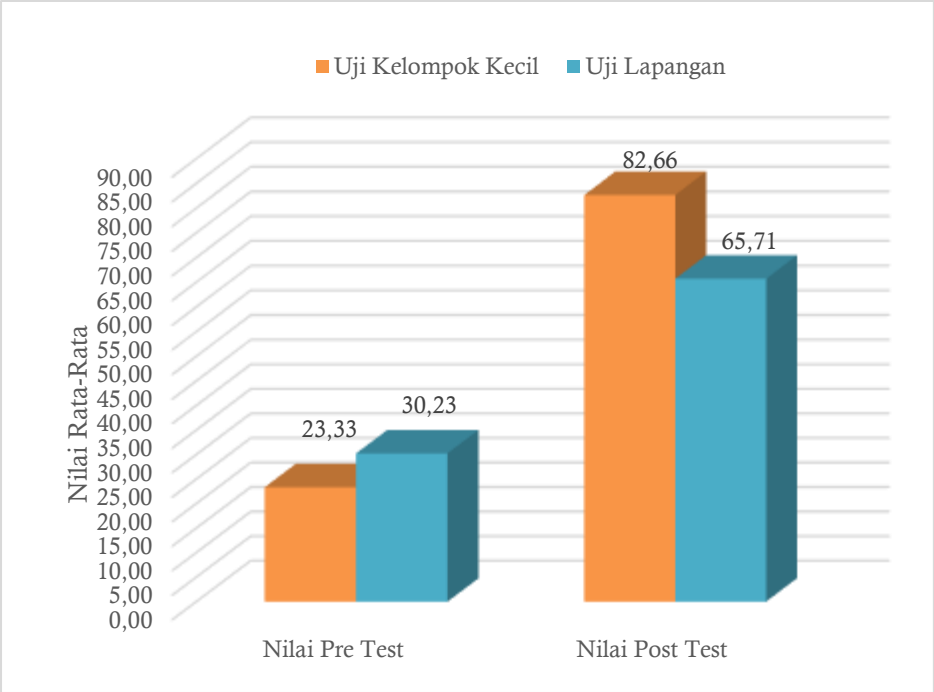


Figure. 6. Graph of Pre-Test and Post-Test Results

Table. 9. Results of Pre-test Post-test Analysis of Small Group Trials

Score	Average	N-Gain	Criteria
Pre-Test	23.33	0.624	Medium
Post Test	82.66		

Table. 10. Results of Pre-test Post-test Analysis of Field Group Trials

Score	Average	N-Gain	Criteria
Pre-Test	30.23	0.505	Medium
Post Test	65.71		

P-ISSN : 1693-2226
E-ISSN : 2303-2219

4.2. Discussion

This research has produced innovation in learning the earth and solar system concepts by developing virtual reality (VR) media, which follows the 4-D model methodology (Thiagarajan et al., 1974). This learning media has been validated and shows high effectiveness, with the percentage of Total Content Validity (TCR) reaching the excellent category. This indicates that the VR media developed meets pedagogical standards for use in educational contexts, as also emphasized by Asdar and Rachmawati regarding the importance of interactive learning media to facilitate understanding of scientific concepts (Asdar et al., 2020; Rachmawati et al., 2020).

The results of significant research findings show that the VR media developed can overcome the lack of interactive media that can visualize the learning of the earth and solar system, which was previously an obstacle to students' understanding of concepts. Muliani said interactive learning with media improved students' attitudes toward understanding concepts in physics (Muliani, 2019). Aini said interactive media significantly improved student understanding (Aini, 2021). Kurniyawan, Wahyuningsih, and Arifin said that using media effectively improved understanding (Kurniyawan, 2019; Wahyuningsih, 2022); Arifin, 2019). The use of CoSpace Edu as a platform was chosen based on its ability to present learning materials in a more interactive and immersive way, supporting Anistyasari and Taufiq's findings on the effectiveness of multimedia tools in learning (Anistyasari, 2022; Taufiq, 2023). This study illustrates how VR technology can support independent learning and enrich students' educational experience, in line with Raja's research (Raja & Priya, 2021). The successful implementation of VR media in this study contributes to the existing literature on interactive learning. It supports the idea that modern educational technology can increase student engagement and understanding of complex subject matter.

The implications of this research are vast. The use of VR media in education can increase student interest and motivation in learning and can be an effective tool in the learning process (Suma, 2022; Dewi, 2020). However, this study has limitations regarding the scope and samples used. The researcher also recommends conducting a longitudinal study to measure the long-term impact of using VR media on knowledge retention.

5. Conclusion

Based on the study results, it can be concluded that the use of Virtual Reality (VR) based learning media using the 4-D model has been validated as feasible. VR in learning significantly improves junior high school students' understanding of the earth and solar system concepts. This conclusion answers the research problem of improving the understanding of complex astronomical concepts through interactive learning media not obtained in other digital media, such as images and videos. This research can answer the shortcomings of previous research, such as the phenomenon of solar eclipses, lunar eclipses, and the non-occurrence of lunar eclipses. Detailed explanations of planets in the solar system have been validated in this research VR application. VR enriches the learning experience and facilitates an in-depth understanding of natural phenomena, which are traditionally difficult to understand through conventional learning. The disadvantage of this learning media on hardware is that the VR Box is expensive; the school in this study does not yet have a VR Box to run VR applications optimally, thus hampering the VR learning process. Suggestions for further research include the development of VR Box hardware that is cheap and easy to make with surrounding items to facilitate schools' optimal use of VR.

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