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Institutionalization of the 5E Instructional Model Integrated Augmented Reality Interactive Book (5E-IMARIB): Its Impact in Increasing Students' Understanding of 3D Geometry Concepts and Self-Efficacy?

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Abstract: 3D geometry is an abstract concept that provides a visual representation of shape and space in mathematics. However, many students consider images in books to be representations of 3D geometry, thus requiring direct visualization for better understanding. Therefore, this research aims to institutionalize the use of 5E-IMARIB in 3D geometry learning to influence students' understanding of 3D geometry concepts and increase students' self-efficacy in geometry subjects. A quasi-experimental nonequivalent comparison group design was used in this research. Participants in this research were class VIII students at one of the private junior high schools in Indramayu Regency, who were then selected into two classes. The first class consisted of 20 students learning using the 5E-IMARIB, and in the second class, 22 students were using conventional learning. Data obtained from the results of the geometry understanding test and self-efficacy questionnaire were analyzed quantitatively using the independent t-test. The results showed that the average pre-test score for the experimental class was 17.83 and the average post-test score was 63.43. The average score of student learning outcomes in the control class was 18.78 for the pre-test and 52.35 for the post-test. Meanwhile, the average gain score in the experimental class was 0.52, and in the control class 0.41. Apart from that, the average increase in self-efficacy (SE) in the experimental class was 0.22, and in the respondent class was 0.20. Furthermore, based on statistical analysis using an independent t-test, it was concluded that there was an increase in understanding of 3D geometry concepts and students' self-efficacy after using 5E-IMARIB . The results of this research indicate that AR in 3D geometry learning has the potential to help students understand geometric concepts and student affectivity.

Keywords: 5E instructional model, augmented reality interactive book, 3D geometry, understanding of geometry concepts, self-efficacy.

▪ INTRODUCTION

A strong understanding of 3D geometry is essential for students because this concept is fundamental to many scientific disciplines and practical applications, including engineering, architecture, design, and information technology (Medina-Herrera et al., 2019; Ibili et al., 2020; Sudirman et al., 2022). Mastering 3D geometry helps students develop important spatial skills, such as visualization, mental rotation, and manipulation of objects in three-dimensional space (Wahab et al., 2016; Huang & Lin, 2017; Rahmawati et al., 2021). Additionally, this ability is useful in solving complex problems and understanding graphical representations in various professional and academic contexts. Skills in 3D geometry also contribute to improved critical and analytical thinking abilities, which are highly needed in many career and research fields. Thus, the importance of 3D geometry is not only limited to academic contexts but also plays a crucial role in students' readiness to face challenges in the world of work and everyday life (Sudirman et al., 2022).

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However, many students face difficulties in understanding 3D geometry concepts. The main challenges include the ability to visualize objects in three dimensions from the two-dimensional representations often found in textbooks and conventional teaching materials (Pittalis & Christou, 2013; Sudirman et al., 2023; Sudirman & Susandi, 2024). Additionally, the limitations of traditional learning media in presenting the dynamics and interactivity of 3D geometry often hinder deep and applicable understanding for students (Sudirman et al., 2021). The lack of adequate visual and interactive support makes it difficult for students to link abstract concepts with their practical applications, rendering the learning process less effective. As a result, many students feel insecure about their ability to master this material, which negatively affects their motivation and learning outcomes.

To address these challenges, the integration of technology in 3D geometry learning emerges as a potential solution. The use of augmented reality (AR) and virtual reality (VR) applications can provide a more immersive and interactive learning experience. With AR and VR technology, students can directly manipulate three-dimensional objects, observe shapes and structures from various angles, and understand the dynamics of changes occurring in three-dimensional space. Additionally, interactive learning platforms utilizing computer simulations can also help students develop their visualization skills more effectively. Studies show that the use of this technology can enhance understanding of 3D geometry concepts, increase learning motivation, and result in better learning outcomes (Cai et al., 2020; Lin & Yu., 2023). Therefore, adopting innovative technology in teaching 3D geometry should be considered a strategic step to improve the quality of learning and address the difficulties faced by students.

Previous research has highlighted the benefits of using augmented reality (AR) technology in 3D geometry learning. For example, a study by Lin et al. (2015) shows that the use of AR in learning 3D geometry can significantly improve students' understanding of these concepts. Similarly, research by Lee & Lee (2021) found that the use of AR in 3D geometry learning can increase student engagement and learning motivation. These studies indicate that the interactive and immersive learning experiences provided by AR can enhance student learning outcomes in 3D geometry. Another study by Kim et al. (2020) concluded that integrating AR into 3D geometry learning can increase students' self-efficacy, making them more confident in learning and applying complex concepts. Additionally, research by Park et al. (2021) shows that using AR in 3D geometry learning can facilitate conceptual understanding and boost students' creativity in solving geometric problems. Recent research by Yang et al. (2023) demonstrates that AR can help students overcome difficulties in visualizing objects in three dimensions, which is often a challenge in learning 3D geometry. These findings confirm that AR can be an effective tool in facilitating students' understanding of 3D geometric concepts.

Although there have been several studies exploring the use of AR in geometry learning, there is still a gap in the literature regarding the specific impact of the 5E-IMARIB 5E-IMARIB on students' conceptual understanding and self-efficacy in 3D geometry. Many previous studies have focused on the use of AR in general or in different contexts, so there is not yet a deep understanding of how 5E-IMARIB5E-IMARIB specifically can improve 3D geometry learning outcomes. This research aims to fill this gap by testing the 5E-IMARIB 5E-IMARIB in learning 3D geometry.

5E-IMARIB5E-IMARIB is designed to provide an immersive and interactive learning experience, allowing students to directly manipulate geometric objects in three-dimensional space. This research will evaluate the impact of 5E-IMARIB5E-IMARIB on students' understanding of 3D geometry concepts and their self-efficacy in this subject. By addressing the challenges students face and leveraging the benefits of AR technology, this study aims to significantly improve learning outcomes and provide valuable insights into the potential implementation of 5E-IMARIB 5E-IMARIB in 3D geometry learning. The 5E instructional model integrated with the Augmented Reality Interactive Book (ARIB) offers a dynamic and immersive approach to learning, especially in complex subjects such as 3D geometry. The 5E model, which includes Engage, Explore, Explain, Elaborate, and Evaluate phases, is designed to foster active learning and deeper understanding. When combined with AR technology, each phase of the 5E model becomes more interactive and engaging. In the Engage phase, ARIB can capture students' interest with interactive 3D visualizations. During the Explore phase, students can manipulate geometric shapes and observe their properties in real-time. The Explain phase allows for augmented explanations and visual aids that can simplify complex concepts. In the Elaborate phase, students can experiment with advanced geometric problems using AR tools, enhancing their critical thinking and problem-solving skills. Finally, the Evaluate phase can be augmented with interactive quizzes and assessments that provide immediate feedback. This integration not only enhances conceptual understanding but also boosts student motivation and engagement, making learning more effective and enjoyable.

This research will also consider practical aspects and student acceptance of using 5E-IMARIB in 3D geometry learning. Through surveys and interviews, researchers will gather data on students' perceptions of the effectiveness and convenience of using 5E-IMARIB, as well as its impact on their learning motivation. Additionally, this study will examine the technical and pedagogical challenges that may arise in the implementation of 5E-IMARIB in the classroom. Thus, this research will not only focus on learning outcomes but also on the implementation aspects that can affect the success of using this technology in everyday learning. The results of this study are expected to provide comprehensive recommendations for educators and educational technology developers on the best ways to integrate 5E-IMARIB into the 3D geometry curriculum.

▪ METHOD

This research employed a non-equivalent comparison group design, which is a type of quasi-experimental design suitable for assessing the impact of educational interventions. The study aimed to evaluate the effectiveness of the 5E-IMARIB (Interactive Augmented Reality Book) in teaching 3D geometry by comparing it with traditional teaching methods. By using this design, the researchers could carefully select and assign participants into experimental and control groups, ensuring a balanced comparison while minimizing bias. This approach allowed for a rigorous examination of how the interactive features of the 5E-IMARIB contribute to students' understanding and engagement in learning complex geometric concepts in three dimensions.

A non-equivalent comparison group design type quasi-experimental design was used in this research to evaluate the effectiveness of the 5E-IMARIB Interactive Augmented Reality Book (5E-IMARIB) in learning 3D geometry.

Participants in this research were class VIII students at one of the private junior high schools in Indramayu Regency. The population consisted of all class VIII students in the school, totalling 120 students. From this population, a sample of 42 students was selected using a purposive sampling technique. These students were then divided into two different class groups, with 30 students in each group, to allow a more accurate comparison between the learning methods applied. One group used the traditional learning method, while the other group used the 5E-IMARIB. This division enabled a thorough evaluation of the differences in learning outcomes and effectiveness between the two methods.

5E-IMARIB The first class, consisting of 20 students, studied using the 5E-IMARIB5E-IMARIB . This design allows students to visualize and interact with 3D geometric concepts through augmented reality technology, which is expected to increase their understanding and self-efficacy. The second class, consisting of 22 students, used conventional learning methods, which generally involved the use of textbooks and teacher explanations without the support of interactive technology. This class division aimed to evaluate differences in learning outcomes and levels of self-confidence between students who use 5E-IMARIB and those who use conventional methods.

In this study, two types of instruments were used to measure students' geometric thinking abilities and self-efficacy. The geometric thinking abilities test referred to concepts identified by Pittalis & Christou (2013), with verified validity and reliability, achieving a Cronbach's alpha reliability coefficient of 0.86. This instrument encompasses three main dimensions: representation, spatial structure, and measurement, assessing students' abilities to depict objects, understand spatial relationships, and measure and compare dimensions of geometric objects. Additionally, the self-efficacy questionnaire was developed based on Cantürk-Günhan & BaĢer's theory (2007), comprising 55 statements on a five-point Likert scale (1-Strongly Disagree, 2-Disagree, 3-Slightly Agree, 4-Agree, 5-Strongly Agree), with tested reliability achieving a Cronbach's alpha coefficient of 0.83. This questionnaire evaluates students' confidence in their abilities to comprehend, manipulate, and apply 3D geometry concepts using augmented reality technology.

Data obtained from the results of the geometry understanding test and self-efficacy questionnaire were analyzed quantitatively using an independent t-test. This analysis was carried out to determine whether there were significant differences between the two groups in terms of understanding 3D geometry concepts and levels of self-efficacy. By using an independent t-test, this research can identify the effectiveness of 5E-IMARIB in improving student learning outcomes and self-efficacy compared to conventional learning methods, thereby providing valuable insight into the potential implementation of 5E-IMARIB in 3D geometry learning.

▪ RESULT AND DISSCUSSION

Implementation of 3D Geometry Learning with 5E-IMARIB5E-IMARIB

In this study, the learning process begins with the teacher instructing students to observe and direct their cameras at an image used as an AR marker (see Figure 1). In addition to observing the image of a prism-shaped object, students are also asked to observe the shape of an aquariu.

Figure 1. Initial instructions

Students are asked to point their smartphone cameras at the aquarium marker image. They are then instructed to note the number of vertices, edges, faces, face diagonals, and space diagonals that appear on the smartphone screen. The animation that appears is shown in Figure 2.

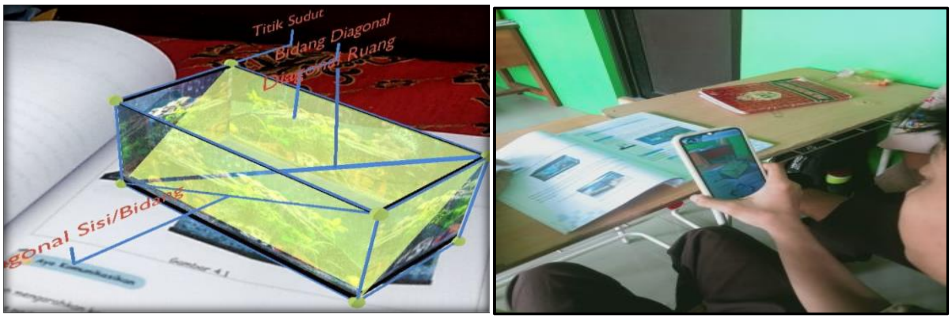

Figure 2. 3D Aquarium animation

While observing the 3D animation of the aquarium, students are seen moving their cameras to view the animation correctly. Once the 3D animation appears, students begin to examine the various viewpoints in detail. Some students immediately record the number of elements that appear on their screens, while others focus solely on observing. After observing the 3D animation, students are asked to write their observations in the provided table. The same procedure is followed when students are asked to understand the properties of a rectangular prism by observing the marker shown in Figure 3.

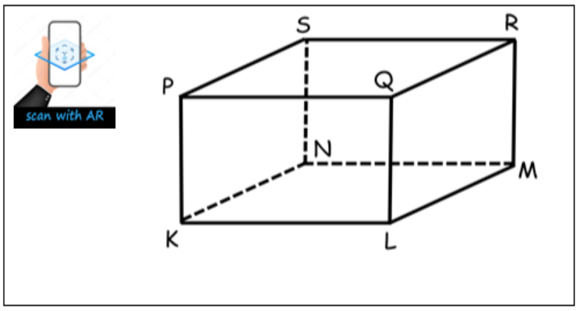

Figure 3. Marker for understanding the properties of a rectangular prism

After observing the elements of the rectangular prism KLMN.PQRS that appear on their smartphone screens, students are asked to identify and write down the vertices, edges, faces, face diagonals, space diagonals, and diagonal planes in the provided table. The students' answers indicate that they are able to identify the elements of the prism and understand its properties.

In addition to the aquarium-shaped object, a die is used to understand the elements of a cube. To understand the elements of a cube, students are asked to direct their smartphone cameras at the marker image shown in Figure 4.

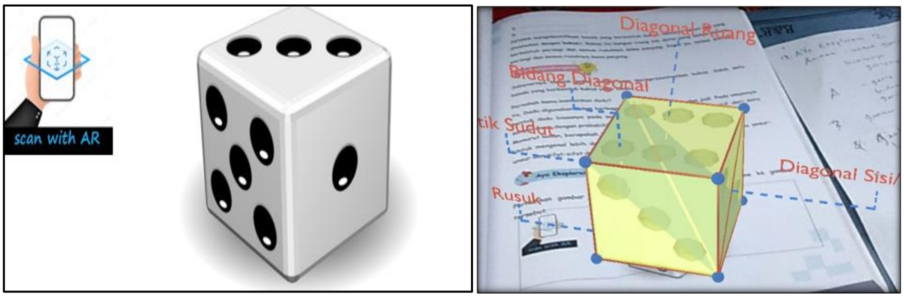

Figure 4. Die marker and animation

Students are then asked to observe the vertices, edges, faces, face diagonals, space diagonals, and diagonal planes of the 3D shape that appears on their smartphone screens. The resulting animation is shown in Figure 4.

During observation, students begin to understand how to properly point their smartphone cameras at the marker image. Students are also seen enlarging, rotating, and viewing the 3D animation from various angles, such as the front, back, right side, left side, top, and bottom. Additionally, students are able to identify the vertices, edges, face diagonals, space diagonals, and diagonal planes.

Next, to understand the properties of a cube, students are asked to direct their smartphone cameras at the marker shown in Figure 4 . They are then asked to observe the vertices, edges, faces, face diagonals, space diagonals, and diagonal planes of the cube ABCD.EFGH that appears on their smartphone screens.

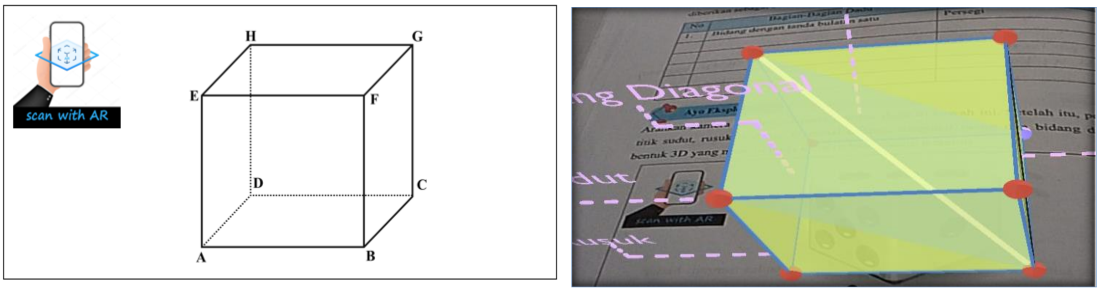

Figure 5. Marker and animation of cube ABCD.EFGH

While observing, students appear to be thoroughly examining the 3D animation that appears on their screens. The animation of cube ABCD.EFGH is shown in Figure 5. Some students start by observing the front part, then rotate and enlarge the animation to view other parts. Others take a holistic view, and some immediately note their observations.

However, some students simply observe without recording their findings immediately. To confirm the accuracy of their answers, students can point their smartphone cameras at the provided QR Code, which links to a YouTube video explaining the given problem.Students can then compare their answers with the explanation in the video.

When watching the video, some students watch attentively, while others cannot view the YouTube video due to lack of data, and some only watch briefly. However, generally, students are able to access the video. After implementing the 5E Instructional Model integrated with Augmented Reality (AR) books in 3D geometry classes, it is evident that students are actively participating in each lesson. They not only engage deeply in exploring the material but also show a high level of interest in learning. Previous research indicates that integrating technologies like AR can significantly enhance student engagement and learning outcomes. For example, Johnson et al. (2016) found that using AR in mathematics education improves students' understanding of concepts and boosts their motivation to learn. Similarly, research by Akçayır & Akçayır (2017) highlights that AR enhances student engagement through its interactive and visually immersive nature.

In the context of 3D geometry learning, AR facilitates concrete and visual exploration of space and objects, enabling students to grasp complex concepts more profoundly. Therefore, the positive experiences observed in your classroom, where students are actively engaged and highly interested, align with findings that AR technology can substantially enhance student engagement in mathematics and other scientific disciplines.

Impact of Using 5E-IMARIB5E-IMARIB

After five learning sessions, the researcher conducted a final test and obtained descriptive data as shown in Table 1. The data described includes the average pre-test and post-test scores, as well as the normalized gain for both the experimental.

Table 1. Descriptive Statistics of Understanding Geometry Concepts (UGC) after using 5E-IMARIB

	Question Number 1			**Question Number 2**			**Question Number 3**			**Question Number 4**			**Question Number 5**		
	Pre-test	**Post-test**	**N-gain**	**Pre-test**	**Post-test**	**N-gain**	**Pre-test**	**Post-test**	**N-gain**	**Pre-test**	**Post-test**	**N-gain**	**Pre-test**	**Post-test**	**N-gain**
N	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Average	20.87	70.4	0.63	20.5	54.7	0.43	18.46	60.1	0.51	16.5	58.5	0.5	12.8	53	0.46

This data shows the improvement in students' understanding after receiving an intervention or new teaching method, evaluated through five different questions. The average pre-test and post-test scores are used to measure the students' level of understanding before and after the intervention, while the N-gain score indicates the degree of improvement. The first question shows a very significant improvement with an average pre-test score of 20.87 and a post-test score of 70.4, and an N-gain of 0.63. This indicates that the teaching method applied was highly effective for the material tested in the first question. Questions two through five also show improvements in understanding, although not as strong as the increase seen in the first question. Consistent improvement is observed in questions three and four with N-gains of 0.51 and 0.5, respectively, indicating that the teaching method had a fairly good impact on students' understanding. The fifth question has the lowest pre-test score of 12.8 and a post-test score of 53 with an

N-gain of 0.46, showing significant improvement despite the students' relatively low initial scores.

Overall, this data shows that the 5E Instructional Model integrated with the Augmented Reality Interactive Book is quite effective in improving students' understanding, with varying effectiveness depending on the specific material or question tested. These results can serve as a basis for evaluating and refining teaching methods to be more effective in the future. These findings align with research conducted by Enyedy et al. (2012), which found that the use of Augmented Reality (AR) in teaching can significantly enhance student engagement and understanding. Additionally, research by Martin-Gonzalez et al. (2016) also indicates that integrating AR into science education curricula can help students better understand complex concepts. In the context of the 5E Instructional Model, research by Sudirman et al (2024) shows that this teaching model, consisting of five stages (Engage, Explore, Explain, Elaborate, Evaluate), is effective in improving students' conceptual understanding and encouraging active learning. Thus, these findings strengthen the evidence that combining the 5E Instructional Model with AR technology can have a significant positive impact on student learning.

5E-IMARIB 5E-IMARIB Furthermore, the Self-Efficacy (SE) data is ordinal scale data that has been converted into interval data using the Method of Successive Intervals (MSI). MSI is used to transform attitude scales/Likert scales into interval scales, allowing for statistical analysis to assess the significance of attitudes between subjects and subject consistency. The differences in the mean SE questionnaire results between those using 5E-IMARIB and conventional learning methods can be seen in Table 2.

Table 2. Descriptive statistics of self-efficacy after using 5E-IMARIB

Stat.Decriptive	**Geometry Learning**		
	5E-IMARIB5E-IMARIB		
	Prerespond	**Postrespond**	$\langle g \rangle$
$\bar{X}$	74.30	88.50	0.42
N	20		

Based on Table 2, it can be explained that the average SE (Self-Efficacy) scores of students before using 5E-IMARIB and conventional learning methods were 74.30 and 72.05, respectively. Descriptively, the difference in the average SE scores of the students is relatively the same. This indicates that before using a specific learning method, students had the same level of SE to successfully learn 3D geometry. Furthermore, the average SE scores after using 5E-IMARIB and conventional learning methods were 88.50 and 78.86, respectively. Additionally, the SE improvement scores for students using 5E-IMARIB and conventional methods were 0.42 and 0.21, respectively. This shows that students who learned with 5E-IMARIB had a greater increase in SE than those who learned with conventional methods.

These findings are consistent with previous research related to the use of augmented reality on self-efficacy. For instance, a study by Di Serio et al. (2013) found that augmented reality significantly enhanced students' motivation and self-efficacy in an educational context. Similarly, research by O'Connor & Mahony (2023) demonstrated that augmented reality applications in educational settings could boost students' self-efficacy by providing interactive and engaging learning experiences. Additionally, Cheng

(2017) discovered that the use of augmented reality in science education improved students' self-efficacy, attributing this to the immersive and hands-on learning environment that AR provides. Therefore, the increased SE scores in this study align well with these previous findings, highlighting the potential of 5E-IMARIB to enhance students' self-efficacy in learning complex subjects like 3D geometry.

5E-IMARIB

5E-IMARIB To assess the impact of the 5E-IMARIB model on enhancing students' understanding of geometry concepts (UGC) and self-efficacy (SE), an independent t-test was used. This statistical test compares the means of two independent groups to determine if there is a significant difference between them. The process involves normality and homogeneity tests.

Based on the results of the normality test presented, we can conclude that the data on the improvement of students' understanding of geometry concepts (UGC) and self-efficacy (SE) measured based on the 5E-IMARIB and conventional learning models are normally distributed. The normality test was conducted using the Kolmogorov-Smirnov test with a significance level (α) of 0.05. This significance level is the probability value indicating whether the data distribution significantly differs from the normal distribution. If the significance value is greater than 0.05, we conclude that the data are normally distributed.

For both learning models, 5E-IMARIB and conventional, the test results show significance values greater than 0.05. Specifically, for the improvement in UGC, the significance value for 5E-IMARIB is 0.200, and for the conventional model, it is 0.106. For the improvement in SE, the significance value for 5E-IMARIB is 0.102, and for the conventional model, it is 0.090. Therefore, all data on the improvement of both UGC and SE for both learning models are normally distributed. This means that the assumption of normality is met, allowing the use of parametric statistical tests for further data analysis.

5E-IMARIB 5E-IMARIB

5E-IMARIB The homogeneity test was conducted to determine whether the variances in the improvement data for understanding geometry concepts (UGC) and self-efficacy (SE) among students from both 5E-IMARIB and conventional learning classes are homogeneous. The results of this test, showcasing the Levene Statistic and the corresponding significance values for both UGC and SE improvements. For both data sources, the test was based on the mean values. Specifically, the Levene Statistic for the gain in SE was 0.531 with a significance (Sig.) value of 0.241, and for the gain in UGC, the Levene Statistic was 0.726 with a significance value of 0.412.

From the results, it is evident that the significance values for both UGC and SE gains are greater than the alpha level (α) of 0.05. This indicates that the variances in the improvement data for UGC and SE among students who received and conventional learning are homogeneous. In other words, the Levene's test results confirm that the assumption of equal variances holds true for both sets of data at the 0.05 significance level. Therefore, we can proceed with further statistical analyses, such as the independent t-test, with the confidence that the data meet the necessary assumption of homogeneity of variances.

Based on the results of the prerequisite tests, it is known that the data on the improvement of UGC and SE for students who received 5E-IMARIB and conventional learning are normally distributed and homogeneously variance at a significance level of $\alpha = 0.05$. Therefore, hypothesis testing was conducted using an independent t-test. The results of the statistical analysis using SPSS are shown in Table 3.

Table 3. Independent t-test for UGC

	t	df	Sig (2-tailed)	Kesimpulan
Equal Variances Assumed	2.46	40	0.001	H_0 ditolak
Equal Variances Not Assumed	2.46	39.999	0.001	

From Table 3, it can be seen that the Sig. value for UGC in the independent t-test is 0.001, which is less than $\alpha = 0.05$. Thus, indicating that there is a significant difference in the improvement of UGC between students who received 5E-IMARIB5E-IMARIB and conventional learning. This suggests that the use of 5E-IMARIB5E-IMARIB has an impact on enhancing UGC. Next, based on the independent t-test for SE between students who received 5E-IMARIB5E-IMARIB and conventional learning, the results are shown in Table 4.

Table 4. Independent t-test for SE

	T	df	Sig (2-tailed)	Kesimpulan
Equal Variances Assumed	1.24	40	0.000	H_0 ditolak
Equal Variances Not Assumed	1.26	39.999	0.000	

From Table 4, it can be seen that the Sig. value for SE in the independent t-test is 0.000, which is less than $\alpha = 0.05$. Thus, indicating that there is a significant difference in the improvement of SE between students who received 5E-IMARIB and conventional learning. This suggests that the use of 5E-IMARIB5E-IMARIB has an impact on enhancing SE.

Discussion

This study found that institutionalizing the use of 5E-IMARIB can help students improve their understanding of 3D geometry concepts and self-efficacy. This confirms that integrating AR technology into geometry teaching materials has the potential to be used in learning and can enhance both the cognitive and affective aspects of students. The results also show that 5E-IMARIB encourages more active geometry learning, where students are directly involved in the learning process. This active learning approach has been proven to be more effective in improving understanding and retention of material compared to passive learning methods. With 5E-IMARIB , students do not just listen to explanations or view images; they can also experiment with 3D objects, manipulate them, and see the results in real-time. This makes learning more engaging and meaningful for students.

The results of this study align with previous research findings showing that the use of AR in learning can enhance representation abilities, understanding of geometry concepts, and 3D geometry thinking skills (Sudirman et al., 2022; 2024; Yaniawati et al., 2023). Research by Ibáñez & Delgado-Kloos (2018) also indicates that AR can increase student engagement and self-efficacy in mathematics learning. Students using AR showed significant improvements in concept understanding and confidence. For example, in this study, students learning with AR on topics like geometry and trigonometry showed gains in learning outcomes and felt more confident in their ability to solve math problems. Additionally, research by Wang et al. (2024) reinforces the finding that AR can enhance the understanding of geometry concepts and visual representation skills. They found that AR helps students build clearer and more accurate mental representations of geometric objects, which in turn improves their ability to solve geometry problems. Wang et al. (2024) also noted that AR use increases student interaction with learning materials, making the learning process more enjoyable and effective.

Furthermore, research by Wojciechowski & Cellary (2013) found that AR is effective in improving student learning outcomes in geometry. Using AR enables students to better understand and manipulate geometric objects in 3D space. In their study, the use of AR in geometry learning allowed students to interact directly with geometric shapes, manipulate them in virtual space, and observe the results in real-time, all of which contributed to a better understanding of geometry concepts. Research by Billinghurst & Duenser (2012) also showed that AR can enhance learning by making abstractions more concrete and facilitating direct interaction with learning content. In the context of 3D geometry, AR allows students to observe, manipulate, and understand geometric shapes from various perspectives, which is difficult to achieve with conventional learning methods. Moreover, research by Dünser et al. (2012) showed that using AR in learning not only improves concept understanding but also increases student engagement and provides a more satisfying learning experience. In this study's context, 5E-IMARIB provides an interactive and engaging learning experience, contributing to increased student motivation and engagement, which in turn enhances their understanding and self-efficacy.

Besides improving the understanding of 3D geometry concepts, this study also shows a significant increase in students' self-efficacy. The increase in self-efficacy among students using 5E-IMARIB can be attributed to several factors. First, 5E-IMARIB provides students with successful experiences. When students successfully understand and apply 3D geometry concepts with the help of 5E-IMARIB , they feel more confident in their abilities. These successful experiences strengthen their self-efficacy. Second, 5E-IMARIB gives immediate feedback to students. Positive and constructive feedback helps students understand their strengths and weaknesses and encourages improvement. Third, 5E-IMARIB creates a supportive learning environment where students feel safe to try and make mistakes. This supportive environment is crucial for boosting students' self-efficacy.

These findings align with Cai et al. (2019; 2021), who concluded that students with high self-efficacy are better able to utilize AR technology optimally, showing greater improvements in concept understanding and adopting a more positive learning approach. Conversely, students with low self-efficacy still benefit from AR use, but their improvements are not as significant as those with high self-efficacy. Additionally, Özçakır & Aydın (2019) in their research stated that experiences using AR significantly enhance the self-efficacy of prospective mathematics teachers in integrating technology into teaching. Prospective teachers involved in AR use felt more confident and ready to adopt this technology in their teaching process. Furthermore, research by O'Connor &

Mahony (2023) showed that the use of AR technology in higher education has a significantly positive impact on students' academic self-efficacy. AR technology not only boosts students' confidence and motivation but also enriches their learning experiences by making them more interactive, engaging, and collaborative.

▪ CONCLUSION

The research on the institutionalization of Augmented Reality Interactive Book Instruction (5E-IMARIB) in 3D geometry learning has yielded significant findings regarding its impact on students' understanding of 3D geometry concepts and their self-efficacy. The implementation of 5E-IMARIB technology in 3D geometry learning shows consistent improvement in several key learning aspects. First, the use of 5E-IMARIB significantly enhances students' understanding of complex geometry concepts. AR technology allows students to visualize and interact with geometric objects in three dimensions more clearly and concretely. This facilitates students' comprehension and application of these concepts in both academic and practical contexts. Additionally, the use of 5E-IMARIB also positively impacts students' self-efficacy. Students learning with 5E-IMARIB show increased confidence in their ability to understand and solve 3D geometry problems. This self-efficacy boost is crucial as it directly affects students' learning motivation and overall academic performance.

5E-IMARIB creates a more interactive and engaging learning environment for students. With AR technology, learning becomes more dynamic and enjoyable, encouraging active participation and student engagement in the learning process. This not only increases students' interest in the subject of geometry but also makes the learning process more effective. Students using 5E-IMARIB tend to adopt a more active learning approach. They are more frequently involved in independent exploration, experimentation, and manipulation of geometric objects, enriching their learning experience and fostering deeper understanding.

Thus, the institutionalization of 5E-IMARIB in 3D geometry learning has proven effective in enhancing students' understanding of 3D geometry concepts and self-efficacy. AR technology provides a powerful pedagogical tool to create richer, more interactive learning experiences, empowering students to fully achieve their academic potential. The findings of this study support the widespread adoption of 5E-IMARIB in education to improve the quality and effectiveness of geometry learning.

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