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Enhancing Reading Literacy through Augmented Reality among Indonesian Migrant Children in Malaysia

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Abstract

Indonesia continues to face persistent challenges in reading literacy, particularly among children of migrant workers who lack access to quality formal education. This study explores the effectiveness of Augmented Reality (AR)-based learning media in enhancing the reading skills of Indonesian migrant children in Malaysia. Utilizing a quantitative pretest-posttest design, this study involved 34 elementary school students enrolled at At-Tanzil Learning Center in Selangor. The intervention consisted of interactive AR-enhanced picture storybooks, designed to improve reading motivation, letter and word recognition, and reading comprehension. Data were analyzed through simple linear regression analysis using SPSS. The findings revealed a statistically significant improvement in students' reading abilities after the use of AR media ($t = 2.629$, $p = .012$), with an R^2 value of 0.136, indicating a 13.6% effect size. The results suggest that AR integration into literacy instruction can meaningfully support early reading development, particularly in the reading skill aspect. Furthermore, the use of immersive and interactive technologies has been shown to increase student engagement, comprehension, and motivation to read. These outcomes underline the potential of AR as a pedagogical tool for marginalized populations and offer practical implications for educators, policymakers, and instructional designers aiming to bridge literacy gaps through accessible and technology-supported interventions. This study contributes to the growing body of research on digital learning innovations and highlights the role of AR in promoting inclusive literacy education across transnational and underserved contexts.

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INTRODUCTION

Developing literacy is crucial for students because it is a general skill that they need to navigate their future lives, especially in this sophisticated era. Adam and Hamm in Widyastuti et al., (2016) emphasized that literacy is "the ability to see, hear, write, read, speak, and think". However, UNESCO reports that the reading interest index of the Indonesian population is merely 0.001%, meaning that just one person out of every 1,000 likes to read. Additionally, the Ministry of Communication and Information of the Republic of Indonesia (Kominfo RI) published the findings of a study titled World's Most Literate Nations on its official website. Indonesia was ranked 60th out of 61 countries in a March 2016 Central Connecticut State University ranking of reading interest, only ahead of Botswana (61) and behind Thailand (59) (Liestari & Muhardis, 2020).

Based on the analysis of PISA 2018, students' basic reading ability is positively influenced by factors such as pleasure in reading, reading metacognitive strategies, and discipline conditions in the classroom. These three aspects play a role in increasing students' interest in reading (OECD & UNICEF, 2021). Instilling an interest in reading from an early age is very important, especially when children are just starting to learn to read, or even when they are just starting to learn various things (Rukayah et al., 2023).

In the PISA 2018 achievement rankings, the average reading ability of Indonesian students was 80 points adrift below the OECD average. Indonesian students have skills in reading, mathematics, and science, with 42 points, 52 points, and 37 points, respectively, adrift of the average achievement of ASEAN students (Machromah et al., 2020). Meanwhile, in 2022, the international reading literacy score in PISA 2022 fell by an average of 18 points, and Indonesia's score fell by 12 points, which is a decline in the lower category compared to other countries. Indonesia ranked 69th out of 80 participating countries in PISA 2022 (OECD, 2023). Indonesia's PISA scores for reading, mathematics, and science literacy were 359, 366, and 383, respectively. Indonesia's reading, mathematics, and science literacy scores are 359, 366, and 383, respectively, which are far below the OECD average (OECD, 2023).

As shown in Figure 1, reading interest must be instilled in children at an early age. This certainly requires an effective way to increase reading interest, specifically for children who currently do not have full access to literacy services, namely, the children of migrant workers abroad, such as in Malaysia. This approach aligns with Molina Vargas et al. (Molina Vargas et al., 2020), who emphasized that the use of appropriate media can bridge the gap between abstract knowledge and real-world experiences through immersive technology, which can be applied in various educational contexts. Based on the results of research conducted by Udhwalalita (2023), there are still many gaps related to the enforcement of the right to education

for children. One of the problems often discussed in the study is the limited access to education for the children of Indonesian migrant workers (PMI) in Malaysia. Malaysia is a destination country for most PMIs seeking employment. In 2017, 2018, and 2019, there were 88,991 Indonesian migrant workers in Malaysia (Udhwalalita & Hakim, 2023).

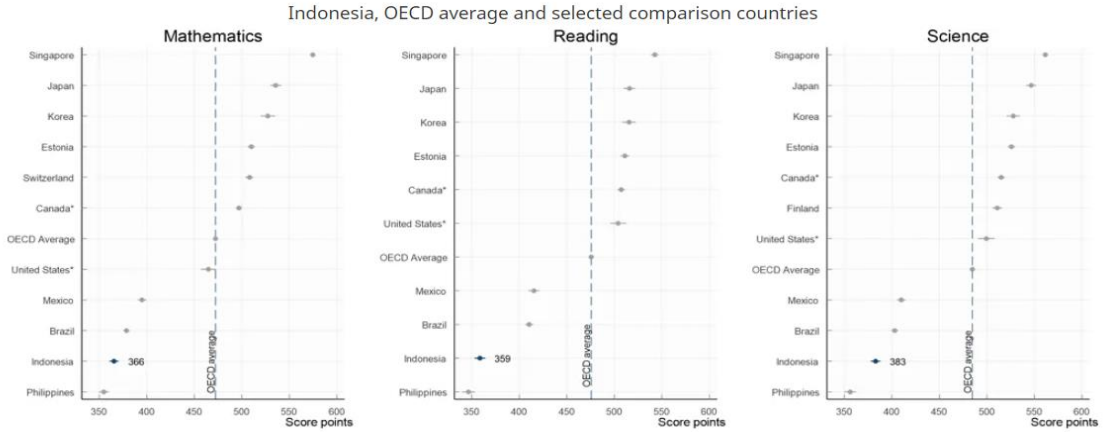


Figure 1. Average achievement in mathematics, reading, and science in PISA 2022

The study is informed by a number of related theoretical frameworks, such as theories on reading literacy skills, and these theories in relation to digital-based media in education. When it comes to reading, the focus is primarily on decoding, fluency, and comprehension as central processes that need to be constructed for all readers, particularly young readers (Reigeluth & An, 2020). The use of digital media, such as Augmented Reality (AR), aligns with Richard Mayer's Cognitive Theory of Multimedia Learning, which suggests that the effectiveness of multimedia in enhancing comprehension and retention is not directly related to its use (Giang et al., 2025). Therefore, the digital learning framework should emphasize portability, accessibility, and contextualized learning that are relevant to children of migrants with a lack of access to the formal education system (Sahrim et al., 2023).

However, most existing research has focused on only a small number of students who are common in formal school settings, leaving a significant gap in empirical research exploring *Augmented Reality* (AR) interventions aimed at the children of migrant workers in Malaysia. Research that explicitly addresses this gap (the use of *Augmented Reality* (AR), digital access, and reading skills from an early age in marginalized contexts) is still minimal. This research overcomes this gap by applying *Augmented Reality* (AR) as an interactive digital-based learning tool specifically designed for Indonesian migrant children in Malaysia. The urgency of this research lies in Indonesia's reading literacy score, which is consistently low in international assessments such as PISA (OECD, 2023). The novelty of this study lies in the combination of AR-based storybooks with interesting deliveries and presentations in informal education. The contribution of this research is to offer a

replicable model for literacy development using immersive media technology that can be aimed at underserved students globally, including the children of migrant workers.

Therefore, the main objective of this study is to improve reading literacy in the children of migrant workers in Malaysia, with a special emphasis on improving their skills and developing their interest in reading through the use of *Augmented Reality* (AR)-based learning media. By integrating innovative digital learning tools, such as Augmented Reality (AR), with limited access to formal education, this study aims to offer practical and measurable solutions to overcome literacy challenges, especially in reading literacy. Given its implementation at the international level and the potential application of Augmented Reality (AR) in the migrant workers' children's community, this study makes a significant contribution to efforts aimed at improving students' reading literacy competencies. It is in line with the broader goal of improving international assessment scores, such as PISA.

The planned research location is SIKL (Sekolah Indonesia Kuala Lumpur), which was chosen because the institution is tasked with providing educational services for Indonesian children. The technology used is Augmented Reality (AR)-based gadgets, which utilize picture storybooks. There is no reason why gadgets should not be used, as most children already use them in their daily lives for entertainment, which does not provide any benefits. Teachers recognize *Augmented Reality* (AR) as a potential AI-based tool that can improve the quality of learning by stimulating student motivation and interactivity (Rachmadtullah et al., 2024). The use of picture story books is an intermediary for children to read; by scanning the pictures in the book, a pop-up story will appear. *Augmented Reality* (AR) can be an alternative medium that can be used to improve students' reading skills. *Augmented Reality* (AR) has emerged as a transformative educational tool that enhances engagement and comprehension, especially in interactive and visualization-heavy content (Giang et al., 2025).

The use of Augmented Reality in literacy instruction appears to share various teaching/learning potentials that can positively contribute to student reading progress. First, AR makes students interested in reading by making conventional texts more interactive and enjoyable. Research has also shown that AR can enhance students' interest in reading materials by 40% through playful interactions (Alsowat, 2016).

Second, AR has been reported to enhance reading comprehension as well, with its capability in helping students understand abstract concepts. AR helps to increase understanding and insight by creating an "experience" with visually rich data. Studies at the University of Michigan indicate that AR can increase learning retention by as much as 30% (Reigeluth & An, 2020).

Third, AR helps students read faster. When attractions are minimized and students' attention is directed to a balanced work assignment, AR elicits efficient reading (see the 25% increase in speed by Litvin et al., 2020). This efficacy is particularly important for students with few opportunities to engage in formal learning or structured literacy contexts.

Fourth, AR promotes student engagement and motivates learners to be a part of the reading process rather than just a recipient of information. This increased interaction creates a dynamic and supportive environment for literacy development. Furthermore, AR enhances motivation by creating more thrilling and novel experiences. The "novelty effect" of immersive technology could keep learners interested and allow them to learn over time autonomously.

Finally, AR promotes better visualization and contextualization of vocabulary, both of which are important for learning new words and extending reading skills. Because AR is multimodal, with a combination of text, images, sound, and motion to enhance information uptake while avoiding complex language processing (Traxler & Kukulska-Hulme, 2007), it leads to richer cognitive processing, resulting in better vocabulary usage and retention (Sahrim et al.,2023).

This research was conducted in Indonesia, but with a different design; therefore, this research is a continuation of previous research. To facilitate an understanding of the flow and direction of this research, a roadmap is presented. The Augmented Reality implementation is achieved through picture story books created by researchers and teams. The process involves children scanning existing images, which are then displayed as pop-up images along with readings. In this way, children feel happy and enthusiastic about reading books.

METHODS

This study employed a quantitative research approach with a pretest-posttest one-group design to measure the effect of Augmented Reality (AR)-based learning media on the reading skills of Indonesian migrant children in Malaysia. This design was selected to allow the researcher to observe changes in reading performance before and after the intervention, thus assessing the effectiveness of the AR media intervention in a real-world, informal educational context.

The participants were 34 students enrolled in the Sanggar Bimbingan (Learning Studio) At-Tanzil, located in Lembah Jaya, Selangor, Malaysia. These children are part of the Indonesian migrant community and have limited or no access to formal education. The sample included both boys and girls aged 6–12 years with varying reading levels, ranging from early readers to students with minimal literacy exposure. The sampling technique was purposive, focusing on students who had not yet mastered basic reading skills and were available during the research period.

This study adhered to ethical standards in educational research, as outlined by the American Educational Research Association (Association, 2011). Informed consent was obtained from the children's guardians and the institution, and the participants were provided with clear information about the research objectives and procedures. Participation was voluntary, and anonymity and confidentiality were maintained throughout the study. Data were collected using standardized reading skill tests administered before and after AR intervention. The test items were developed to assess three key indicators: (1) letter and word recognition, (2) reading comprehension, and (3) the ability to respond to text-based questions. The instrument was reviewed by two content experts in language education and instructional media to ensure its content validity. In addition, a small-scale pilot test was conducted with a comparable student group in Indonesia to check construct validity and instrument clarity. The reliability of the instrument was confirmed using Cronbach's alpha, which yielded a coefficient of 0.82, indicating a high level of internal consistency. The AR intervention involved the use of picture storybooks enhanced with Augmented Reality features, such as image scanning that triggered pop-up animations, voice-over narration, and interactive content. The implementation was carried out in three sessions over two weeks, with students engaging individually and in small groups under the facilitators' supervision.

Data analysis was conducted using SPSS version 25.0. Preliminary analyses included a normality test using the Kolmogorov-Smirnov test and a linearity test using ANOVA. Upon meeting these assumptions, the effectiveness of the AR intervention was analyzed using a simple linear regression test supported by descriptive statistics. The significance level was set at $p < 0.05$. This approach enabled the researcher to determine both the statistical significance and the effect size of the intervention on students' reading skills

RESULTS

1. Implementation of *Augmented Reality*

One way to improve literacy is through reading skills, and researchers have implemented learning media with Augmented Reality (AR) technology. One of the researchers implemented an informal education program for the children of Indonesian migrant workers in the Selangor area, Malaysia, namely the SB At Tanzil Lembah Jaya Guidance Studio. Children have difficulty getting an education, so they experience a decline in reading, counting, and writing skills. For this reason, it is necessary to increase awareness of collaboration between the government and education volunteers to improve children's skills.

The researcher's initial observation at the SB at Tanzil Guidance Studio in Lembah Jaya, Malaysia, consisted of 81 students from kindergarten to junior high

school levels. Some of the 81 students with different abilities or strata experienced slow learning. At the kindergarten and grade 1 levels.

The activities carried out in this study included compiling learning media in the form of *Augmented Reality* (AR) books. These stages include needs analysis, redesign, trials, and evaluation. Based on these stages, this research collaborates with Islamic library and information science students to design an *Augmented Reality* (AR) book model. At the stage of analyzing the need to make *Augmented Reality* (AR)books, it is based on the need that many children cannot read. Based on the above data, the next step was to compile a book using the *Procreate* application on an iPad to create pictures and stories.



Figure 2. *Augmented Reality* (AR) book model

In the second stage, Design, the research team began to compile an Augmented Reality book by paying attention to the existing problems. *Augmented Reality (AR)* has features that support three main aspects of reading skills:

a. Letter and word recognition, with average improvement before and after learning using *Augmented Reality* (AR);
b. Reading comprehension, which is enhanced through interactive content that improves reading skills; and
c. Answering questions from the text, showing improvement in learning, was measured using multiple-choice questions based on the scanned story.

The immersive experience presented by *Augmented Reality* (AR) also encourages student engagement and motivation in learning, as observed through field notes and teacher interviews. The children responded positively and enthusiastically, showing an increase in participation.

After designing the *Augmented Reality* (AR) book, a validation process was carried out by a team of experts, namely Dr. Choirudin, M.Pd, from Lampung. Several minor errors were identified based on the validation results, which resulted in relatively minor changes.



Figure 3. Implementation of the *Augmented Reality* book model

In the implementation stage, existing lecturers are trained using scenarios prepared by researchers and partners. Furthermore, the study's results were analyzed and calculated to determine their influence on children's reading activities.

At this stage, the *Augmented Reality* (AR) media developed also consists of an interactive picture storybook with the theme of Reyog, where students must scan a barcode that will bring up illustrations using their mobile devices. Once the scanning process is complete, a visual pop-up appears, accompanied by animations, and audio storytelling in a single book enriches children's reading experience. This *Augmented Reality* (AR) book integrates several visual, auditory, and kinesthetic elements that support diverse learning styles. Content or stories tailored to children's reading levels include vocabulary recognition, sentence structure, and simple story comprehension..

To collect data on students' reading ability before and after the implementation of *Augmented Reality* (AR) media, researchers used a test instrument. The test consisted of reading comprehension tasks tailored to the ability level of the children at SB, given in paper format, and directly observed by the teacher and the researcher. In addition, observation sheets and field notes were used to document student engagement and responses during the implementation of *Augmented Reality* (AR) learning. Data collection was conducted over two weeks by the researchers through three meetings at SB At Tanzil in Lembah Jaya, Malaysia, involving 34 students. This mixed data collection approach is consistent with the research methodology.

2. Students' Reading Skills Before and After the Intervention

The results showed a significant improvement in students' reading skills after being given an intervention through Augmented Reality (AR)-based learning media. This is shown in Table 1, which details the average pre-test and post-test scores on three main indicators of reading skills: letter and word recognition, reading comprehension, and ability to respond to text-based questions.

Table 1. Reading Comprehension of Elementary School Students

Indicator	Pretest Mean	Posttest Mean	N-Gain	Category
Letter and Word Recognition	53,97	74,26	0,43	Medium
Reading Comprehension	51,32	71,91	0,42	Medium
Responding to Text-Based Questions	51,32	69,85	0,38	Medium
Overall Average	**52,20**	**72,01**	**0,41**	**Medium**

In the letter and word recognition indicator, the average score increased from 53.97 in the pretest to 74.26 in the posttest, with an N-Gain value of 0.43, which is included in the medium category. The same thing also happened in the reading comprehension indicator, where the average score increased from 51.32 to 71.91, with an N-Gain value of 0.42. Meanwhile, the ability to respond to text-based questions showed an increase from a score of 51.32 to 69.85, with an N-gain of 0.38, also in the medium category.

Overall, the average pretest score was 52.20, which increased to 72.01 in the posttest, resulting in an N-Gain of 0.41. This increase shows that the use of AR media has a significant impact on the development of students' reading skills, especially in informal contexts and marginalized populations, such as the children of migrant workers in Malaysia.

These findings confirm that AR-based media can provide a more interactive and immersive learning experience that increases students' engagement and motivation in reading activities. Thus, the implementation of AR technology in early literacy education can be an innovative solution, especially in overcoming limited access to formal education.

3. Effect of Implementing AR on Students' Reading Skills

The results of this study show that the implementation of Augmented Reality (AR)-based learning media has a significant influence on improving students' reading skills. As shown in Table 2, the results of the simple regression test showed a significance value of 0.012 ($p < 0.05$), which means that there was a statistically significant influence between the pre- and post-test scores on reading skills after the application of AR media. The value of the determination coefficient ($R^2 = 0.136$) indicated that the use of AR media could explain 13.6% of the variation in students' improvement in reading skills. In contrast, other factors outside the variables studied influenced the remaining 86.4%.

Table 2. Coefficient of Determination (R^2)

Model	Coefficient (B)	Std. Error	t-value	Sig. (p)	R	R^2	Adjusted R2
Constant	60,375	5,763	10,477	0,000			
Pretest Score	0,342	0,130	2,629	0,012			
Regression					0,368	0,136	0,116

Furthermore, the effectiveness of the implementation of AR media is also demonstrated through the N-Gain analysis in Table 3, which includes three indicators of reading skills: letter and word recognition, reading comprehension,

and the ability to respond to text-based questions. All three aspects improved in the moderate category, with N-gain values of 0.41 for letter and word recognition, 0.42 for reading comprehension, and 0.38 for responding to text questions. The overall average N-Gain was 0.41, which confirmed that the use of AR had a positive impact on the overall improvement of students' reading skills.

Overall, the quantitative data obtained strengthen the finding that AR media can make a real contribution to improving the important aspects of reading literacy. High student engagement during the AR-based learning process was also observed through field observations, which showed significantly increased enthusiasm and motivation for learning. This proves that the integration of immersive technologies such as AR is not only relevant in the context of formal education but is also effective in strengthening literacy skills in non-formal educational environments, especially for Indonesian migrant children in Malaysia.

Table 3. N-Gain of Reading Skill

Aspect	Pretest Mean	Posttest Mean	N-Gain	Category
Letter and Word Recognition	53,97	74,26	0,41	Medium
Reading Comprehension	51,32	71,91	0,42	Medium
Responding to Text-Based	51,32	69,85	0,38	Medium
Questions				
Overall Average	52,20	72,01	0,41	Medium

4. Implementation of Augmented Reality

This research focuses on the results of the implementation of *Augmented Reality* (AR) books that influence the reading outcomes of migrant workers' children in Malaysia. The data analysis process in this study included a prerequisite test and a hypothesis test. The prerequisite tests in this study included normality and linearity tests. The results of the normality test showed that.

Table 4. Normality Test using One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		46
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	8.28319970
Test Statistic		.088
Asymp. Sig. (2-tailed)		.200[c,d]

The results of the normality test show that the value of sig is 0.200 > 0.05, which means that it is normally distributed. Furthermore, the second test was a linearity test. Based on the results of the linearity test, the following data were obtained:

Table 5. Linierity Test using Anova Table

			Sum of Squares	df	Mean Square	F	Sig.
Posttest * Pretest	Between Groups	(Combined)	1732.571	20	86.629	1.177	.346
		Linearity	485.096	1	485.096	6.591	.017
		Deviation from Linearity	1247.475	19	65.657	.892	.596
	Within Groups		1840.038	25	73.602		
	Total		3572.609	45			

Based on the table above, we can see a deviation from the linearity value of 0.596, which is greater than 0.05. Thus, the data were considered linear. Therefore, when the prerequisite test was met, the hypothesis test process was performed using a simple linear regression test. Hypothesis testing was performed using a t-test and simple linear regression. From the results of the tests performed, the following data were obtained:

Table 6. T-test Results using Coefficients Table

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	60.375	5.763		10.477	.000
	Pretest	.342	.130	.368	2.629	.012

a. Dependent Variable: Posttest

To determine if the regression coefficient is significant, we can conduct a test at a 0.05 probability level. Based on the results of the above test, it can be concluded that the sig value < 0.05, with a sig value of 0.012 < 0.05, which means that H0 is rejected and Ha is accepted, which means that "there is a significant influence between *Augmented Reality* (AR)-based learning media and reading skills in migrant worker children in Malaysia. Furthermore, the value of the determination coefficient in this study is as follows:

Table 7. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.368[a]	.136	.116	8.377

a. Predictors: (Constant), Pretest

b. Dependent Variable: Posttest

Based on the table summary above, the R Square value was 0.136. This means that the AR influence on students' reading ability was 13.6%, while 86.4% was influenced by other variables that were not studied. Based on the above data, it can be concluded that the use of AR on reading ability has a total effect of 13.6%. This means that the decreasing use of *Augmented Reality* (AR) in learning will affect the reading ability of migrant workers' children.

The results of this study can also be seen from the equation of the regression line from the simple linear regression, namely, Y = a + bX. We can see the values of a and b; the regression equation is as follows: Y = 60.375 + 0.342X. The constant number of unstandardized coefficients is denoted by a'. The value in this instance was 60.375. Given that this figure is constant, the consistent value of reading ability (Y) in the absence of AR (X) is 60.375, where b is the number of regression coefficients. The value is 0.342. This figure indicates that every 1% increase in the level of AR (X) use corresponds to a 0.342% increase in reading ability (Y).

DISCUSSION

1. Interpretation of Findings

Based on the results of the research conducted, it can be seen that the use of *Augmented Reality* (AR) learning media has an influence of 13.6% on improving the reading skills of migrant worker children. This suggests that modern media can serve as an alternative to traditional methods for improving reading skills.

According to Azuma (1997), AR provides real-time interaction and 3D visualization, which enhances learner engagement and comprehension. This supports the finding that AR can significantly contribute to reading comprehension improvement, particularly among students with limited learning resources, such as migrant workers' children.

Furthermore, Hwang et al. (2016) found that AR-based learning environments positively influenced students' motivation and understanding of reading comprehension tasks, especially when texts were integrated with interactive media. These results align with the findings of this study, which indicate that AR facilitates active cognitive engagement, which is essential for constructing meaning from texts.

Reading ability is one of the indicators of students' competence in supporting 21st-century education through reading literacy, whereas reading comprehension is necessary for technological advancements, particularly during the Industrial Revolution 4.0, in the direction of Society 5.0 (Kholisna & Sukasih, 2025). Proficient readers can absorb ideas or inspiration conveyed or suggested in a text. Because reading comprehension is one of the outcomes of reading activities that can be tested in learning, it is crucial. (Avivah et al., 2022). Students' reading ability in Indonesia is low in the ASEAN ranking, based on the Programme for International Student Assessment (PISA) 2022 report released by the Organization for Economic Co-operation and Development (OECD) (Nada, 2023).

From a theoretical standpoint, the application of AR in this study reflects Mayer's Cognitive Theory of Multimedia Learning (Mayer & Fiorella, 2021), which posits that students learn more deeply from words and pictures than from words alone. The dual-channel processing and spatial contiguity principles support the use of AR to simultaneously present text and interactive elements, leading to better

retention and comprehension. In addition, Dunleavy and Dede (2014) emphasized that immersive technologies, such as AR, provide contextual learning experiences, which are crucial for under-resourced student populations. This further reinforces the relevance of using AR to bridge educational gaps for marginalized learners.

2. Pedagogical and Policy Implications

The main problem with reading skills is related to students' learning and learning activities; thus, the important problem of reading is how to shape students' learning to read. Given that reading skills are a crucial requirement for students, teachers must design innovative and creative learning that aligns with the current curriculum. Among them is learning that focuses on the construction and development of students' reading skills.

Therefore, efforts have been made to improve reading skills by directly involving students in reading activities, such as the use of *Augmented Reality* (AR). The extraordinarily rapid development of technology provides many problem-solving solutions in learning, one of which is the use of technology. Today's technology-based learning media are not only limited to e-books, videos, and e-learning, but also use newer technologies such as Augmented Reality (Rachmadtullah et al., 2024).

This medium is based on message processing/information processing technology or materials carried out by students to obtain the knowledge, skills, and values expected by students (Widayanti & Juhji, 2023). Through this learning medium, students are trained to understand a problem in the form of reading texts, which they then learn part by section so that their understanding becomes complete, and they achieve the desired learning goal state (*goal state*) (Molina Vargas et al., 2020). In the application of this learning, students are not only assessed by the final result, but also see how students do stage by stage, as well as the process of obtaining and finding the final answer desired by the student(Giang et al., 2025). This is the basis for selecting this learning medium, as it addresses problems related to reading skills.

Some existing studies show that the use of *Augmented Reality* (AR) increases several skills, including student learning outcomes (Sahrim et al., 2023). They explained that the use of *Augmented Reality* (AR) is very beneficial for students in understanding Arabic vocabulary, making it easier (Sahrim et al., 2023). This is in line with the research conducted by Putra et al. (2024), who explained that the use of augmented reality technology as a learning medium has a positive impact on concept understanding and increases student involvement. However, the use of *Augmented Reality* (AR) still has drawbacks, especially related to technology gaps, costs, infrastructure, and teacher training. Therefore, policymakers and educators are expected to strengthen competencies, improve infrastructure, and ensure equitable access to AI in schools (Yusuf, 2025).

To ensure the effective integration of Augmented Reality (AR) in literacy instruction, particularly for students in marginalized communities, educators and policymakers must implement several strategic actions. First, teachers should receive continuous professional development in the use of AR technologies to support pedagogical goals and literacy frameworks. Research by Bacca et al (Bacca et al., 2014) reveals that AR can improve learner engagement, especially when combined with reflective reading strategies and appropriate scaffolding by trained educators

Second, curriculum planners must adapt literacy content to be AR-compatible, ensuring that the available materials are easily accessible, contextually relevant, and aligned with students' cultural backgrounds. This is especially important in areas where traditional printing resources are limited. According to Wu et al. (2013), AR-based learning improves information retention when the content is contextualized and multimodal.

Third, policy-level interventions are essential. Governments and educational authorities should formulate inclusive digital education policies that integrate AR into national literacy strategies. This includes providing funding for devices, localized content development, and robust teacher support systems, as emphasized by Furio et al. (Furió, et al., 2013) in their review of AR implementation in public education.

Meanwhile, from the perspective of practical implications for policy and learning, the results of this study have important implications for policymakers and educators, especially in Indonesian schools abroad. The Indonesian government and educational institutions can consider technology integration, such as Augmented Reality (AR), to improve student literacy, particularly in marginalized areas like migrant communities abroad. Research conducted by Yusuf (2025) suggests that the use of artificial intelligence (AI) and immersive technologies such as Augmented Reality (AR) can enhance learning understanding by increasing student engagement in providing more contextual and personalized learning. In addition, in the context of informal learning abroad, such as SB at Tanzil, *Augmented Reality* (AR) can be an effective distance education solution without relying fully on the energy of face-to-face teachers, in accordance with the direction of the Education 4.0 policy (UNICEF, 2021).

Fourth, gamification elements can be included in *Augmented Reality* (AR) learning media. The purpose of incorporating gamification elements into augmented reality learning media is to motivate children to learn and follow problem-solving flows with enthusiasm, as students at the elementary school level tend to be more engaged with content that incorporates game-like elements. This is in line with research from Udjaja, who explains that gamification is a creative way of learning that has an extraordinary impact on increasing the level of learning independence

and improving one's mathematical skills(Udjaja et al., 2018). Therefore, when designing learning media, it must align with the needs and final goals of the application, which is consistent with A. Biloch conveying that most game elements, as components of games, require task instruments that can be understood by students or unambiguous objectives to function properly, and are preferred by students(Biloch & Löfstedt, 2013).

3. Limitations and Future Research Directions

The findings of the study show that the use of *Augmented Reality* (AR)-based learning media has a positive effect of 13.6% on reading ability, showing that technology can improve reading skills so that early reading literacy is formed. According to Paivio's dual-coding theory (Merç, 2013), cognitive processes can work more effectively when information is presented to students in visual and verbal forms together. *Augmented Reality* (AR) has directly supported this theory because combining text with interactive visual elements can strengthen students' understanding and retention as a whole (Giang et al., 2025). Furthermore, the use of *Augmented Reality* (AR) is also in line with the framework of Constructivist Learning Theory, which explains that students can build meaning through active and contextual experiences (Putra et al., 2024).

Although the implementation of Augmented Reality (AR) in literacy learning has shown promising results, several limitations must be acknowledged to understand the scope of these findings critically. First, the study was conducted on a relatively small group of elementary school students, specifically from a population of children of migrant workers. This limits the generalizability of the results to broader student populations, such as those in urban schools, higher-grade levels, and different cultural backgrounds. Ibáñez and Delgado-Kloos also highlighted that AR interventions often yield different results depending on learners' age, digital literacy, and sociocultural contexts (Ibáñez & Delgado-Kloos, 2018).

Second, the duration of the intervention was relatively short; therefore, it is unclear whether the positive effects of AR on reading skills can be sustained over time. Longitudinal studies, such as those suggested by Radu (2014), are necessary to examine how persistent and transferable these learning gains are, particularly in contexts outside structured learning environments.

Future research should explore the long-term impact of AR on reading comprehension and learner motivation across various educational levels and cross-cultural settings. Additionally, it is important to investigate how blended approaches that combine AR with conventional reading strategies can optimize outcomes. Studies such as those by Yuen et al. (2011) suggest that hybrid models offer a scalable path forward for the sustainable integration of AR in literacy instruction.

CONCLUSION

The results of this study confirm that the use of Augmented Reality (AR)-based learning media has a positive influence on improving the reading ability of Indonesian children in the migrant worker community in Malaysia. With an increase in the average score and N-Gain that is in the medium category and a statistical significance of 0.012, it is proven that AR not only attracts students' attention but is also effective in building basic reading skills, such as letter recognition, reading comprehension, and the ability to respond to text. High student engagement and an interactive learning atmosphere show that immersive technologies such as AR can bridge the limitations of formal education access with a fun and accessible approach.

The novelty of this study lies in the application of picture storybook-based AR in the context of informal education for migrant children, a group that has rarely been addressed by similar research. This study has important pedagogical and policy implications, suggesting that AR-based educational technology can be an innovative solution to address literacy gaps in marginalized environments. In the future, the integration of AR with gamification elements and hybrid approaches at different levels of education should be studied further to expand its impact in a sustainable and cross-cultural context..

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