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Exploring the Impact of Virtual Reality and Learning Styles on Student Outcomes: Insights into Synergistic Effects and Academic Success

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Abstract

This study explored the interactive effect between virtual reality-based learning media and student learning styles on student learning outcomes. Although the use of virtual reality (VR) in education is increasingly widespread, research has yet to thoroughly examine how VR-based learning media interact with students' individual learning styles to influence learning outcomes. VR has demonstrated potential in boosting student engagement and comprehension, especially in subjects rich in content such as learning for type of field of Fact. However, there remains limited understanding of how learners with visual, auditory, and kinesthetic preferences respond uniquely to immersive learning experiences. A quasi-experimental factorial design (2×2) was employed in the study. Participants were divided into two groups that carried out the learning process using VR and video. The results of the study showed that the group learned using VR significantly improved their learning outcomes compared to video. Mixed learning styles students in experiment groups achieved higher average learning outcomes than students with visual or auditory learning styles. Meanwhile, a group of students with auditory learning styles performed better than both visual and mixed learning styles in control group. Furthermore, this research found an interactive effect that significantly affected the connection between instructional media and learning styles in relation to student learning outcomes. As the main purpose of holding why this research was conduct, it is recommended for teachers not to use VR just like that, but must first ensure that students' learning styles are indeed suitable for learning using this media.

Keywords: Instructional Media; Learning Outcomes; Learning Styles; Virtual Reality

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INTRODUCTION

Education was an important aspect of life that played a major role in improving the quality of human resources. One of the cores of education was the learning process, which was designed to help students acquire knowledge and skills (González-pérez & Ramírez-montoya, 2022). During the learning process as a whole, teachers employing a combination of internal and external strategies in a

distinctive manner to enhance students' learning process. Learning was a complex and unique process (Degeng, 2013). It was called complex because, in the learning process, a person involved all aspects of their personality—physical, mental, and emotional. The involvement of all these aspects was reflected through the individual's learning behavior. In addition, learning was also said to be unique because the behaviors that appeared occurred only in certain individuals and were not the same as others. Therefore, everyone showed different learning patterns. In other words, students shaped their cognitive behavior and experiences from pieces of knowledge and then interpreted all new things they got earlier as a complete knowledge they gained (Setyosari et al., 2023).

In connection with the complexity and uniqueness of learning, learning technology emerged to simplify the learning process by providing various learning resources and helping to overcome problems in the learning process. In the learning process, there was communication between teachers and students. The teacher played the role of the sender of information, while the student played the role of receiving the information provided. The communication process conveyed from teachers to students needed to run smoothly to support successful learning. Therefore, tools or media were needed in learning as intermediaries for communication between teachers and students. The word "media" came from Latin, which literally meant intermediary or introduction (Anisaturrahmi, 2021). Learning media is one of the main factors that can affect student learning outcomes, because through the medium learning messages can be conveyed according to the learning objectives (Basuki et al., 2024). Learning media served as tools that helped the teaching and learning process by conveying messages effectively so that it achieved better and more perfect learning outcomes (Hartati, 2023).

The development of learning science and technology brought changes to learning materials. As revealed by Dick and Carey, there were two types of learning materials: written teaching materials and mediated teaching materials—also called printed teaching materials and non-printed teaching materials (Dick & Carey, 1990). In line with this, Reisser and Dempsey revealed that non-printed teaching materials were developed to enrich content, overcome time limitations, and address diverse student learning styles (Reiser & Demsey, 2002). In other words, developers of non-print teaching materials maximized media capabilities by selecting appropriate content for specific media. Additionally, they elaborated on material using simple, communicative language that involved students' thinking processes and allowed them to achieve mastery independently.

Learning resources were designed, selected, and utilized as real products that could interact with learners. With advancements in technology, innovations in virtual reality learning media emerged. Virtual reality was a technology that combined two-dimensional or three-dimensional image objects and projected these virtual objects to resemble real-world environments (Sukmawati et al., 2023). Virtual reality allowed users to experience direct interaction through a simulated virtual environment (Neuburger et al., 2018). The use of virtual reality in education engaged students in the learning process while making them more interested in the material taught. Virtual reality technology helped students enrich their understanding of concepts, strengthen existing knowledge, practice practical skills, and create a more enjoyable learning atmosphere (Begum, 2024). Learning with

virtual reality media provided meaningful experiences and engaged students directly (Muslim et al., 2024).

The strategy for producing individuals capable of thriving in modern times relied on appropriate theoretical foundations that offered learners opportunities for growth. One such strategy involved organizing environments to make learning exciting for learners (Degeng, 1997). Developing interesting teaching materials was one way to inspire learners' passion for studying. Virtual reality had great potential in this regard because it offered both real-world simulations and fictional worlds relevant to educational content (Hustanto et al., 2024). Learning that uses virtual reality media allows for a more meaningful learning experience and engages students directly (Maulana et al., 2024). Research on virtual reality's use in educational media demonstrated significant potential for improving educational effectiveness (Mottelson et al., 2021). Furthermore, studies showed that using virtual reality in history lessons—such as reconstructing Roman cities virtually—significantly enhanced students' learning experiences and academic outcomes (Villena Taranilla et al., 2022).

Despite the growing integration of virtual reality (VR) in education, existing studies had not sufficiently explored the interactive effects between VR-based learning media and students' individual learning styles on learning outcomes. Although VR had shown promise in enhancing engagement and understanding—particularly in content-heavy subjects like Social Studies—little was known about how visual, auditory, and kinesthetic learners responded differently to immersive learning environments. Thus, the application of VR in teaching factual topics remained underexplored. Instructional designs at the time often overlooked the alignment between learner characteristics and media delivery strategies, resulting in a gap in understanding how personalized approaches using VR could have optimized learning effectiveness.

The learning outcomes achieved reflected the success of the educational goals for students who followed the learning process. Learning outcomes could also be interpreted as changes that led a person to change their attitudes and behaviors (Kurniawan, 2022). Learning outcomes included students' abilities after undergoing learning experiences, which encompassed cognitive, affective, and psychomotor aspects (Indrakusuma et al., 2024). These results occurred in individuals who learned, not only as an increase in knowledge but also in skills and appreciation for the material learned (Rahmawati et al., 2024). Learning outcomes included all effects that could be used as indicators to assess the effectiveness of implementing learning strategies in different conditions (Degeng & Degeng, 2018).

Social Science (IPS) subjects had unique and complex characteristics, which included various social science disciplines such as geography, history, sociology, and economics. At the secondary education level, social studies aimed to develop students' understanding of social and cultural phenomena that occurred in society. One of the materials taught in social studies subjects was the Lithic or "Zaman Batu," which was part of human history and contained a lot of factual knowledge. This factual knowledge included concrete information about the tools, culture, and life patterns of the people at that time. Social studies subjects sought to connect theory with social facts so that students not only learned about abstract concepts but also understood the real context around them. Lithic material in social studies

focused on the introduction of historical facts about the development of ancient humans, including the tools used, their way of life, and their interaction with the environment. Learning about the lithic provided students with an in-depth understanding of human evolution and the socio-cultural context of that time (Syafruddin et al., 2024).

In the context of the teaching and learning process, it was essential to recognize that students did not all learn through a one-size-fits-all approach, moreover in a standardized manner. Every each students, not even two, got their inmate characteristics—cognitive, affective, and physiological—significantly impacted their knowledge acquisition and competency development (Molina-Cabello et al., 2023). Various learning methodologies took these specific traits into account to understand why students might have engaged with the same educational materials in different ways. The concept of learning style was based on the idea that students had diverse approaches to receiving and processing knowledge, which aided them in recognizing and integrating information mentally as well as acquiring experiences and skills (Naqeeb & Awad, 2011). The term "learning style" described how a learner organized, processed, represented, and synthesized information, storing it in their cognitive framework and later retrieving it in a manner that reflected their unique communication techniques (El-Sabagh, 2021).

The learning styles described individual characteristics closely associated with learning activities, which served as potential variables influencing the perception of learning spaces. However, this area was confusing and complex regarding how accurately learning styles could be measured and applied, as well as the extent of their impact on learning outcomes (An & Carr, 2017). Although inconsistent opinions limited their use in educational research, learning styles were shown to reflect personality traits, including preferred information processing and decision-making styles, which provided insights or methods for understanding preferences regarding learning environments (Hall & Moseley, 2005). The learning styles motivated better task performance, more efficient learning actions, and higher desires to learn (Wang & Han, 2021).

Individuals with a visual learning style tended to favor learning through illustrations, pictures, maps, and diagrams. Seeing the written word was crucial for their comprehension and retention of new information due to their reliance on visual memory. They also preferred written directions and learned more successfully when studying independently. Individuals who were auditory learners tended to learn more effectively by listening to speeches or others' explanations. They associated ideas with various sounds and usually preferred to study with music in the background. With a heightened auditory memory, they enjoyed group discussions and debates, favored verbal directions for academic tasks, and memorized information well through vocal repetition. Kinesthetic learners thrived in learning activities that allowed them to experiment, apply knowledge, and engage in hands-on tasks. They benefited from touching and participating through movement and manipulation during the learning process. They retained information best through actions, often showing a tendency to fidget with small objects while attending group or studying. Additionally, they had a preference for physical and sports-related activities.

At that time, instructional designers often overlooked the interdependent effects that emerged between learner traits and strategies for delivering subject matter. Consequently, even though they might have taught the students effectively, their methods did not correspond with the underlying structure of the subject. This study was conducted to explore the interactive effects between virtual reality-based learning media and student learning styles on educational learning outcomes. The relationship among these variables, which served as the foundational theory for this research, was illustrated as follows:

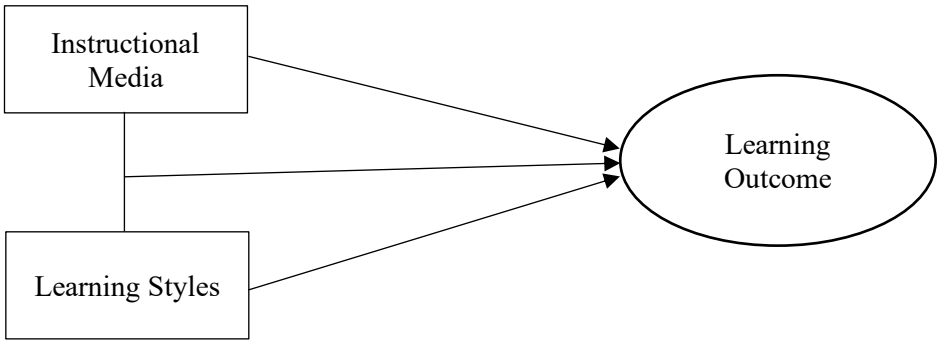

Figure 1. Theoretical Framework

Based on the background of the problem, the research hypotheses were as follows: First, there was a difference in the learning outcomes of students who used virtual reality media and those who used video. Second, there were differences in learning outcomes among groups of students with different learning styles. Third, there was an interaction between virtual reality-based learning media and students' learning styles.

However, this study had certain limitations. It focused solely on the interaction between virtual reality-based learning media and students' learning styles, without taking into account other potentially influential variables such as students' prior knowledge, socio-emotional factors, technological literacy, or the role of teacher facilitation. Additionally, the study was limited in scope to a specific subject area (Social Science, particularly Lithic material) and educational level, which might have restricted the generalizability of the findings to other disciplines or learner populations.

METHODS

A quasi-experiment was conducted in this study to investigate whether introducing a specific element or treatment influenced the students. Given the heterogeneous nature of the existing student population and the lack of formation of new groups, a quasi-experimental approach was deemed appropriate (Gopalan et al., 2020). In this study, 105 students were divided into two groups: a control groups and experiment groups. Each group consisted of 55 students in the control group and 50 students in the experimental group. The subjects were between 12 and 14 years old and were enrolled in history subjects. The treatment was carried out over four meetings, each lasting 90 minutes.

A data summary at the conclusion of the study indicated that not all subjects participated and could be used for data analysis, both in the control and experimental groups. To uphold the internal validity of the experiment's results, data collected from subjects who did not take part in every stage like pre-test nor post-test and learning styles test were excluded from the statistical analysis. A total of 86 subjects qualified for further analysis in each phase of the experiment, including the treatment, post-test, and other variable assessments. All subjects confirmed to the predetermined variable sorting criteria.

Table 1. Research Subjects

Learning Style	Instructional Media		Total
	Videos	Virtual Reality	
Visual	20	21	41
Auditory	9	11	20
Mixed	13	12	25
Total	42	44	86

According to the learning style model, learners were classified into three groups that represented which learning styles they had based on their responses to 36 questions. The questionnaire used in this study consisted of twelve items for each type of learning style. The measurement results obtained from this questionnaire were in the form of scores, with a minimum total of zero and a maximum total of twenty-four for each style type. The highest score among the three tested styles indicated which learning style—visual, auditory, or kinesthetic—was the most dominant trait possessed by the learner. This questionnaire was taken from Bobbi DePorter's learning styles measurement instrument. Students filled in the questionnaire by them self (DePorter et al., 2007).

To maintain the equality of the data obtained during the research, it was found that not all learning styles proposed at the beginning of the research hypothesis were present in sufficient numbers within the subject groups, both in the control group and in the experimental group. The total number of students with a kinesthetic learning style was too small and was considered not to meet the requirements for data analysis. Based on this, to address the lack of research subjects with a kinesthetic learning style, a mixed learning style was created. As for that, students who did have similar score in two of the learning styles, either visual or auditory, were categorized as mixed type. A mixed learning style meant that the research subjects had at least two learning styles score that were close to or equal to each other. These mixed style can be visual with kinesthetic, auditory with visual, etc.

The entire experimental procedure conducted was analyzed at the end of the research using a two-way ANOVA (2x2), which corresponded to the number of variables involved. The use of ANOVA was conducted after first performing a normality test followed by a homogeneity test.

Table 2. Experimental Procedure: posttest only control group design

Group	Treatment	Posttest
K1	X1	O2
K2	X2	O2

RESULTS & DISCUSSION

The results of measuring the variables were organized in a worksheet; Table 3 showed this statistical data. Using a questionnaire to measure students' learning styles, out of 86 students, 41 students had visual learning style tendencies, 20 students had auditory learning style tendencies, and 25 students had mixed learning styles. In this study, each group received different treatments on the same material during the same period.

Table 3. Descriptive Statistic

Group	Learning Styles	N	Mean	Std. Deviation
Control	Visual	20	60.25	16.261
	Auditory	9	67.22	13.489
	Mixed	13	50.38	9.887
Experiment	Visual	21	70.71	10.522
	Auditory	11	73.64	12.667
	Mixed	12	76.25	13.505

Based on Table 3, the descriptive statistics of student learning outcomes across control and experimental groups based on learning styles. In the control group, auditory learners achieved the highest mean score (M = 67.22), followed by visual (M = 60.25) and mixed learners (M = 50.38). In contrast, the experimental group, which used virtual reality-based media, showed higher overall mean scores, with mixed learners scoring the highest (M = 76.25), followed by auditory (M = 73.64) and visual learners (M = 70.71). These results suggest that the use of virtual reality media positively impacted learning outcomes across all learning styles, with the most significant improvement observed among mixed-style learners. Judging from the learning style variables, in the control group that used video media as a medium in the learning process, students with auditory learning style tendencies had the highest average compared to others. However, in the experimental group that used virtual reality media to deliver material, students with mixed learning style tendencies had an average score above other learning styles. To determine all hypothesis answered with an accurate results, the most appropriate parametric test for the data analysis was conducted using the two-way ANOVA. Thus, all the quantitative data that has been successfully collected can be analyzed collectively. The Levene technique was use for the homogeneity test as one of the preliminary requirements before conducting the ANOVA, which was performed to confirm that the data exhibited an acceptable degree of homogeneity, $\alpha = 0.05$, in level of significance.

Table 4. Homogenity Test

Levene Statistic	df1	df2	Sig.
1.212	5	80	.311

Based on Table 4, the calculation of the significance level of data homogeneity between the control and experimental groups showed a value of 0.311. This indicated that the level of data homogeneity was equivalent or homogeneous.

Furthermore, a two-way ANOVA test was applied to examine the effects that emerged among the three previously mentioned variables.

Table 5. Tests of between-subjects effect

Dependent Variable: LearningOutcomes

Source	Sum of Squares	df	Mean Squares	F	Sig.
Corrected Model	6213.525	5	1242.705	7.376	<.001
Group	3972.713	1	3972.731	23.581	<.001
LearningStyle	579.068	2	289.534	1.719	.186
Group*LearningStyle	1291.421	2	645.710	3.833	.026
Error	13477.464	80	168.468		
Total	394175.000	86			
Corrected Total	19690.988	85			

a. R Squared = .316

Based on the analysis presented in Table 5, one null hypothesis (Ho) remained accepted, specifically regarding the influence of learning styles on the learning process. Different learning styles did not cause significant differences in learning outcomes. The other two null hypotheses (Ho) related to the primary effect and interaction of the use of learning media with learning styles were rejected. Using this calculation, it was concluded that learning with virtual reality media and video media had a significantly different effect on learning effectiveness. This also occurred for the interaction between learning media and student learning styles; simultaneously, the learning media and learning styles that students had affected their learning outcomes.

This study was very urgent in providing empirical findings to enhance the quality of learning, particularly in the subject of Social Sciences in secondary education. These findings were crucial for developing theoretical and instructional principles, especially those related to identifying the most effective instructional media to achieve predetermined instructional objectives. Based on the results of the analysis in Table 5, the learning media used significantly affected the learning outcomes of students, as shown by a significant value of 0.001 ($\alpha < 0.05$). These results further emphasized the importance role of well-designed instructional media was able to improve students performance, which implied the need for teachers to carefully consider and select the media to be used in the learning process. In addition, the interaction between learning media and learning styles also had significant results, with a significant value of 0.026 ($\alpha < 0.05$). These findings indicate that both independent variable and the moderator interact in a significant way altogether to contribute to the observed effect, which was learning outcomes. On the other hand, learning style on its own did not show any measurable impact that significantly affecting learning outcomes and did not influence directly in learning, with a significance value of 0.186 ($\alpha > 0.05$). The overall model accounted for 31.6% (R-Squared = 0.316) of the variability in learning outcomes, this indicated that, in addition to the moderator variable mentioned above, there might have been other factors or possibilities that still needed to be investigated in relation to the improvement of learners' learning outcomes. Future research should start including similar variables that were believed to strengthen the interaction between the use of VR as a learning medium and students' learning outcomes.

CONCLUSION

This study investigated the impact of virtual reality (VR) learning media and learning styles on student outcomes. The analysis of the data led to the following conclusions: virtual reality media significantly improved learning outcomes. The experimental group that used virtual reality media demonstrated higher average scores compared to the control group that used traditional video media. Statistical analysis revealed a significant effect, confirming VR's effectiveness in enhancing procedural learning outcomes. While students were categorized into visual, auditory, and mixed learning styles, these classifications did not lead to statistically significant differences in learning outcomes.

This suggested that inherent learning preferences alone did not substantially influence academic performance. The combination of VR technology and learning styles created a synergistic effect. Although learning styles alone were insignificant, their interaction with VR media amplified learning effectiveness. Students with mixed learning styles achieved the highest scores in VR environments.

The model explained 31.6% of outcome variability, indicating that additional factors beyond media and learning styles contributed to academic success. These findings emphasized the importance of strategic media selection to fulfill individual learning styles. Other research shows that that the use of VR can be effective in learning sustainable behavior (Ronaghi, 2023). The use of virtual reality media for learning fact-based subjects is beneficial, but educators still needed to be concerned about the innate characteristics of students' learning styles. Given the demonstrated effectiveness of virtual reality (VR) learning media, future research should prioritize larger, balanced samples for kinesthetic learners. In addition, other moderator variables that may influence student outcomes can also be used, such as learning motivation, achievement motivation, locus of control or self-regulate learning, etc.

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