Journal of English Language and Education
ISSN 2597- 6850 (Online), 2502-4132 (Print)
Journal Homepage: https://jele.or.id/index.php/jele/index

OPEN ACCESS Article

The Effect of Augmented Reality in Gamification-Based Lessons on Students' Reading Comprehension

https://doi.org/10.31004/jele.v10i4.1178

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A B S T R A C T

This study was carried out to find out the effect of gamified Augmented Reality on the reading comprehension of students at a vocational high school in Indonesia. Since Indonesia performs poorly in PISA reading scores, it adopted AR and gamification as means to enhance attention and understanding. It applied a quasi-experimental design that compared the reading scores of students who learned through gamified AR versus those who received conventional treatment. The participants were 10th-grade students from a public vocational high school in East Java, divided into a control and experimental group. Pre-tests and post-tests were used to measure comprehension. Although the Post-test scores of the experimental group were higher, the difference was not statistically significant. The small effect size implies potential benefits from gamified Augmented Reality on enhancing reading. This study justifies integration of AR into English curricula for richer learning experiences and overcoming challenges in reading within vocational education.

Keywords: *Gamified Learning, Augmented Reality (AR), Reading Comprehension, Vocational High School*

Article History:
Received 29th June 2025
Accepted 04th August 2025
Published 09th August 2025

INTRODUCTION

Reading comprehension is one of the critical academic skills. However, there has been a long-standing issue with Indonesian students concerning reading comprehension. Research conducted by Nanda and Azmy (2020) explains that poor reading comprehension skills among Indonesian school students in the English context are mainly influenced by three factors: students' lack of motivation, low level of basic knowledge, and poor English vocabulary. Even after so many literacy reforms, reading literacy among Indonesians lags far behind common international standards. This is proven by a decline in PISA (Program for International Student Assessment) scores conducted by the Organisation for Economic Co-operation and Development (OECD). The results of the PISA 2022 study, released in December 2023, show that Indonesia ranks low, with a reading score of 359, which is far below the OECD average scores for reading, which is 476 (OECD, PISA 2022 Database). These values are decreasing compared to the results of 2018 and are the lowest values since Indonesia participated in the PISA study. The most significant contribution to this disparity is the unavailability of appropriate reading resources in schools, both printed and digital form, with the latter being the most difficult to assess. Since most educational institutions lack access to modern technology, this further prohibits decades of modern learning from spreading its wings conventionally. Moreover, students find the conventional methods used by teachers, which only use textbooks, workbooks, and classroom discussion, very boring. Although there may be some achievement using these methods, the level of interest created does not bring out the enthusiasm for reading. Hence, many students experience a loss of motivation and become disinterested in enhancing their reading skills.

At the rate at which technology is developing, there is more interest in using digital tools, such as gamification and augmented reality (AR), in the methods of teaching (Ivarson et al., 2024). As an area such as reading cannot be put through the old conventional methods, it lacks an interesting approach that these two innovations hold in overcoming reading problems. AR and gamification merge reality with virtual objects for highly engaging learning experiences and can positively affect motivation and engagement. In a country like Indonesia, which faces low reading comprehension and under-resourced schools, this technology could bridge the motivation and engagement gap. For instance, gamification may introduce a reading activity that is both rewarding, competitive, and challenging, making the process interesting and at the same time fun. AR will allow learners to perceive elements of the story or theme in a 3D perspective, enhancing their understanding and interest in the topic presented. This way, educators would be able to provide much more dynamic and effective learning environments that improved reading comprehension for students and thereby countered systemic educational problems.

This research is based on the constructivist theory, which defines learning as an active and experience-based process. According to Piaget (1950) and Vygotsky (1978), constructivist theory presents active learning as involving the learner's direct participation in tasks and decision-making, while experience-based learning connects new information with prior knowledge and personal experiences, making it more meaningful and easier to remember. It thus follows that learners construct knowledge through interaction that has personal significance and relevance. Game-based learning, rooted in this wider context, integrates gameplay principles into the educational environment. It employs gamified activities that correspond with recognized theories of game-based learning in pursuit of engagement, as well as motivation and deeper learning outcomes. Such gamified activities worked well toward making dynamic and interactive learning, resonating with the intrinsic motivations of the learners.

Reading assignments, when gamified into a series of challenges with prizes and interactive feedback, become dynamic and engaging activities. Such tasks involve students actively in some text-based puzzles, with immediate feedback on their levels of understanding. Reading, treated as a passive activity, will become a very engaging and interactive task with the combination of augmented reality (AR) and gamification. AR makes it possible to have an immersive contextual experience wherein students can visualize content and interact with it in ways unimagined before. This paper discusses the possibility of using AR and gamified approaches to help improve reading comprehension skills among Indonesian vocational students. The tools are discussed based on constructivist and game-based learning theories. Indonesian students, who are highly adaptable to technological innovation and prefer collaborative and interactive learning environments (Fitrianto, 2024), can hugely benefit from the implementation of culturally relevant AR content within an educational setting.

Studies conducted throughout the world have shown that from the mid-2010s, gamification and augmented reality (AR) gained increased popularity as techniques in education due to technological progress and a shift in views toward a pedagogy that puts the student at the center. Over the past few years, AR and gamification have been increasingly researched and considered as viable methods for enhancing classroom learning outcomes as well as boosting students' motivation and deep engagement. Research by Bursali and Yilmaz (2019) conducted on Turkish secondary school students and Çelik and Ersanlı (2022) conducted on Turkish high school students showed measurable gains in student achievement, including improvements in reading comprehension, attitude, and autonomy when AR was used. The same results were reported by Chang, Chen, and Liao (2020), conducted on Chinese junior high school students, and Bai, Hew, and Huang (2020), conducted on Chinese university students. They found significantly higher scores reflective of increased motivation, enjoyment, and self-efficacy among students after the treatment. Which then translates to better performance. However, these results were found in well-resourced schools where advanced technological resources are available. Despite the growing adoption of AR and gamification

worldwide, very little research has been done on the application of these innovative technologies to under-resourced schools, such as many in Indonesia. Seeking to fill this gap, the present study explores the possibility of applying these tools to create a more dynamic and interactive learning environment that would make reading more engaging and thus more effective for struggling readers in less advantaged educational settings.

In Indonesia, studies on the utilization of Augmented Reality in English Language Teaching are not widely conducted, the existing ones show positive outcomes toward better student engagement. For example, research by Shaumiwaty et al. (2022) conducted on a teacher who teach English in elementary school proved that AR technologies would be able to increase the engagement of students in the Indonesian classroom significantly; at the same time, this aspect would identify the challenges that need to be rectified in terms of teacher readiness and availability of resources. Moreover, the study by Yelia et al. (2021) conducted on Indonesian university students also found a sudden increased interest and participation among students, but also noted the huge barrier formed by an environment with limited infrastructure and the unavailability of a group of teachers familiar with gamification and augmented reality concepts. The teachers' readiness to use technology acts as another great hindrance due to inadequate preparation and experience. This supports Laliyah and Cahyono's (2017) study on Indonesian English teachers, with her evidence revealing low self-efficacy among Indonesian teachers in integrating technology effectively within the learning environment. Another study by Atmojo and Nugroho (2020) conducted on EFL teachers from 11 different cities and 16 distinct secondary schools in Indonesia indicated that infrastructure barriers, such as low Internet access and low availability of devices, among other problems present in most schools, limit the potential for AR. The current study fills these gaps by evaluating the influence of AR and gamification on reading comprehension, engagement, and motivation of English learners.

Despite the heavy influence in contemporary educational methods, gamification and AR are currently facing difficulties in being properly implemented in Indonesian vocational schools for improving English reading comprehension. There is a scarcity of related studies that give concrete implementation directions. Inequality regarding the availability of technology, as well as the readiness of teachers, serves as an additional barriers to its integration. These would directly provide interactive and immersive experiences that would remove students' low engagement and motivation in reading comprehension, toward developing meaningful and enjoyable connections with texts. This study attempts to evaluate these strategies in the context of improving reading outcomes for vocational high school students in Indonesia.

Although numerous international studies have been carried out on AR and gamification and have proven that these technologies are effective, very little to no research has been conducted on the applicability of such technologies to enhance the reading skills of English language learners in an Indonesian vocational school. That research gap has persisted because, until very recently, these technologies were not used within the local teaching and learning situation. And even now, teacher readiness is a stumbling block, not to mention the lack of appropriate technological infrastructure. It therefore remains unclear how AR and gamification can be implemented in English Language Teaching (ELT) classrooms in Indonesian vocational schools and, consequently, how they influence the reading process, both from a theoretical as well as practical viewpoint. The present paper is an attempt to fill this gap by discussing how those modern reading strategies might be adjusted to the prevailing conditions in a typical Indonesian vocational school, thereby offering some useful suggestions for a more inclusive and effective way of teaching reading.

The primary aim of this study is to assess the effectiveness of integrating gamification with augmented reality in reading comprehension among Indonesian vocational high schools in Indonesia. This study fills various research gaps about the limited exploitation of AR and gamification in Indonesian classrooms and the present impeding barriers, including insufficient technological infrastructure and the low readiness of teachers in adopting these innovative technologies. The success of this research is expected to offer practically useful

evidence that will equip educators to improve reading comprehension, motivation, and engagement, as well as provide actionable recommendations for teaching. That is, it will indicate positive effects from the influence that gamification and AR have on enhanced academic achievement and favourable learning attitudes about closing this gap and moving forward the teaching of English in Indonesia.

This study aims to contribute to the body of knowledge in the field of education research by discussing the influence of using gamification and augmented reality in teaching on the enhancement of English reading comprehension skills among vocational high school students in Indonesia. This study will provide the teaching staff with not only practical methods to integrate these innovations into their lesson plans but also pinpoint the problems related to the diffusion of such knowledge and its outcome. It would also enrich the growing body of knowledge about digital learning by adapting AR and gamification to a low-resourced education system in Indonesia and giving some initial feedback on how well it works. The findings could be of direct relevance to policymakers and curriculum development specialists in helping them generate an informed choice with regard to the effective integration of such methodologies and general reforms in education. Eventually, this research will also improve the program for teaching English in Indonesia to produce more dedicated, capable, and adequately trained students prepared to meet future workplace challenges.

METHOD

The study used a quantitative quasi-experimental design in investigating the effect of gamified Augmented Reality on the reading comprehension of Indonesian vocational high school students. The study was conducted on-site at a public vocational high school in Sidoarjo, East Java, from April 14 to May 09, 2025. This site was selected because the researcher had previously completed a Teaching Internship Program there and noticed that student motivation to read was low. Two non-randomized groups were assigned: an experimental group exposed to gamified AR and control group exposed to conventional treatment. The researcher acted as the main intervener to maintain consistency throughout four meetings. Data was collected through a reading comprehension test adapted from TOEIC/TOEFL as pre-test and post-test. In the scavenger hunt of the experimental group, they used QR codes and Zappar for accessing AR reading tasks whereas the control group received traditional teaching. Data collection consisted of three phases; pre-test, treatment and post-test. Shapiro-Wilk and Levene's for normality and homogeneity in SPSS 26 were checked. Followed by an Independent Samples T-test to check the mean differences, and Eta squared effect size based on Pallant (2020) and Gravetter & Wallnau (2017). This rigorous design made a valid impact on the evidence of integrating gamified AR into English Language Learning

FINDINGS AND DISCUSSION

This study investigated the effects of augmented reality on vocational high school students' reading comprehension in a gamification-based course. The researcher had to perform several steps, including a normality test, a homogeneity test, an independent sample t-test, and effect size test. These steps were necessary to determine significant differences and answer the hypotheses of this study. The results are shown below.

Normality and Homogeneity Assumptions

The Shapiro-Wilk normality test indicated the following: Pre-test Control (Sig. = 0.108) and Experimental (Sig. = 0.161) groups; Post-test Control (Sig. = 0.112) and Experimental (Sig. = 0.105) groups- all greater than 0.05, meaning the data is normally distributed. Additionally, Levene's test for homogeneity showed that the variance of the reading test scores was homogenous because its significance values ran from 0.083 to 0.118 (all > 0.05). The data therefore, met the assumptions for parametric analysis.

Pre-Test Score Comparison

Before the treatment was given, both groups completed a pre-test to assess their baseline reading comprehension. This step was essential to ensure that both groups began the intervention at a similar level of understanding.

Group	N	Mean	Std. Deviation	Std. Error of Mean
Control	35	63.69	17.563	2.969
Experimental	38	60.18	17.292	2.805
Total	73	61.86	17.390	2.035

Figure 1. The Mean Score of Pre-Test from Experimental and Control Groups

According to the pre-test results, the experimental group (N = 38) had a marginally lower mean score of 60.18 with a standard deviation of 17.292, while the control group (N = 35) had a mean score of 63.69 with a standard deviation of 17.563. 61.86 was the overall average for both groups. Prior to the treatment, the two groups' reading comprehension skills appear to have been about the same, based on the comparatively similar means and standard deviations.

The researcher used SPSS 26 to analyze the independent sample t-test after obtaining the mean score from the pre-test. The following explains the findings of the independent sample T-test between the experimental and control groups:

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pre-test Score	Equal variances assumed	.865	.355	.858	71	.394	3.502	4.082	-4.637	11.640
	Equal variances not assumed			.857	70.31	.394	3.502	4.084	-4.644	11.647

Figure 2. The Result of the Independent Sample T-Test of the Pre-Test Score

The results of the independent samples t-test show a t-value of 0.858 with a degree of freedom (df) = 71, and a Sig. (2-tailed) value of 0.394. Since this p-value is greater than α = 0.05, the result is not statistically significant. This indicates that there is no statistically significant difference in the mean pre-test scores between the experimental group (M = 60.18) and the control group (M = 63.69). To put it another way, prior to the application of the gamified AR treatment, both groups' reading comprehension skills were essentially equal. This supports the fairness of comparing their performance on the post-test later on and validates the validity of the experimental design.

Post-Test Score Comparison

For the second phase, the researcher examines post-test data from the experimental and control groups using SPSS 26 in order to get the average score for both classes. The following lists both groups' average post-test scores and an explanation for each:

Group	N	Mean	Std. Deviation	Std. Error of Mean
Control	35	71.83	12.126	2.050
Experimental	38	76.13	15.370	2.493
Total	73	74.07	13.982	1.637

Figure 3. The Mean score of Post-Test from Experimental and Control Group

The post-test mean scores show that students in the experimental group, who were taught using gamification-based augmented reality (AR), had a higher mean score (M = 76.13, SD = 15.370) than students in the control group, who were taught using conventional methods (M = 71.83, SD = 12.126). The potential benefits of incorporating gamification and augmented reality tools into the English language learning process, especially in enhancing reading

comprehension skills, are indicated by this numerical difference of roughly 4.3 points. The data also points to a reasonably consistent score distribution within each group, as both groups' standard deviations were rather comparable.

Although descriptive statistics show an observable difference, an independent sample t-test was used to perform an inferential statistical test to ascertain whether the observed difference is statistically significant or could have happened by chance.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Post-test Score	Equal variances assumed	3.037	.086	-1.320	71	.191	-4.303	3.259	-10.80	2.195
	Equal variances not assumed			-1.333	69.41	.187	-4.303	3.228	-10.74	2.135

Figure4. The Result of the Independent Sample T-test of the post-test score

The findings of the independent samples t-test indicate a Sig. (2-tailed) value of 0.191 and a t-value of -1.320 with a degree of freedom (df) = 71. Given that the p-value exceeds α = 0.05, the outcome is not considered statistically significant. In other words, although the experimental group did outperform the control group on average, the difference is not significant enough to be deemed statistically significant.

Effect Size (Eta Squared)

The effect size was computed to give further understanding of the influence of the treatment. The outcome was an Eta Squared value of 0.024, which is, according to Pallant (2020), within the "small effect" range (criteria: .01 = small, .06 = moderate, .14 = large). This finding suggests that the experimental group's mean score was only a little higher than the control group's, and in reality, there isn't much difference between these two teaching methods (gamified AR vs. conventional) on the reading comprehension of learners. This result goes hand in hand with the t-test outcome, whereby it was found that there is no statistically significant difference in post-test scores.

Discussion

The research examined how gamified augmented reality (AR) learning affects reading comprehension among vocational high school students. To answer this, a quasi-experimental design was applied by comparing two groups, in which scavenger hunt activities facilitated by AR were introduced to one group as a supplementary reading lesson (experimental group), while the other received its reading instruction through teacher-centered approaches (control group) without any AR intervention. The discussion attempts to explain, based on differences in pre-test and post-test scores of these groups, how AR gamification may mold students' comprehension abilities. The discussion will also relate these findings to learning theories, previous research, and the conditions of the Indonesian vocational school setting where this data was collected.

The findings show that the experimental group achieved a higher post-test mean score of 76.13 compared to the control group's score of 71.83, indicating positive results from AR-based instruction. However, the independent samples t-test resulted in a p-value of 0.191, which exceeds the standard significance threshold of 0.05. Therefore, the null hypothesis (H0 which stated that there is no significant difference in reading comprehension scores between students taught using gamified AR and those taught using a conventional method, cannot be rejected. From a statistical point of view, it shows that the treatment did not produce enough effect to meet the significance threshold, although it does not deny that a real-world difference may occur in practice.

Comparison of the findings of this study with that of other leading works shows a contrast in the way gamified augmented reality (AR) affects reading comprehension outcomes in different settings. Previous works, such as those by Çelik and Ersanlı (2022) and Bai, Hew,

and Huang (2020), have made it pretty clear that AR integration into the English language learning process can lead to significant gains in reading skills, vocabulary knowledge and motivation among students. For example, Çelik and Ersanlı (2022) pointed out that AR applications improve students' comprehension because they provide interactive visualization support for abstract concepts, such support makes texts more understandable. Similarly, the finding reported by Bai, Hew & Huang (2020) was that AR-supported reading activities foster a higher degree of learner engagement as they combine traditional text with immersive multimedia that can facilitate active learning and sustained attention. These studies often indicate that students not only performed better on comprehension tests but also developed more positive attitudes toward reading activities. Research further carried out in well-resourced educational settings revealed that AR serves as a link between the theoretical reading material and real-life contexts, hence, it increases the authenticity and relevance of language tasks, mainly for EFL learners. All these points to the fact that the visual, auditory, and kinesthetic stimuli provided by AR seem to fit multi-modal learning theories and thus help take information more effectively from different kinds of learners. The present study, although it recorded a higher post-test mean score in the experimental group, failed to be statistically significant. In other words, while international evidence has great confidence in the inherent potential of AR to enhance comprehension, the impact varies with implementation and circumstance. In the Indonesian vocational school setting, challenges revolve around technology readiness and consistent infrastructure that can affect the smooth integration of AR into daily lessons. This general contextual gap helps explain why the transformative benefits of AR that are widely documented abroad might not immediately produce comparable measurable outcomes when applied in less digitally mature environments.

The short intervention period was most probably the main factor that limited the full potential of the gamified AR treatment in this study. The experimental group only interacted with the activities based on AR for a few meetings within a couple of weeks. In terms of technology-integrated learning, a short exposure period typically doesn't give students enough time to adjust to new digital tools and to absorb content in a meaningful way. As stated by Bursali and Yilmaz (2019), long-term use of AR-based reading materials should lead to significant comprehension gains since learners require repeated practice and exposure to multimedia content to help deepen their understanding. Thus, it is also problematic because it allows even less time for teachers to further develop their scaffolding skills and adjust the pace of lessons according to students' growing comfort with using the technology. Additionally, complex AR content may take longer for learners to interactively investigate and make connections in their prior knowledge. In this study, though learners showed excitement during the AR scavenger hunt, the short duration didn't give much room for that enthusiasm to translate into measurable improvements in test performance.

Another influential factor relates to the students' different levels of digital literacy and intrinsic motivation in using AR technology appropriately. In this study, some students did not have much prior experience with AR applications or interactive learning environments, therefore, they might not be able to fully avail themselves of the offered tools. As Ertem (2009) indicates, reading comprehension is not only a result of decoding the text but also depends on background knowledge and cognitive strategies of the readers as well as familiarity with supportive technologies. If learners do not feel confident in using new interfaces, then more of their attention might be devoted to struggling with navigation than with constructing meaning from the text. Furthermore, individual differences in motivation might multiply that difference as less motivated learners quickly disengage when there are technical glitches or even unfamiliar tasks. The study observed that although some students accepted the changes and participated effectively, some students were less enthusiastic, thus affecting the uniformity of the AR impact.

Additionally, the positive aspects of gamified AR's visual and interactive features did not guarantee that improved comprehension outcomes would occur due to other factors such as students' motivation and engagement levels. During the research period, the experimental

group's learning hours were in the last 4 periods of the school day, which were after noon, a time when students typically experience fatigue and decreased concentration and motivation due to prior academic activities. This observation is supported by Deng and Wu (2022), who found that students generally exhibit lower levels of motivation and learning effectiveness during later hours of the school day due to accumulated fatigue and decreased alertnessFurthermore, while AR's novelty can initially catch students' attention, keeping that interest requires sustained interactivity and task variation which may not be possible within short fixed time slots. A combination of end-of-day fatigue and limited practice time probably prevented students from fully internalizing the reading strategies embedded in the AR materials. So, while observations indicated that AR gamification boosted short-term engagement, the broader impact on comprehension performance was muted by circumstantial drops in motivation and focus.

Another crucial pedagogical factor that might have influenced the outcome is the abrupt shift in teaching styles. Before this, students were used to having structured lessons with lectures, and the teacher would control the tempo and flow of information. However, the gamified AR activities demanded more autonomy from learners to navigate the tasks on their own, and also work with peers in scavenger hunts, which corresponds well with constructivist principles of learning as advocated by Piaget (1950) and Vygotsky (1978). This abrupt change without gradual scaffolding might lead to confusion and cognitive overload in unprepared learners for self-regulated exploration. Several students in the experimental group appeared to have difficulty in simultaneously managing content comprehension with technical navigation, therefore, a mismatch between their previous habits of learning and the demands of a new method probably watered down the effectiveness of the AR intervention.

Finally, technological infrastructure limitations continued to pose challenges during the implementation of AR activities in this study. Though tools like Zappar were chosen based on their availability, app performance seemed to be running slowly for some of the students, with unresponsive QR code scanning, and unstable internet, particularly in less technologically robust parts of the school. These issues delayed scavenger hunt tasks that were assigned to the students, which ended up making some of them frustrated. Atmojo and Nugroho (2020) noted a lack of adequate infrastructure as one of the main obstacles in Indonesian schools; this study reaffirms that even well-designed digital interventions can fizzle without reliable technical support. It frustrates not only learners' attention but also their motivation to engage with AR material. For many learners, repeated technical failure can overshadow the novelty and appeal of AR content, leading to superficial interaction rather than deep reading comprehension

Although the results of the independent samples t-test were not statistically significant, further analysis using Eta squared showed an effect size of 0.024, which, according to Pallant (2020) belongs to the "small effect" range. This finding indicates that the implementation of gamified augmented reality (AR) has a small observable effect on improving students' reading comprehension performance. A small effect size indicates that in the short run, it may have limited practical significance, nonetheless, it does demonstrate that AR-based learning leads to some learning gains beyond chance. This is in line with Danaei et al.'s (2020) and Bacca et al.'s (2014) research that even small AR interventions can positively influence motivation and engagement, a key factor leading to improved comprehension, as their enhancement leads to better understanding. The small effect size also supports the idea that just a short time of treatment and the novelty of the AR method might have held back its readily noticeable impact. In future uses, lengthening the exposure period and making AR a more regular part of the course could increase this effect. Overall, the small but positive effect shows that gamified AR has potential and needs further development as a helping learning tool for improving reading comprehension in vocational high school settings.

This study also offers valuable insights into how augmented reality (AR) and gamification can be successfully merged with the Indonesian English Language Teaching (ELT) curriculum to improve students' reading comprehension and engagement. The implementation of AR was done through scavenger hunts based on QR codes that led students

to engage in active, exploratory learning with immediate feedback, in other words, learning that is constructivist as promoted by Piaget (1950) and Vygotsky (1978). But for this integration to take place on a larger scale, important aspects have first to be considered. First, teachers need training, not just one-time training but continuous professional development opportunities, to acquire technical skills and pedagogical strategies for managing AR-based gamified activities. More importantly, there has to be a gradual shift from conventional teacher-centered pedagogy to student-centered approaches so that learners will not get confused during the change in the style of learning. Infrastructure improvements, stable internet connections, and readily available mobile devices are also part of what is needed to address seamless AR experiences without technical disruptions. More importantly, in the context of vocational schools, the design of AR and gamified learning materials should closely relate to the students' practical training and future working environment for maximum relevance and motivation. The reading tasks, being a part of or operating within the AR environment and relating real-world applications to students' majors, enhance retention as well as practical language use.

Based on the findings and limitations of this study, the following recommendations are proposed for future research to maximize the potential of gamified augmented reality (AR) in improving reading comprehension. First, future studies should have a longer intervention duration so that the long-term effects of AR and gamification on students' reading skills can be ascertained. As noted by Bursali and Yilmaz (2019), extended exposure provides students with more time to get acquainted with technology and adjust to new ways of learning while deepening their understanding through practice reinforced several times over. Second, it is highly recommended that future researchers provide comprehensive training for both the teachers and students before and during the intervention. The training should include technical skills, troubleshooting, and pedagogical strategies so that AR tools can be used effectively rather than becoming a source of distraction or frustration. Also, adding qualitative research methods like classroom observations, interviews, and noting student thoughts would give a deeper understanding of how students see AR-based gamification and how it affects their drive, feelings, and involvement beyond what scores alone can show. Finally, fixing the infrastructure problems that still exist in many Indonesian schools is key. Researchers and educational stakeholders should find ways to make sure there is a steady internet link, enough devices available, and easy AR tools that work well even in places with few resources. By thinking about these recommendations, future studies can build on current work and provide stronger proof on how gamified AR can be made a lasting part of language learning plans, especially in vocational high schools where hands-on and engaging learning is critical for student achievement.

To sum up, this study proves that the integration of gamified augmented reality in reading comprehension activities has immense prospects to engage students and make the learning environment more dynamic in vocational high schools. The quantitative data indicated that the experimental group registered higher mean post-test scores than the control group, however, the difference was not statistically significant. In other words, short-term implementation on its own may not be adequate to yield substantial gains in test performance. However, qualitative observations and a small effect size suggest that AR gamification positively influences students' enthusiasm, active participation, and motivation, all critical factors for sustained learning progress. Infrastructure support, teacher readiness, and students' technological competence are crucial for the successful uptake of AR in the Indonesian ELT setting. There should be stable internet connectivity in schools with functional devices and accessible AR applications to avoid technical disruptions during lessons. Equally important is the gradual shift of the traditional teacher-centered approaches to the more student-centered exploratory learning, which must be carefully scaffolded and guided so as not to become confusing and lead to disengagement. It is therefore highly recommended that future research extend the treatment period, provide more intensive training for both teachers and students, and include qualitative methods such as interviews and observations in order to obtain deeper insights into the learning process. With those factors addressed, gamified AR

could graduate from being just a novel experiment in the classroom to a strong mediator between theoretical knowledge and practical application, leading to enrichment in reading comprehension as well as equipping vocational students with essential 21st-century skills

CONCLUSIONS

This study investigated the impact of gamified Augmented Reality (AR) on students' reading comprehension in English language learning at an Indonesian vocational high school, revealing that the experimental group engaging in AR-based scavenger hunt activities achieved higher mean post-test scores than the control group taught through conventional methods; however, the difference was not statistically significant ($p = 0.191$) and the effect size (Eta squared = 0.024) suggested only a small positive effect. While the findings indicate that gamified AR holds potential to enhance engagement and comprehension, short-term application alone may not lead to substantial score improvements. The research contributes to the understanding of AR and gamification in vocational ELT by outlining interactive, student-centered approaches and highlighting challenges such as limited intervention duration, disparities in students' digital skills, and inadequate infrastructure. It emphasizes the need for specialized teacher training and enhanced school digital resources to fully leverage AR's benefits, recommending that future studies implement longer interventions, combine quantitative and qualitative methods, and adapt AR tasks to vocational contexts to ensure sustained engagement and measurable literacy gains, thereby advancing technology-driven language instruction and preparing students with essential 21st-century skills.

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