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EMERGING EDTECH MEDIA IMPACT: ENHANCING SCIENCE LEARNING ENGAGEMENT IN JUNIOR HIGH SCHOOL

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Abstract

This study aims to analyze the impact of Emerging Educational Technology (Emerging EdTech) media on student engagement in science learning at junior secondary schools located in the rural–urban transitional area of Kubu Raya Regency. The study employed a quantitative approach using a quasi-experimental design with a nonequivalent control group design. The sample consisted of 205 seventh-grade students divided into an experimental group (utilizing Emerging EdTech media) and a control group (utilizing H5P interactive video). Student engagement data were collected through a questionnaire based on Keller's ARCS motivational model and behavioral observation sheets. The results indicated that the mean engagement score of students in the experimental group reached 3.26, which was higher than that of the control group at 2.98. The Independent Samples T-Test yielded a significance value of 0.000 ($\rho < 0.05$), indicating a statistically significant difference between the two groups. These findings suggest that the integration of Emerging EdTech media can influence student engagement in science learning. The study recommends the provision of immersive technology-based digital hands-on experiences as a strategic approach to transforming science education in secondary schools.

Keywords: Emerging EdTech, student engagement, immersive technology, science learning.

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INTRODUCTION

Science education at the Junior High School level should ideally facilitate students in understanding abstract concepts through concrete and interactive learning experiences. However, the primary challenge in science learning often stems from difficulties in visualizing subject matter that is not easily comprehensible through conventional instructional approaches. This perspective aligns with that of Ayuningtias et al. (2018) who emphasize that virtual laboratory multimedia plays a pivotal role in transforming abstract scientific phenomena into more tangible and meaningful learning experiences. In developing regions or rural–urban transitional zones such as Kabupaten Kubu Raya, this challenge is further exacerbated by limitations in digital infrastructure. The adoption of educational technology in Indonesia continues to encounter significant obstacles, particularly in terms of device readiness and teachers' digital literacy (Surani, 2019). Therefore, the integration of Emerging EdTech should not be regarded merely as an innovation, but rather as an urgent necessity to establish an inclusive learning ecosystem capable of transcending geographical constraints.

In today's digital era, student engagement has become a crucial indicator of success in science learning. The ideal condition is the creation of a learning environment that does not merely provide one-way information but is also capable of stimulating students' cognitive, emotional, and behavioral aspects through the utilization of cutting-edge educational technology. The use of innovative learning media, such as Emerging Educational Technology (EdTech), which includes Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence, promises a major transformation in visualizing complex scientific phenomena, such as the solar system, making them more tangible and accessible. This is in line with the increasingly massive and sophisticated development of AR technology, including hardware such as more sophisticated sensors, cameras, and the cloud, which have enabled increasingly realistic and interactive AR experiences (Rohmah et al., 2025).

However, the reality on the ground shows a significant gap. Science learning in many secondary schools is still dominated by conventional methods and the use of static media, which results in low student enthusiasm. Literature studies indicate that a lack of student engagement is often caused by the difficulty of visualizing abstract science material (Yunita & Irawan, 2025). In developing regions such as Kubu Raya Regency, this challenge is even more evident due to limited access to immersive digital learning tools. Although interactive videos have begun to be used, the resulting level of engagement often remains at a passive level, where students are merely spectators without deep interaction. This gap creates an urgency to introduce media capable of providing hands-on digital experiences to enhance holistic student engagement.

Previous research confirms that immersive technology holds great potential for increasing motivation and active participation (Sviridova et al., 2023). VR and AR-based media allow students to conduct independent exploration within safe and controlled simulated environments. Keller's ARCS framework (Attention, Relevance, Confidence, Satisfaction) has proven effective in analyzing how technological elements can capture student attention and provide profound learning satisfaction (Keller, 1985). However, research regarding the specific impact of Emerging EdTech on student engagement in science subjects within schools characterized by rural-urban transition areas is still very limited.

This study offers novelty through the integration of various Emerging EdTech tools, not limited to a single medium, but rather a digital ecosystem encompassing VR, AR, and other interactive elements specifically adapted for the Junior High School science curriculum. The innovative value of this research lies in the "Immersive Exploration" approach, where students do not simply receive information but "enter" the learning objects (such as planets and atoms). Unlike previous studies that focused on cognitive learning outcomes, this study evaluates student engagement in-depth as a multidimensional variable influenced by future technologies.

Based on these issues, this study aims to analyze the use of Emerging EdTech media in enhancing student engagement in Junior High School science subjects. Specifically, this research will compare the effectiveness of such immersive media with standard digital media to provide practical recommendations for the digital transformation of education in secondary schools.

METHOD

This study employs a quantitative approach with a quasi-experimental design, specifically utilizing the Nonequivalent Control Group Design (Cook, T. D., & Campbell, 1979). The research subjects were divided into two groups: an experimental class treated with Emerging EdTech media and a control class utilizing interactive video media (H5P). The population for this study comprises all seventh-grade students at junior high schools (SMP) in Kubu Raya Regency during the odd semester of the 2024/2025 academic year. The sample was selected through purposive sampling, based on considerations of equivalent academic ability characteristics. The determined sample included (1) each school has a computer or laptop with a Windows 10 or Windows 11 operating system and an internet connection speed of at least 50 Mbps, (2) computer devices in schools can access emerging edtech media through spatial.io smoothly, (3) students have equivalent academic ability characteristics. Based on the eligibility criteria and observations, the sample for this study consisted of four schools: SMP Negeri 1 Sungai Raya, SMP Negeri 2 Sungai Raya, SMP Negeri 3 Sungai Kakap, and SMP Negeri 3 Sungai Ambawang. The sample consisted of eight classes, one control class and one experimental class at each school. The total sample size was 205 students. The distribution of the research sample is presented in Table 1.

Table 1. Research Sample

Class	Experimental Class (Emerging Edtech Media)	Control Class (H5P Video Media)
SMP Negeri 1 Sungai Raya	26	27
SMP Negeri 2 Sungai Raya	26	21
SMP Negeri 3 Sungai Ambawang	21	29
SMP Negeri 3 Sungai Kakap	28	27
Total	101	104

Data on student engagement were collected through two primary techniques: questionnaires and student observations. The engagement questionnaire focuses on student motivation, adapting Keller's ARCS model (Attention, Relevance, Confidence, and Satisfaction) (Keller, 1985). This instrument consists of 12 items measured on a four-point Likert scale (1–4). Furthermore, observation sheets were employed to record students' active behaviors during the instructional process.

The next step was to test the instrument's validity and reliability. Content validity testing was conducted on the questionnaire and observation sheets, involving expert validators (expert judgment). The analysis technique used was Aiken's V formula, which measures the level of expert agreement on the relevance of each instrument item (Aikenhead & Ogawa, 1995). Before the instrument was used, a content validity test was conducted using (Lawshe, 1975) content validity ratio by two expert judges. The results of the content validation test for the observation sheet are presented in Table 2.

Table 2. Validation Results of the Observation Sheet Contents

Items	Expert s		s_1	s_2	$\sum s$	n(c-1)	CVR	Results
	1	2						
Item 01	4	4	3	3	6	6	1	High
Item 02	4	4	3	3	6	6	1	High
Item 03	4	4	3	3	6	6	1	High
Item 04	3	4	2	3	5	6	0,833	High
Item 05	3	4	2	3	5	6	0,833	High
Item 06	4	4	3	3	6	6	1	High
Item 07	4	3	3	2	5	6	0,833	High

Items	Expert s		s_1	s_2	$\sum s$	n(c-1)	CVR	Results
	1	2						
Item 08	3	4	2	3	5	6	0,833	High
Item 09	3	4	2	3	5	6	0,833	High
Item 10	4	4	3	3	6	6	1	High
Item 11	4	3	3	2	5	6	0,833	High
Item 12	4	3	3	2	5	6	0,833	High

Based on the results of Aiken's V validation, the 12 statement items on the observation sheet yielded a CVR value greater than 0 (meeting Lawshe's standard for two experts); therefore, these 12 items were deemed valid and suitable for use. The results of the content validation for the questionnaire instrument are presented in Table 3.

Table 3. Validation Results of the Questionnaire

Item	Experts		s_1	s_2	$\sum s$	N(c-1)	CVR	Results
	1	2						
Item 01	4	4	3	3	6	6	1	High
Item 02	4	4	3	3	6	6	1	High
Item 03	4	4	3	3	6	6	1	High
Item 04	4	3	3	2	5	6	0,833	High
Item 05	3	4	2	3	5	6	0,833	High
Item 06	4	3	3	2	5	6	0,833	High
Item 07	4	3	3	2	5	6	0,833	High
Item 08	3	4	2	3	5	6	0,833	High
Item 09	3	4	2	3	5	6	0,833	High
Item 10	4	3	3	2	5	6	0,833	High
Item 11	4	3	3	2	5	6	0,833	High
Item 12	4	3	3	2	5	6	0,833	High
Item 13	4	3	3	2	5	6	0,833	High

Based on the results of Aiken's V validation, 13 questionnaire items showed a CVR value greater than 0 (meeting Lawshe's standard for two experts); therefore, these 13 items were deemed valid and suitable for use. Next, the content-valid items were piloted on 20 respondents to test the instrument's reliability. Data processing was performed using the Cronbach's Alpha formula. The analysis results showed a Cronbach's Alpha coefficient of 0.875. Because the α value was >0.60, this research instrument is categorized as having very high reliability, making it highly suitable for use.

RESULTS AND DISCUSSION

The implementation of emerging educational technology (EdTech) media to enhance engagement in science learning was conducted at SMP Negeri 1 Sungai Raya, SMP Negeri 2 Sungai Raya, SMP Negeri 3 Sungai Ambawang, and SMP Negeri 3 Sungai Kakap. This study employed a quasi-experimental design, utilizing one experimental class and one control class at each school.

The experimental groups were treated with emerging EdTech media, whereas the control groups utilized H5P-assisted video media. The Emerging EdTech media employed in this study is an immersive learning medium supported by advanced technologies, including Virtual Reality (VR) and Augmented Reality (AR), which enable students to engage in highly realistic virtual learning environments. The instructional content focuses on the Solar System topic for seventh-grade junior high school students. The learning scenario is designed as an astronaut mission in which students explore a virtual representation of the Solar System. The virtual environment encompasses learning materials on the inner planets, outer planets, and other celestial bodies, providing an interactive and immersive learning experience. The emerging educational technology (EdTech) media employed in this study consisted of a virtual reality (VR) learning environment supported by the Spatial.io platform. The use of Spatial.io requires hardware specifications that include a computer or laptop running the Windows 10 or Windows 11 operating system, an internet connection with a minimum speed of 50 Mbps, and a VR headset, if available. The implementation of the emerging EdTech media was conducted through collaborative group activities after ensuring that all students had read the user guide for the emerging EdTech media. Each group was provided with one device to participate in the learning activities by completing a series of solar system exploration missions. The H5P interactive video used in the control group was developed using the H5P platform (https://h5p.org/). The H5P video could be accessed through a desktop computer, laptop, or smartphone. During the implementation of the learning activities, each group was provided with one device to access and use the H5P interactive video.

Student engagement was assessed using two distinct instruments: observation sheets and questionnaires. Data from the observation sheets were recorded using a four-point Likert scale (1–4). The results of the observations are presented in Table 4.

Table 4. Average Score of Observation Result

Class	Average Score of Observation Result
Experimental Class (Emerging Edtech Media)	3,26
Control Class (H5P Video Media)	2,98

The pre-treatment and post-treatment student engagement questionnaire scores are presented in Table 5.

Table 5. Student Engagement Questionnaire Results

Class	Average Score Before Treatment	Average Score After Treatment
Experimental Class (Emerging Edtech Media)	53	54
Control Class (H5P Video Media)	50,6	51,18

The student engagement data obtained were subsequently subjected to prerequisite testing as follows.

Normality Test

Prior to conducting hypothesis testing, a normality test is required. The purpose of this test is to determine whether the distribution of data for each variable is normal. The normality test was specifically applied to identify the distribution of post-test data in both the control and experimental groups. To assess whether the data were normally distributed, the Kolmogorov-Smirnov technique was employed, utilizing SPSS for Windows version 22.0, with the results presented in Table 6.

Table 6. Normality Test Results

Class	Test Type	P (0,05)	Conclusion
Experimental Class	Kolmogorov Smirnov	0,062	The data are normally distributed
Control Class		0,115	The data are normally distributed

The normality test conducted on the post-test data yielded significance values of 0.115 for the control group and 0.062 for the experimental group. Given that the significance values for both groups exceed the 0.05 threshold, the assumption of normality is satisfied, indicating that the data are normally distributed.

Homogeneity Test

The homogeneity test was applied to verify the equality of variances between the control and experimental groups. This test was conducted on the post-test data of both groups using the Based on Mean statistic via SPSS software version 22.0. A summary of the homogeneity test results is presented in Table 7.

Table 7. Homogeneity Test Results

Test Results	Sig	Conclusion
Based on Mean	0,730	The data are homogeneous

The results of the homogeneity test yielded a significance value of 0.730 (Asymp. Sig. > 0.05) based on the Mean criterion. This indicates that there are no significant differences in variance between the data groups; therefore, the assumption of homogeneity is satisfied.

Once the prerequisite assumptions established through normality and homogeneity tests were satisfied, the analysis proceeded to hypothesis testing. An Independent Samples T-Test was employed to compare the post-test data between the control and experimental groups. The results of this analysis are presented in Table 8.

Table 8. Independent Sample Test Result

Test Result	Sig
Sig. (2-tailed)	0,000
Df	203
Mean Difference	2,520
Std. Error Difference	0,517
Decision	H_0 is rejected and Ha is accepted
Conclusion	the use of Emerging EdTech media significantly enhances students' engagement in science learning

Based on the results of the Independent Samples t-test analysis, the interpretation of the research findings can be described as follows. Hypothesis testing was conducted to compare the alternative hypothesis (Ha), which posits that there is student engagement in science learning through the use of Emerging EdTech media, with the null hypothesis (H_0), which states otherwise. The test employed a significance level (α) of 5% (0.05) as the decision-making threshold.

The testing criterion specified that if the significance value (Asymp. Sig.) was less than 0.05, then Ha would be accepted. The data analysis results indicated an Asymp. Sig. value of 0.000, which is lower than 0.05. Therefore, H_0 is rejected and Ha is accepted. It can thus be concluded that at a 95% confidence level, the use of Emerging EdTech media significantly enhances students' engagement in science learning.

Discussion

Science education at the junior secondary level ideally facilitates students in understanding abstract concepts through concrete, interactive, and meaningful learning experiences. However, conventional instructional approaches that rely heavily on lectures and static media often fail to support deep conceptual comprehension (R. Mayer, 2017; Moreno & Mayer, 2007). In science subjects, many concepts such as planetary motion, atomic structures, and energy transformation are inherently abstract and difficult to visualize, which frequently results in low student engagement (Yunita & Irawan, 2025). This condition confirms that visualization constraints remain a fundamental barrier in science learning.

The findings of this study demonstrate that the integration of Emerging Educational Technology (Emerging EdTech), including VR and AR-based immersive media, significantly enhances student engagement compared to conventional interactive video (H5P). The experimental group achieved a higher mean engagement score (3.26, very high category) than the control group (2.98, high category), with statistical analysis confirming a significant difference ($\rho < 0.05$). These results indicate that immersive digital ecosystems provide stronger stimulation across cognitive, emotional, and behavioral engagement dimensions. Based on these data, it can be concluded that the integration of technology in education significantly stimulates students' cognitive and emotional engagement (Amin, 2023).

Theoretically, this improvement can be explained through the multidimensional engagement framework proposed by (Fredrick et al., 2004), which conceptualizes engagement as consisting of behavioral, emotional, and cognitive components. Observation data in this study show increased active participation, attentiveness, and interaction among students in the experimental group, reflecting enhanced behavioral engagement. Emotional engagement was also evident in students' enthusiasm and curiosity during immersive exploration activities. Cognitive engagement increased as students demonstrated deeper inquiry and conceptual understanding while interacting with three-dimensional simulations.

From a motivational perspective, the findings align with Self-Determination Theory (Ryan & Deci, 2000), which emphasizes that intrinsic motivation develops when learners experience autonomy, competence, and meaningful interaction. The immersive exploration approach enabled students to independently navigate and manipulate virtual scientific objects, thereby strengthening autonomy and competence perceptions. This supports previous research indicating that immersive virtual environments enhance intrinsic motivation and presence (Makransky & Lilleholt, 2018; Makransky & Petersen, 2021).

The effectiveness of Emerging EdTech is also supported by Keller's ARCS motivational model (Keller, 1985). The immersive features successfully captured students' Attention through interactive 3D visualization, increased Relevance by contextualizing abstract phenomena, strengthened Confidence through guided exploration, and generated Satisfaction through experiential discovery. These findings reinforce the argument that motivational design principles play a crucial role in technology-enhanced learning environments.

In addition, the Cognitive Theory of Multimedia Learning (R. E. Mayer, 2009) and Cognitive Load Theory (Sweller, 2011) provide further explanation for the observed outcomes. Immersive media integrates visual and auditory channels effectively, enabling dual coding and meaningful knowledge construction. By spatially presenting abstract scientific phenomena, VR and AR reduce extraneous cognitive load while promoting deeper processing. Immersive VR can facilitate meaningful learning when properly designed according to multimedia principles. Empirical evidence from previous systematic reviews further supports these findings. Virtual reality-based instruction produces a moderate positive effect on learning outcomes, particularly in science education (Merchant et al., 2014). Similarly, immersive VR enhances motivation, engagement, and experiential learning (Radianti et al., 2020). More recent research by Sviridova et al. (2023) confirms that immersive technologies significantly improve academic motivation compared to traditional instructional methods. These studies collectively validate the present findings that immersive ecosystems outperform standard digital media in promoting active participation.

The present study also contributes to the discourse on digital transformation in education. Digital technologies function not merely as supportive tools but as catalysts for pedagogical innovation (Haleem et al., 2022). In rural–urban transitional regions such as Kubu Raya Regency, technological adaptation is particularly critical due to limited infrastructure and digital literacy challenges (Surani, 2019). The successful implementation across multiple schools in this study demonstrates that immersive technology can be adapted within local educational ecosystems when appropriately designed (Purba et al., 2025).

From a constructivist perspective, learning occurs most effectively when students actively construct knowledge through interaction with their environment. Immersive EdTech aligns strongly with this paradigm by enabling experiential, exploratory, and socially interactive learning. The immersive interfaces promote engagement by situating learners within authentic problem-solving contexts (Dede, 2009). Similarly, AR supports situated cognition by blending digital elements with real-world contexts, thereby strengthening conceptual understanding (Dunleavy & Dede, 2014).

The novelty of this research lies in the integration of multiple immersive technologies into a cohesive digital ecosystem rather than relying on a single technological intervention. Unlike previous studies focusing primarily on cognitive learning outcomes, this study evaluates engagement as a multidimensional variable influenced by futuristic technologies. This approach provides a more holistic understanding of educational transformation in secondary science classrooms.

Overall, the results confirm that immersive digital hands-on experiences significantly enhance student engagement across behavioral, emotional, and cognitive dimensions. The integration of Emerging EdTech represents not merely technological innovation but a pedagogical advancement that addresses longstanding visualization barriers in science education. Therefore, providing immersive digital ecosystems should be considered a strategic priority for improving science learning quality in secondary schools, particularly in developing and transitional regions.

CONCLUSION

The mean engagement score of students in the experimental group was categorized as very high, whereas the control group fell within the high category. The Independent Samples T-Test indicated a statistically significant difference between the two groups ($\rho < 0.05$). These findings confirm that the integration of immersive technologies based on Virtual Reality (VR) and Augmented Reality (AR) significantly enhances student engagement across behavioral, emotional, and cognitive dimensions. Theoretically, the results reinforce the multidimensional framework of engagement as well as motivational learning theories that emphasize the importance of attention, relevance, confidence, and satisfaction in technology-enhanced learning environments. Practically, this study demonstrates that immersive technology-based digital hands-on experiences effectively address the limitations of visualizing abstract concepts in science education. Therefore, Emerging EdTech should not be viewed merely as a technological innovation, but rather as an effective pedagogical strategy for promoting the transformation of science education in secondary schools, particularly in rural–urban transitional regions.

Based on the findings of this study, the integration of Emerging Educational Technology (Emerging EdTech) in science instruction is recommended to be developed more systematically as part of a broader strategy for educational transformation in schools. Schools and policymakers need to support the provision of adequate digital infrastructure, the enhancement of teachers' professional competencies, and the strengthening of instructional design grounded in immersive technologies to ensure optimal and sustainable implementation. Science teachers are encouraged to utilize immersive technologies in a structured and pedagogically informed manner, particularly for abstract subject matter that requires conceptual visualization, while adhering to established multimedia and motivational design principles. Furthermore, future research should investigate the long-term effects of immersive technology integration on learning outcomes, concept retention, and 21st-century skills in order to provide a more comprehensive understanding of its effectiveness across diverse educational contexts.

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