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The Role of STEAM-Integrated Virtual Reality Media in Improving Cultural and Social Understanding of Elementary School Students

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Abstract: This study aims to analyze the implementation of Virtual Reality (VR) media integrated with the STEAM approach (VR-STEAM) in improving students' learning understanding. Significant research gaps in this study include the limited availability of VR learning media explicitly aimed at improving elementary school students' sociocultural understanding, as well as the suboptimal integration of the STEAM approach in developing VR media oriented toward sociocultural learning. This study used a quantitative approach with a quasi-experimental design. Data collection techniques were carried out through pre-test and post-tests as well as observations, which involved an experimental group and a control group. Participants were fifth-grade students who were selected through simple random sampling. A total of 18 students participated, with 9 students in the experimental group (A) and 9 students in the control group (B). Group A receiving learning through VR-STEAM, while Group B learned by using conventional methods. The results indicate that the use of VR-STEAM can improved student engagement, clarify socio-cultural concepts through immersive visualizations, and encourage collaborative and creative skills through STEAM-based projects. Students appeared more focused, engaged in discussions, and enthusiastic about completing group assignments after experiencing learning through VR. This study concludes that structured VR-STEAM integration not only strengthens cognitive understanding but also creates a more contextual and reflective social learning experience..

Keywords: elementary school; immersive technology; socio-cultural; STEAM; virtual reality

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Introduction

Socio-cultural learning at the elementary school level plays a fundamental role in fostering students' character development, cultural awareness, and understanding of diversity. In contemporary society, where social interactions are increasingly complex and multicultural, students are expected not only to acquire factual knowledge about cultural traditions and social practices but also to internalize values such as tolerance, empathy, respect, and social responsibility through meaningful learning experiences (Sapolsky, 2017). However, classroom implementation often remains dominated by conventional instructional approaches, including textbook-centered learning and one-way lectures, which provide limited opportunities for students to actively explore social realities and cultural contexts. Such approaches tend to encourage memorization rather than meaningful understanding, making abstract socio-cultural concepts difficult for students to visualize and relate to their daily lives. As a consequence, students frequently demonstrate low engagement and superficial understanding of cultural content. Previous studies have shown that integrating social and cultural values into learning can improve students' participation, contextual understanding, and appreciation of cultural identity (Amalia & Wuryandani, 2020; Alwi et al., 2024; Hanik et al., 2025; Prihatiningsih et al., 2025). These findings suggest the need for more innovative learning approaches capable of presenting socio-cultural phenomena in authentic and meaningful ways.

Recent educational literature highlights the importance of immersive learning environments in overcoming the limitations of traditional classroom instruction, particularly when students are required to learn about social and cultural contexts that are geographically or temporally distant from their direct experiences. One technology that has gained considerable attention in this regard is Virtual Reality (VR), which enables users

to interact within three-dimensional environments that closely simulate real-world conditions. VR is recognized for its ability to enhance learners' sense of presence, engagement, and immersion during learning activities (Puspitasari et al., 2026; Potkonjak et al., 2016). Studies have demonstrated that VR-based learning media can increase student involvement and improve learning outcomes by providing interactive experiences that are difficult to achieve through conventional methods (Nasrullah et al., 2025; Widyaningrum & Yulianto, 2025). Through immersive simulations, students can virtually visit social environments, cultural heritage sites, and community settings without leaving the classroom. Furthermore, Zhao et al. (2025) found that VR has the potential to improve student motivation and conceptual understanding, while Nugraini and Abduh (2025) reported that VR promotes active engagement and deeper understanding of learning materials. These findings indicate that VR offers substantial opportunities for creating more engaging and meaningful learning experiences in elementary education.

The educational benefits of VR have also been supported by studies conducted across various learning contexts. A qualitative study by Laine et al. (2023) and Nugraini & Abduh (2025) revealed that immersive VR (I-VR) enhances students' physical, cognitive, and emotional engagement during learning activities. Similarly, Iasha et al. (2023) demonstrated that VR-based field trips improved students' cultural literacy, interest, and learning satisfaction, while Zhang et al. (2024) emphasized the effectiveness of VR in enabling virtual visits to cultural sites. Beyond socio-cultural learning, VR has shown significant contributions to cognitive development and STEM education. Jiang et al. (2025) reported that VR technology provides meaningful benefits for K–12 STEM learning, while Jannah et al. (2025) found that inquiry-based STEAM digital modules positively influence students' independent learning. From a socio-cultural perspective, Muali and Setiawan (2025) further demonstrated that integrating AR/VR with inquiry-based learning enhances students' digital empathy and social understanding. Likewise, Adiputra et al. (2024) showed that VR learning grounded in local wisdom improves students' interest and understanding of social studies content. Collectively, these studies indicate that VR can facilitate contextual, immersive, and meaningful learning experiences that support the development of cognitive, affective, and social competencies.

Despite these promising findings, existing research reveals several limitations that warrant further investigation. First, many VR applications in elementary education remain focused on visualization and demonstration, allowing students to observe virtual environments without being systematically guided to analyze, evaluate, and reflect on their experiences. Second, most studies have examined VR implementation in science, STEM, or general learning motivation contexts, whereas its application in socio-cultural learning remains relatively underexplored. Third, previous studies have frequently investigated VR and pedagogical approaches such as inquiry learning, STEAM, and Project-Based Learning (PjBL) separately, rather than integrating them into a coherent instructional framework (Hu & Ng, 2025; Supianti et al., 2025). Consequently, there is limited empirical evidence regarding how immersive technology can be combined with interdisciplinary learning approaches to promote deeper socio-cultural understanding among elementary school students. This gap is particularly important because meaningful cultural learning requires not only exposure to cultural content but also opportunities for critical reflection, creativity, collaboration, and contextual problem-solving.

Addressing these gaps, the present study proposes a novel integration of Virtual Reality and the STEAM approach (VR-STEAM) within elementary socio-cultural learning. Unlike previous studies that primarily employed VR as a visualization tool, this research positions VR as an immersive learning environment that supports inquiry, reflection, collaboration, and critical thinking through interdisciplinary STEAM-based activities. The novelty of this study lies in the systematic integration of VR technology with STEAM principles to facilitate cultural literacy and socio-cultural understanding in elementary classrooms. This approach is expected to encourage students not only to explore cultural environments virtually but also to construct knowledge, solve contextual problems, and reflect on social values through meaningful learning experiences. While previous research has shown that technology integration can increase student motivation and support deeper exploration of social concepts (Utari et al., 2025), and that STEAM combined with VR can improve practical skills and scientific literacy (Bai et al., 2020), empirical studies examining this integration in socio-cultural learning remain scarce. Therefore, this study aims to analyze the implementation of VR media integrated with the STEAM approach (VR-STEAM) in improving elementary school students' understanding of socio-cultural concepts. The findings are expected to contribute both theoretically and practically to the development of contextual, technology-enhanced learning models that support cultural literacy, social understanding, and twenty-first-century competencies among elementary school learners.

Methods

This study used a quantitative approach with a quasi-experimental design (Creswell, 2009), applying an experimental research method. A random sampling technique was employed. Therefore, the sample consisted

of fifth-grade students at Sunia Baru 1 elementary school, Banjaran District, with a population of 18 students. The fifth-grade students were divided into two groups: Group A, consisting of 9 students, and Group B, consisting of 9 students. Group A served as the control group, receiving no treatment, and Group B, the experimental group, received treatment using VR video with STEAM. This study employed a multiple-choice data collection technique, consisting of a pretest and posttest. This allows for more accurate results, allowing for the platform's effectiveness. The use of VR video aims to enhance students' cultural and social understanding in elementary schools. A non-equivalent control group design was implemented in this study, comparing two non-randomly selected groups through pre-test and post-test measurements. This design was chosen because the study was conducted in a predetermined classroom environment, which did not allow for full randomization of subjects.

The research was conducted through four main stages: preparation, implementation, data analysis, and reporting. During the preparation stage, the researchers developed the research proposal, which included identifying the research objectives, formulating the research design, and determining the procedures for data collection and analysis. Subsequently, research instruments consisting of learning outcome tests and learning motivation questionnaires were developed to measure students' achievement and perceptions toward the learning process. To ensure the quality and appropriateness of the instruments, an expert validation process was conducted prior to their use in the study. This validation stage aimed to assess the content relevance, clarity of items, and suitability of the instruments with the research objectives. Feedback obtained from experts was used to revise and refine the instruments, ensuring that they were valid and reliable for data collection.

The implementation stage began with the administration of a pretest to determine students' initial understanding before the learning intervention. Subsequently, the experimental group participated in VR-based STEAM learning activities, while the comparison group received instruction through conventional learning methods. Following the completion of the instructional sessions, a posttest was administered to evaluate changes in students' learning outcomes. In addition, learning motivation questionnaires were distributed to gather students' perceptions and responses toward the learning experiences. The collected data were then analyzed through the calculation of N-Gain scores to determine the effectiveness of the intervention in improving students' understanding. Questionnaire data were analyzed descriptively to identify students' motivation levels and attitudes toward the implemented learning approach. Finally, the findings from both quantitative and questionnaire analyses were compiled, interpreted, and presented in the research report to provide comprehensive conclusions regarding the effectiveness of the VR-based STEAM learning intervention.

The research employed a social and cultural understanding test. The test instrument was designed to measure elementary school students' understanding of social and cultural concepts, including their ability to recognize cultural diversity, interpret social interactions, understand cultural values, and relate these concepts to everyday life situations. Meanwhile, the questionnaire was used to assess students' motivation and responses toward the implemented learning approach. Prior to data collection, all instruments underwent a validation process involving three experts in the fields of content, media, and language. The content expert evaluated the alignment of the test items with the learning objectives and socio-cultural concepts being assessed, while the media expert examined the presentation, layout, and usability aspects of the instruments. The language expert reviewed the clarity, readability, and age appropriateness of the wording to ensure that the items could be easily understood by elementary school students. Following expert validation, the test instrument was subjected to reliability analysis. The results yielded a Cronbach's Alpha coefficient of 0.439 for the 18-item test, indicating a low level of internal consistency because the value was below the recommended threshold of 0.60. This finding suggests that the instrument required further refinement to improve its consistency in measuring students' social and cultural understanding. Therefore, revisions were made based on expert feedback and reliability results before the instrument was administered in the main study.

The collected data were analyzed using a series of statistical procedures to determine the effectiveness of the learning intervention. Initially, prerequisite tests were conducted on the students' test scores to ensure that the data met the assumptions required for parametric analysis. The normality test was performed to examine whether the distribution of the data approximated a normal distribution, while the homogeneity test was used to determine whether the variances of the experimental and control groups were statistically equivalent. After the data were confirmed to be normally distributed and homogeneous, an independent samples t-test was conducted to compare the mean scores of the two groups and identify any significant differences in students' social and cultural understanding following the learning intervention. The results of the t-test were used to determine whether the implementation of the VR-based STEAM learning approach produced a statistically significant improvement compared with conventional learning methods. All statistical analyses were conducted at a significance level of 0.05.

Result and Discussion

Prior to hypothesis testing, prerequisite analyses were conducted to ensure that the data met the assumptions required for parametric statistical procedures. The normality test using the Shapiro–Wilk statistic indicated that all pretest and posttest scores in both the control and experimental groups were normally distributed, as evidenced by significance values greater than 0.05. Specifically, the control group obtained significance values of 0.317 for the pretest and 0.284 for the posttest, while the experimental group obtained significance values of 0.129 and 0.176 for the pretest and posttest, respectively. In addition, the homogeneity test yielded a significance value of 0.218, which exceeded the threshold of 0.05. This result indicates that the variances of the two groups were homogeneous and comparable, thereby satisfying the assumptions required for further parametric analysis.

Since both the normality and homogeneity assumptions were fulfilled, an independent samples t-test was conducted to examine differences in learning outcomes between the experimental and control groups. The analysis produced a significance value of 0.032, which was lower than the predetermined significance level of 0.05 (**Table 1**). This finding demonstrates the existence of a statistically significant difference in cultural and social understanding between students who participated in STEAM-based Virtual Reality learning and those who received conventional instruction. The superior performance of the experimental group suggests that the integration of Virtual Reality within a STEAM learning framework provided a more engaging and meaningful learning experience, enabling students to develop a deeper understanding of social and cultural concepts. Therefore, it can be concluded that the implementation of STEAM-based Virtual Reality media had a significant positive effect on improving elementary school students' cultural and social understanding.

Table 1. Statistic of Students Results

Statistical Test	Group/Data	Sig. Value
Normality Test (Shapiro–Wilk)	Control Pretest	0.317
	Control Posttest	0.284
	Experimental Pretest	0.129
	Experimental Posttest	0.176
Homogeneity Test	Pretest–Posttest Scores	0.218
Independent Samples t-Test	Experimental vs. Control	0.032

The study results show that Virtual Reality (VR)-based learning media combined with the STEAM approach proved effective in improving students' understanding of socio-cultural material. This is evident in the difference in learning outcomes between the experimental and control groups, where the group using VR-STEAM media achieved superior performance. These findings indicate that immersive technology can be a solution to address the challenges of abstract and less engaging learning for elementary school students (Radianti et al., 2020; Suh & Prophet, 2018). Digital technology-based learning media plays a crucial role in increasing the effectiveness and efficiency of the learning process. The use of VR allows students to gain more realistic learning experiences through visualizations that approximate real-world conditions. This opinion aligns with Pellas et al. (2021), who stated that immersive technology in education can increase student engagement and critical thinking skills through more interactive and collaborative learning experiences. Furthermore, STEAM-based VR also encourages student-centered learning. In the process, students not only receive information but also engage in exploration, observation, and analysis. The STEAM approach facilitates the integration of various disciplines, which can develop higher-order thinking skills such as critical and creative thinking (Günther-Hanssen et al., 2026; Nurramadhani et al, 2024; Apriliana et al., 2018).

Inquiry STEAM as a learning method allows students to actively participate in the learning process. According to Pramitasari et al. (2024), this approach helps develop critical and creative thinking skills through exploratory activities. The integration of VR into Inquiry STEAM allows students to experience social and cultural situations firsthand, thereby strengthening their understanding. The findings of this study also align with previous research showing that the use of technology in learning can increase student engagement and learning outcomes. Interactive learning media can create a more dynamic learning environment and encourage active student participation in the learning process. Thus, the integration of technology such as VR in learning is a relevant alternative to meet the demands of 21st-century education (Lytvynova et al., 2026; Rivas et al., 2020). The use of VR in sociocultural learning also helps students understand concepts that were previously difficult to visualize, such as cultural diversity, social interactions, and community life. With engaging and interactive visual displays, students can directly observe the learning objects, resulting in deeper and more meaningful understanding.

The findings of this study are also consistent with previous research indicating that the use of technology in learning can enhance student engagement and learning outcomes. Students who learn using interactive media tend to have higher levels of participation compared to students who learn using conventional methods. This has a positive impact on improving learning outcomes. However, the implementation of STEAM-based Virtual Reality media faces several challenges. As noted by Muvid et al. (2024) successful digital transformation requires not only advanced tools but also equitable infrastructure and enhanced digital literacy among educators to ensure technology effectively fosters knowledge democratization. Makransky & Petersen (2021) explaining that VR implementation requires adequate technological support, appropriate learning design, and teacher preparedness. Implementing virtual reality (VR)-based learning requires adequate technological support to optimize the immersive experience. Successful VR use also relies heavily on appropriate learning design, ensuring the technology serves not only as a visual medium but also effectively supports the achievement of learning objectives. Furthermore, user readiness, both teachers and students, is a crucial factor in determining learning success.

Despite its positive outcomes, this study encountered several limitations that should be considered when interpreting the findings. One of the primary challenges was the availability and accessibility of VR devices and supporting technological infrastructure, which may limit the scalability of implementation across different school contexts. In addition, some students required additional guidance and adaptation time to become familiar with the VR environment and navigate the learning activities effectively. The study was also conducted within a limited sample and instructional period, which may restrict the generalizability of the findings (Kamper, 2020; Schreier, 2018) to broader educational settings. Furthermore, the research focused primarily on students' cultural and social understanding, without examining the long-term impact of STEAM-based VR learning on other competencies such as critical thinking, empathy, collaboration, or cultural literacy. Future studies are therefore recommended to involve larger and more diverse participant groups, extend the duration of implementation, and investigate additional learning outcomes to provide a more comprehensive understanding of the effectiveness of STEAM-based Virtual Reality learning in elementary education.

This study have important implications for both educational practice and future learning innovation. The results demonstrate that STEAM-based Virtual Reality media can serve as an effective instructional tool for enhancing elementary school students' cultural and social understanding by providing immersive, interactive, and contextual learning experiences. Unlike conventional learning approaches that often rely on verbal explanations and textbook materials, VR-supported learning enables students to directly explore socio-cultural environments in a virtual setting, thereby facilitating deeper conceptual understanding and meaningful knowledge construction. Furthermore, the integration of STEAM principles encourages students to develop critical thinking, creativity, collaboration, and problem-solving skills while engaging with cultural and social issues. These findings support previous research emphasizing the educational potential of immersive technologies in fostering student engagement and learning outcomes (Radianti et al., 2020; Suh & Prophet, 2018). Therefore, educational stakeholders, including teachers, curriculum developers, and policymakers, should consider integrating STEAM-based VR learning into elementary education as part of broader efforts to promote innovative and technology-enhanced learning environments that are aligned with the demands of twenty-first-century education.

Conclusion

This study shows that the integration of STEAM-based VR media in cultural and social learning in elementary schools has a positive impact on students' cognitive understanding and learning attitudes. The use of VR not only increases attention and motivation but also helps students understand socio-cultural concepts more concretely through immersive visual experiences followed by STEAM-based collaborative projects. Structured teacher strategies including the formation of heterogeneous groups, discussion management, and reinforcement through creative projects are key factors in successful implementation. Going forward, strengthening pedagogical training for teachers and developing a more adaptive VR-STEAM implementation model are needed so that they can be applied sustainably across various material contexts and educational levels. Based on the findings of this study, several recommendations can be put forward to support the optimization of the implementation of STEAM-based VR media in socio-cultural learning in elementary schools. For instance, teacher competency development is needed through ongoing training that focuses not only on the technical use of VR technology but also on its pedagogical integration within the STEAM approach. Future study are recommended by the development of a more adaptive and flexible VR-STEAM implementation model for various content contexts and educational levels is needed. Longitudinal research is also important to examine the long-term impact on the development of cultural literacy, learning motivation, and student character.

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