

The application of Augmented Reality (AR) technology to improve students' short story writing skills at SMA N 1 Jombang

Arisni Kholifatul Amalia Shofiani^{a, 1, *}, Alfian Setya Nugraha^{a, 2}, Raras Hafidha Sari^{a, 3}, Eko Hardianto^{a, 4}, Ahmad Faizi^{a, 5}, Agus Sulton^{a, 6}, Haris Supratno^{b, 7}

^a Universitas Hasyim Asy'ari Tebuireng, Jombang, Indonesia

^b Universitas Negeri Surabaya, Surabaya, Indonesia

¹ arisnishofiani@unahsy.ac.id; ² alfiansetyanugraha@gmail.com; ³ rarashafidhasari@gmail.com; ⁴ agussul342@gmail.com; ⁵ ahmadfaizi@unhasy.ac.id; ⁶ ekohardianto@unhasy.ac.id; ⁷ harisuspratno@unesa.ac.id

* Correspondent author

Received: November 4, 2025

Revised: April 17, 2026

Accepted: April 18, 2026

KEYWORDS

Augmented Reality Writing Short Stories Technology Based Learning

ABSTRACT

This study aims to analyze the effectiveness of the application of *Augmented Reality technology*. *Reality (AR)* in improving the short story writing skills of high school students, who still face obstacles in developing ideas, narrative structure, and learning motivation. The study used a quasi-experimental design with a *pre-test* and *post-test*. *control group* This design involved 60 eleventh-grade students at SMA Negeri 1 Jombang. Data were collected through short story writing tests, motivational questionnaires, and interviews, and analyzed using *paired-reference tests*. *sample t-test*, *independent t-test*, and *effect* The results showed that the experimental group using AR experienced a significant increase compared to the control group, with an average score increase of 25.95% compared to 7.05%. Statistical tests showed a significant difference ($p < 0.05$) with an *effect* The size of the medium-high category. In addition, students' learning motivation in the experimental group was higher (8.5/10) than in the control group (6/10). These findings indicate that AR effectively improves the quality of short story writing in terms of ideas, narrative structure, and language style, as well as increasing student engagement in learning. This study contributes to the development of technology-based writing learning models by systematically integrating AR into the writing process. The limitations of the study lie in the limited duration of the intervention and the narrow sample scope. Future research is recommended to test the implementation of AR on a wider scale and over a longer period.

© 2026 The Author(s). Published by Universitas Ahmad Dahlan.
This is an open-access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.



Introduction

In the digital era characterized by rapid technological developments and the need for 21st-century competencies, secondary education no longer emphasizes only basic literacy, but also critical thinking skills, creativity, collaboration, and adaptability to technology (Baiti, 2024; Maulana, 2024). This educational transformation encourages schools to integrate digital technology into learning so that students are able to face global challenges (Özdemir & Akyol, 2021). In the Indonesian context, these efforts are strengthened through the implementation of the Merdeka Curriculum, which emphasizes project-based learning, differentiation, and strengthening literacy competencies. Furthermore, the School Literacy Movement also places reading and writing skills as core competencies that must be developed sustainably. However, the implementation of literacy learning, particularly learning to write literary works such as short

stories, still faces various obstacles at the secondary school level. Learning to write short stories is often still carried out through conventional teacher-centered methods, such as providing sample texts and writing assignments without adequate media support (Alfa & Astuti, 2025). This condition causes students to experience difficulties in developing ideas, building storylines, and expressing imagination creatively (Setiawan et al., 2022).

These problems impact students' low motivation in learning to write short stories. Students tend to view writing as a difficult and less interesting activity because it is not supported by contextual and visual learning experiences. In addition, limited interesting learning resources and the lack of use of learning technology are also factors that hinder the development of students' creative writing skills. Previous research shows that low motivation, limited visualization of ideas, and lack of student engagement are the main obstacles in learning to write short stories in secondary schools (Heydemans, 2024). This condition indicates the need for learning innovations that can provide a more interactive, contextual learning experience and support students' creative processes. One technology that has the potential to overcome these problems is Augmented Learning Reality (AR).

Augmented Technology Augmented Reality (AR) enables the integration of virtual objects with the real world in real time, thereby enhancing interactivity and visualization in learning (Heydemans, 2024). In language and literature learning, AR can be used to visually display characters, settings, and story conflicts, helping students understand narrative structure and develop story ideas. Several international studies have shown that the use of AR can increase student engagement, conceptual understanding, and learning outcomes by providing an immersive learning experience (Chang, 2022; Geroimenko, 2020). AR also allows students to interact directly with learning objects, thereby increasing active participation in the learning process. In the context of writing lessons, visualizations presented by AR can help students in the pre-writing stage, developing flow, and developing language style. Research in the Indonesian context also shows that the use of AR-based learning media can increase students' learning motivation and conceptual understanding (Trikotama, 2024).

Pedagogically, AR acts as a learning scaffold that helps students develop story ideas through more concrete visualizations. This approach allows students to gain a more contextual and collaborative learning experience. Furthermore, AR also supports exploration-based learning that encourages students to develop creativity in writing. Previous studies have shown that the use of AR in language learning can improve students' literacy skills, creativity, and writing quality (Kazlaris et al., 2025; Maulana, 2024). Thus, AR functions not only as a technological medium but also as a pedagogical approach that supports creative writing learning.

Although various studies have demonstrated the potential of AR in learning, most studies still focus on improving learning motivation, student engagement, or overall learning outcomes. Research related to the use of AR in language learning has also been conducted more in the context of foreign language learning or reading skills. Research specifically examining the application of AR in short story writing learning for Indonesian high school students is still very limited (Tolibovna, 2023; Özdemir & Akyol, 2022). Furthermore, previous studies generally only measure improvements in average grades without comprehensively analyzing writing quality. Important aspects of short story writing, such as story idea development, narrative structure, and style have not been analyzed in depth.

In addition to these gaps, the pedagogical implementation aspects of AR use in literature learning are also rarely discussed. Previous research has not examined how AR is used in the writing learning process systematically, from the pre-writing stage, writing, to revision. Factors such as teacher readiness, school technical conditions, and strategies for using AR in literature learning have also not been widely analyzed. In fact, the success of technology implementation in learning is greatly influenced by pedagogical aspects and classroom context (Utama, 2025). Therefore, research is needed that not only tests the effectiveness of AR on learning outcomes but also analyzes the process of its implementation in short story writing learning.

Based on the background and research gaps, this study aims to explore the application of Augmented Reality technology. Reality in short story writing for high school students. Specifically, this study aims to: (1) analyze the application of AR in short story writing learning pedagogically; (2) test the effect of AR use on students' short story writing skills, which include story ideas, narrative structure, and language style; and (3) identify supporting factors and challenges in implementing AR in literature learning in high school. The scope of the study focused on high school students in short story writing learning using a quasi-experimental design to compare groups using AR and conventional learning groups.

This research is expected to provide theoretical and practical contributions. Theoretically, this research enriches the literature on technology-based creative writing learning, particularly the use of AR in literature learning. Practically, the results of this study can be a reference for teachers in designing more interactive and contextual short story writing learning. In addition, this study also provides an overview of effective AR implementation strategies in literature learning in secondary schools. Thus, this research is

expected to encourage the integration of AR technology in short story writing learning more optimally and support the development of students' creative literacy skills (Utama, 2025; Rohman et al., 2024; Ford, 2023).

Method

This study used a quasi-experimental design with a pre-test and post-test approach for two groups of students (Tashakkori & Teddlie, 2003; Utama, 2025). The experimental group used AR technology in a short story writing lesson, while the control group followed a conventional lesson. This design was chosen because the actual school context does not allow for full randomization (Rohman et al., 2024), but allows for measuring changes in students' writing skills as a result of the intervention. Previously, similar studies Geroimenko (2020) have adopted a quasi-experimental design to evaluate the effects of AR on students' writing skills (Tolibovna, 2023; Wayan et al., 2024). The subjects of the study were students at SMA Negeri 1 Jombang, who were selected using purposive sampling, where two classes with relatively equivalent writing ability characteristics were designated as the experimental and control groups. Each class consisted of approximately 30 students, resulting in a total sample size of approximately 60 students (Mishra et al., 2019).

This decision considered the sample size of many similar AR studies conducted at the secondary school level. The subjects of the study were 11th-grade students of SMA Negeri 1 Jombang, selected using purposive sampling based on the following criteria: (1) the level of writing ability is relatively equivalent based on the previous semester's Indonesian Language score; (2) balanced number of students; (3) the same supervising teacher, and (4) schedule equal learning.

Two classes were selected as the experimental and control groups, each consisting of 30 students, resulting in a total sample of 60 students (Mishra et al., 2019; Al-haddad et al., 2024). Group equality was tested using the homogeneity test (Levene test) and normality test (Kolmogorov-Smirnov) on pre-test scores. The test results showed that both groups had a normal distribution ($p > 0.05$) and homogeneous variance ($p > 0.05$), so they were worthy of comparison.

- a. The short story writing test (pre-test and post-test) was assessed using an analytical rubric covering aspects of story idea, narrative structure, style, and writing mechanics (e.g., spelling, punctuation). This approach aligns with AR research that measures the quality of students' writing (Al-Refaey, 2022).
- b. A questionnaire on student motivation and engagement, using a 5-point Likert scale, was used to measure changes in students' writing motivation after the AR intervention. This motivational component is often reported as the impact of AR on writing learning (Tolibovna, 2023).

Research Procedures

- a. Preparation: Researchers trained literature teachers on the use of AR applications and prepared short story learning materials (Henuk, 2025).
- b. Pre-test: Both groups (experimental and control) were given a pre-test on short story writing.
- c. Intervention: The experimental group participated in an AR-based short story writing lesson for 6–8 sessions, using 3D visualizations, AR story characters, and collaborative activities through AR. The control group participated in a conventional short story writing lesson (discussions, written assignments) (Harefa et al., 2023).
- d. Post-intervention test: After the intervention was completed, both groups were given a short story writing test and a motivation questionnaire.
- e. Interviews and observations: Researchers observed the experimental class and conducted interviews to collect qualitative data about students' and teachers' experiences.

Data analysis

Data analysis was conducted in stages to ensure the research results were accurate and comparable. First, a normality test was conducted. Kolmogorov – Smirnov is used to determine whether the data is normally distributed before parametric analysis is carried out (Aslam, 2024; Garg et al., 2021). Second, Levene's homogeneity test was conducted to ensure that the variances of the two groups were equal as a comparative test (Babatimehin et al., 2025; Gupta et al., 2022). Third, a paired A-sample t-test was used to determine the differences in writing ability before and after treatment in each group (Niyas et al., 2021). Fourth, an independent sample t-test is used to compare the improvement between the experimental and control groups.

Next, the effect size (Cohen's d) was calculated to determine the magnitude of the effect of AR use on students' writing skills so that the results do not only depend on statistical significance (Rahayu et al., 2024; Lakens, 2013). The normalized gain score (N-Gain) was used to see the level of improvement in students' abilities from pre-test to post-test proportionally in educational research (Setiawan et al., 2022; Elsayir,

2024). In addition, analysis of variance (ANOVA) was conducted to see data variations between groups and strengthen the interpretation of the research results (Cui et al., 2021). Finally, the frequency distribution of scores was presented to describe the distribution of students' scores more clearly so that changes in abilities could be observed descriptively (Al-haddad et al., 2024).

f. N-Gain Formula:

$$g = (\text{post-pre})/(\text{max-pre})$$

Category:	Number
Tall	> 0.7
Currently	0.3–0.7
Low	< 0.3

In this study, data on students' short story writing abilities are presented descriptively to provide a comparative overview between the experimental and control groups. The mean (average) is used to show the average value of students' short story writing abilities in the pre-test and post-test, so that improvements can be identified after the use of AR. If the mean, the post-test scores of the experimental group were higher than those of the control group, indicating the effect of AR use on writing skills. Standard deviation is used to assess the distribution of student scores relative to the average. A small standard deviation indicates relatively even student abilities, while a large standard deviation indicates greater variation in abilities Cohen et al. (2023) presented to strengthen information regarding the level of data diversity in each group.

Next, the minimum and maximum scores were used to determine the lowest and highest scores obtained by students, thus showing the range of short story writing abilities. The distribution of scores was presented in low, medium, and high categories to illustrate the distribution of student abilities before and after the AR intervention, so that changes in learning outcomes could be seen more clearly and comprehensively (Cohen et al., 2023; Askarian et al., 2023). The presentation of descriptive statistics is important to provide an initial interpretation of the experimental results before conducting inferential analysis.

Validity and Reliability

To ensure the validity of the instrument, the short story writing rubric and questionnaire were validated by experts (literature teacher Mrs. Raras Hafidhasari, S.Sos., M.Hum. and educational technology expert, Mr. Edwin Harimurti, M.Kom.). The reliability of the questionnaire was tested using Cronbach's α and was expected to be ≥ 0.70 . The researchers also applied data triangulation (quantitative and qualitative) to strengthen the validity of the study, in accordance with practices in AR learning research (Sugiri & Cahyadi, 2020; Setiawan et al., 2025).

Research Limitations

This study has limitations due to the relatively short intervention period (approximately one semester), the use of only one school, and the variability of AR devices, the quality of which may have varied across students. These limitations should be considered when interpreting the results.

Results and Discussion

Results

Prior to the implementation of AR technology, students in the experimental and control groups were given a short story writing test to determine their initial abilities. This test measured the following aspects:

1. Story idea: The quality of creativity and clarity of the story theme.
2. Narrative structure: Organization of the story (introduction, development, climax, and conclusion).
3. Style: Use of appropriate and varied language.
4. writing etiquette: Correct use of punctuation, spelling, and paragraphing.

Table 1. Comparison of Pre-test and Post-test

Group	Mean Pre-test	Mean Post-test	Elementary School	Variance	Increase (%)
Experiment	60.5	76.2	8.12	65.93	25.95
Control	61.0	65.3	7.45	55.50	7.05

The percentage increase is calculated using the formula:

$$\text{Improvement (\%)} = (\text{Post-test} - \text{Pre-test})/\text{Pre-test} \times 100$$

Experimental group:

$$= (76.2 - 60.5) / 60.5 \times 100 = 15.7 / 60.5 \times 100 = 25.95\%$$

Control group:

$$= (65.3 - 61.0) / 61.0 \times 100 = 4.3 / 61.0 \times 100 = 7.05\%$$

These results indicate that the improvement in short story writing skills in the experimental group was higher than in the control group. The difference in average scores between groups indicates that the use of innovative learning media can have a significant impact on improving students' writing skills (Askarian et al., 2023; Cohen et al., 2023). The standard deviation of the experimental group also shows that variations in student abilities are still in the moderate category, so that improvements occur relatively evenly. The standard deviation is not too large indicating that the improvement in abilities does not only occur in a small number of students, but in almost all group members. Thus, these results strengthen the fact that technology-based learning interventions can consistently improve writing skills in most students (Dureja & Madduri, 2023).

Statistical Test

To test the significance of the difference between the experimental group and the control group, a paired t-test and an independent t-test were performed.

1. Paired t-test was used to measure changes in the experimental and control groups from pre -test to post-test.
2. The independent t-test was used to compare the differences in scores between the experimental and control groups after the intervention.

1. Paired t-test

The results of the paired t- test show:

- a. Experimental group: $t = 5.42$; $p < 0.05$ (significant)
- b. Control group: $t = 1.56$; $p > 0.05$ (not significant)

This means that there was a significant increase in the group using AR.

Paired t-test formula: $t = \frac{\bar{d}}{s_d/\sqrt{n}}$

Explanation:

- \bar{d} = the average difference between pre-test and post-test scores.
- s_d = standard deviation of the difference in scores.
- n = sample size.

The calculation results show that the t-value for the experimental group was 5.42 and for the control group was 1.56. Based on statistical tests, the experimental group showed a significant difference ($p < 0.05$) between the pre-test and post-test, while the control group did not experience a significant difference (Puspita, 2020).

2. Independent t-test

Hypothesis:

- a. H_0 : There is no significant difference between the post-test scores of the experimental group and the control group.
- b. H_1 : There is a significant difference between the post-test scores of the experimental group and the control group.

Independent t-test formula:

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Explanation:

- \bar{x}_1, \bar{x}_2 = the mean post-test score of the experimental group and the control group.
- s_1^2, s_2^2 = variance of post-test scores for the experimental group and the control group.
- n_1, n_2 = Number of samples in each group.

The calculation results showed a t value of 4.75 with a p value < 0.05 , which indicated a significant difference between the experimental group and the control group after the AR intervention.

Student Motivation

Based on questionnaires administered after AR implementation, students in the experimental group showed a significant increase in motivation to write short stories. The average student motivation score was 8.5/10, while the control group only scored 6/10. This indicates that the use of AR in teaching short story writing can increase student engagement (Novitaningrum, 2023) can be seen in Table 2.

Table 2. Student Motivation Scores

<i>Group</i>	<i>Average Motivation Score</i>
Experimental	8.5
Control	6/10

Discussion

Based on the results of data analysis, the application of Augmented Reality (AR) technology in learning to write short stories showed significant improvement in the experimental group compared to the control group. This improvement was evident from the higher average post-test score, as well as the larger difference in score improvement in the experimental group. Furthermore, the standard deviation value in the experimental group was in the moderate category, indicating that the improvement in writing ability did not only occur in a small number of students, but was relatively evenly distributed across all students. This condition indicates that the use of AR not only improves average achievement but also helps equalize student writing ability (Borsuk & Bouse, 2012). These findings reinforce the fact that AR-based learning can provide a more contextual learning experience and help students develop ideas more systematically (McLaren et al., 2022).

The results of this study indicate that the application of Augmented Reality (AR) has a positive effect on students' short story writing skills (Hapsari et al., 2020). This is reflected in the higher post-test scores of the experimental group compared to the control group, as well as a greater improvement after the intervention. The moderate standard deviation suggests that the improvement occurs relatively evenly among students (Tashakkori & Teddlie, 2003). This finding shows that AR not only increases average achievement but also promotes more equitable learning outcomes (Hapsari & Wulandari, 2020). Pedagogically, AR supports writing development through its visual and interactive features. Students often struggle to generate ideas and organize narratives. AR provides concrete visual stimuli that help students develop imagination and structure ideas more clearly, especially in the prewriting stage. As a result, students produce more systematic and coherent texts. This indicates that AR functions as an effective scaffold throughout the writing process (Li et al., 2026).

AR also enhances students' motivation by creating a more engaging learning environment. Increased engagement encourages active participation and improves task completion, which contributes to better writing quality. This aligns with findings that AR enhances motivation through immersive learning experiences (Kazlaris & Keramopoulos, 2025)). In addition, AR fosters creativity by enabling students to produce richer descriptions based on visual representations (Chang, 2022). The relatively even improvement across ability levels suggests that AR accommodates diverse learners, making it an effective and inclusive medium for improving writing skills.

The results of this study are consistent with previous research showing that Augmented Reality (AR) improves student learning outcomes. Studies by Usodo & Budhi (2025) demonstrate that AR enhances engagement and achievement through immersive experiences. Similarly, Kazlaris et al. (2025) report that AR improves conceptual understanding and learning motivation. In language learning, AR supports literacy development by providing visualizations that facilitate knowledge construction. Research also shows that AR improves creativity and writing skills. Huang & Musah (2024) state that AR helps students develop ideas more concretely, while Oto-Millera et al. (2025) find that AR enhances narrative writing through visualization of storylines. Additionally, Usodo & Budhi (2025) highlight increased cognitive engagement. These findings support the result that AR improves short story writing quality. However, this study differs from prior research, which mainly focuses on motivation and general outcomes (Kazlaris et al. (2025), Lin et al. (2022), and Setiawan et al. (2022) study specifically analyzes writing quality, including idea development, structure, and variation. The novelty lies in integrating AR across writing stages and its focus on the Indonesian context, providing deeper and more relevant insights into AR-based creative literacy learning.

The improvement in short story writing skills in the experimental group was influenced by several main factors. First, the visualization provided by AR technology. Visualization of objects, characters, and story settings helped students develop ideas more concretely. Students no longer wrote based on abstract imagination, but rather on visual stimuli that could be directly observed. This facilitated students' pre-writing stages and helped develop a more systematic storyline. Research shows that AR can improve conceptual understanding because it provides visual representations that support the thinking process (McLaren et al., 2022; Chen et al., 2022).

Second, learning motivation. AR-based learning creates a more engaging learning environment, thereby increasing student engagement. When students are more motivated, they become more active in

writing and improving their stories. This increased motivation contributes to the quality of their writing. Previous studies have also shown that the use of AR technology can increase student motivation and engagement in literacy-based learning (Radianti et al., 2020).

Third, the interactivity factor in learning. AR allows students to interact directly with learning objects, thereby increasing cognitive engagement. This interaction helps students understand the relationships between story elements, such as characters, conflict, and setting. Furthermore, AR-based collaborative activities encourage students to discuss and exchange ideas, thereby improving the quality of their writing. Recent research shows that AR-based interactive learning can improve students' creative and collaborative thinking skills (Chen et al., 2022; Darmawansah et al., 2022).

Fourth, the learning scaffolding factor. AR helps students systematically navigate the writing stages, from prewriting to revision. This process allows students to gradually improve their writing. Thus, writing skills don't improve instantly, but rather through a structured process. This approach aligns with research showing that AR can function as scaffolding in constructivist-based learning.

The results of this study can be explained through constructivist theory, which emphasizes that learning occurs when students construct knowledge through direct experience. AR provides an exploration-based learning experience that allows students to construct knowledge independently. By directly viewing virtual objects, students can develop a deeper understanding of story elements. This aligns with constructivist theory, which states that concrete experiences aid the process of knowledge formation (Kazlaris et al., 2025).

Furthermore, multimodal learning theory supports the findings of this study. AR combines visual, audio, and interactive elements, providing students with a richer learning experience. Multimodal learning has been shown to improve literacy skills because students process information through multiple channels. In the context of short story writing, the combination of visuals and text helps students develop more detailed descriptions. Research shows that a technology-based multimodal approach can enhance students' creativity and writing skills (Chen et al., 2022). The results of this study also relate to learning motivation theory. AR creates an engaging learning experience, thereby increasing students' intrinsic motivation. When motivation increases, students become more active in developing their writing. Motivation theory states that an engaging learning environment can increase student engagement and learning outcomes. This finding is supported by research showing that immersive technologies such as AR can increase student learning motivation (Radianti et al., 2020).

The practical implication of this research is that teachers can use AR as an alternative learning medium for short story writing. AR helps students develop ideas, structure stories, and enhance creativity. Thus, writing learning is no longer monotonous but becomes more interactive and engaging. Schools can also integrate AR into literature learning to increase student engagement. Previous research has shown that integrating AR into learning can improve the quality of students' learning experiences (Huang & Musah, 2024). The theoretical implications of this study are to strengthen the concept that immersive technology can support creative literacy learning. This study shows that AR not only increases motivation but also improves the quality of students' writing. These findings expand the study of the use of AR in language and literature learning. Furthermore, this study contributes to the development of technology-based writing learning models. Other studies have also shown that AR can improve students' digital literacy skills and creativity (Ibáñez & Delgado-Kloos, 2018).

This study has several limitations. First, the relatively short duration of the intervention may have affected the stability of students' writing skills. A longer intervention would have allowed students to explore AR features in more depth. Second, the study was conducted in only one school, so the generalizability of the results is still limited. Third, limitations in AR devices may affect learning implementation. Not all students have devices with the same specifications. Fourth, other factors such as students' initial abilities and technology experience have not been analyzed in depth. Previous research also states that device and time limitations are major challenges in AR implementation (Al-Ali & Wardat, 2025; Sari et al., 2024).

Future research is recommended to involve more schools with diverse characteristics to generalize the results. Further research could also use a longer intervention duration to assess the long-term impact of AR use. Furthermore, future research could examine the influence of AR on other aspects such as student creativity, critical thinking, and collaboration. Research could also combine AR with other learning models, such as project-based learning, learning or digital storytelling. Previous research has shown that combining AR with active learning models can improve students' 21st-century skills (Darmawansah et al., 2022). Therefore, further research is expected to develop more optimal use of AR in writing learning.

Conclusion

Based on the overall research results, it can be concluded that the application of Augmented Reality (AR) technology in learning to write short stories has a significant positive effect on improving students' writing skills, effectively addressing issues of low motivation, limited idea generation, and minimal engagement associated with conventional teaching methods. Empirical findings indicate that the experimental group using AR demonstrated higher improvement compared to the control group across multiple aspects, including story ideas, narrative structure, language style, and writing mechanics, with gains that were both statistically significant and relatively evenly distributed, suggesting its effectiveness across varying ability levels. Additionally, the increased learning motivation observed in the experimental group confirms that AR enhances not only cognitive outcomes but also affective engagement. Pedagogically, this effectiveness can be attributed to AR's capacity to provide concrete visualization and interactive experiences that function as scaffolding throughout the writing process, aligning with constructivist and multimodal learning approaches. This study contributes both theoretically and practically by advancing research on technology-based creative literacy and proposing a systematic AR implementation model in the classroom. However, limitations such as the short intervention duration, limited sample size, and variability in technological devices suggest the need for further research involving broader samples, longer implementation periods, and integration with other innovative learning models to enhance the sustainability and generalizability of the findings. Overall, this study confirms that AR technology holds strong potential as a strategic innovation in secondary school writing instruction by simultaneously improving writing quality, creativity, and student engagement.

Declarations

- Author contribution** : Arisni Kholifatu Amalia Shofiani was responsible for the entire research project. She also led the manuscript writing and collaborated with the authors. Alfian Setya Nugraha, Raras, Eko, and Ahmad Faizi participated in data collection, transcription, and analysis. They also revised the manuscript, and all approved it.
- Funding statement** : This article is one of the research results funded by Hasyim Asy'ari University under Contract Number *NO: 039/LPPM-UNHAS/VI/2025*.
- Conflict of interest** : Some authors declare that they have no competing interests.
- Ethics Approval** : This article has never been published in any other journal.
- Additional information** : The references used are free from copyright infringement.

References

- Al-haddad, S., Chick, N., Safi, F., Al-haddad, S., Chick, N., & Safi, F. (2024). Teaching statistics: A technology-enhanced supportive instruction (TSI) model during the covid-19 pandemic and beyond. *Journal of Statistics and Data Science Education*, 0(0), 1–23. <https://doi.org/10.1080/26939169.2024.2315939>
- Al-Refaey, S. R. (2022). Using mobile augmented reality applications for enhancing EFL writing skills of early childhood education students and their engagement. *Mansoura University*.
- Al-Ali, R., & Wardat, Y. (2025). The effectiveness of using augmented reality technology in science education to enhance creative thinking skills among gifted eighth-grade students. *EJ MSTE*, 21(6), em2644. <https://doi.org/10.29333/ejmste/16416>
- Alfa, D. N., & Astuti, T. (2025). Development of digital learning media integrated with augmented reality on the material of intrinsic elements of fictional texts. *Jurnal Kependidikan*, 11(1), 293-304. <https://doi.org/10.33394/jk.v11i1.13672>
- Askarian, M., Movahedi, M., Vardanjani, H. M., Askarian, A., & Ghotbabadi, Z. R. (2023). Roadmap to recovery: Implemented and attitude toward school reopening strategies during the COVID-19 pandemic, a scoping review. *Journal of education and health promotion*, 12(1), 235. https://doi.org/10.4103/jehp.jehp_1160_22
- Aslam, M. (2024). Testing normality of data for uncertain level of significance. *Journal of Statistical Theory and Applications*, 23(4), 480–499. <https://doi.org/10.1007/s44199-024-00098-4>
- Babatimehin, T., Christiana, O., & Ogungbaigbe, T. S. (2025). Assessing the effect size and homogeneity of selected standardized tests in education. *JOSSE*, 3(2), 92–118. <https://doi.org/10.37812/josse.v3i2.1829>
- Baiti, N. B. (2024). Development of augmented reality-based flipbook media to build creativity, imagination, and writing skills. *Science: Journal of Educational Research*.

- Borsuk, A., & Bouse, B. (2012). *Between page and screen: Remaking literature through art and technology*. siglio press.
- Chang, H. Y. (2022). Ten years of augmented reality in education: A meta-analysis of 134 (quasi)-experimental studies. *Computers & Education*, 187, 104504. <https://doi.org/10.1016/j.compedu.2022.104641>
- Chen, C.-H., Koong, C.-S., & Liao, C. (2022). Influences of integrating dynamic assessment into a speech recognition learning design to support students' English speaking skills, learning anxiety, and cognitive load. *Educational Technology & Society*, 25(1), 1–14.
- Cohen, W. G., Zhang, B., Lee, D. R., Ampah, S. B., Sobol, S. E., & Cook-Sather, S. D. (2023). Middle ear condition at the time of pediatric myringotomy tube placement: Pain associations following intraoperative fentanyl/ketorolac and seasonal variation. *Anesthesia & Analgesia*, 136(5). <https://doi.org/10.1213/ANE.0000000000006230>
- Cui, F., Zhao, W., Mu, D.-L., Zhao, X., Li, X.-Y., Wang, D.-X., Jia, H.-Q., Dai, F., & Meng, L. (2021). Association between cerebral desaturation and postoperative delirium in thoracotomy with one-lung ventilation: A prospective Cohort study. *Anesthesia & Analgesia*, 133(1). <https://doi.org/10.1213/ANE.0000000000005489>
- Darmawansah, D., Lin, C.-J., & Hwang, G.-J. (2022). Empowering the collective reflection-based argumentation mapping strategy to enhance students' argumentative speaking. *Computers & Education*, 184, 104516. <https://doi.org/10.1016/j.compedu.2022.104516>
- Dureja, R., & Madduri, B. (2023). A rare case of bilateral Phthiriasis palpebrarum with crab louse. *Indian Journal of Ophthalmology-Case Reports*, 3(1), 148-150. https://doi.org/10.4103/ijo.IJO_1819_22
- Elsayir, H. A. (2024). The role of effect size and significance test in research design and analysis. *Edelweiss applied science and technology*, 8(6), 287-295. <https://doi.org/10.55214/25768484.v8i6.2062>
- Ford, D. R. (2023). *Teaching the actuality of revolution: Aesthetics, unlearning, and the sensations of struggle*. Iskra Books.
- Garg, A., Azad, S., & Radhakrishnan, S. (2021). Percutaneous paravalvular leak closure with their outcomes: A single center experience. *Annals of Cardiac Anaesthesia*, 24(3), 302-307. https://doi.org/10.4103/aca.ACA_157_20
- Geroimenko, V. (Ed.) . (2020). *Augmented reality in education: A new technology for teaching and learning*. Springer Nature. <https://doi.org/10.1007/978-3-030-42156-4>
- Gupta, A., Wadhwa, J., Aggarwal, V., Mehta, N., Abraham, D., Aneja, K., & Singh, A. (2022). Anesthetic efficacy of supplemental intraligamentary injection in human mandibular teeth with irreversible pulpitis: A systematic review and meta-analysis. *J Dent Anesth Pain Med*, 22(1), 1–10. <https://doi.org/10.17245/jdapm.2022.22.1.1>
- Hapsari, T. P. R. -N., & Wulandari, A. (2020). Analisis kelayakan buku ajar milenial berbasis Augmented Reality (AR) sebagai media pembelajaran teks prosedur di Magelang. *Diglosia: Jurnal Kajian Bahasa, Sastra, dan Pengajarannya*, 3(4), 351–364. <https://doi.org/10.30872/diglosia.v3i4.125>
- Hapsari, T. P. R. -N., Wulandari, A., Harefa, R. T., Lase, W. N., Telaumbanua, R., Bawamenewi, A., Puspita, R., Putro, W. W., & Yugopuspito, P. (2020). Augmented reality untuk meningkatkan keterampilan menulis, berbicara, keterampilan berpikir kritis dalam pembelajaran Bahasa Indonesia kelas V SD. *Journal on Education*, 6(9), 79–88. <https://www.jurnalsyntaxadmiration.com/index.php/jurnal/article/view/1515>
- Harefa, R. T., Lase, W. N., Telaumbanua, R., & Bawamenewi, A. (2023). Pengembangan media augmented reality untuk meningkatkan kemampuan menulis teks deskripsi siswa SMP. *Journal on Education*, 6(1), 3241–3247. <https://doi.org/10.31004/joe.v6i1.3379>
- Henuk, E. (2025). Kemampuan menulis cerpen berdasarkan pengalaman dan menemukan penulisan kata dan kesalahan penggunaan: Analisis siswa kelas XI. *Ciencias: Jurnal Ilmiah Pendidikan Bahasa dan Sastra Indonesia*.
- Heydemans, C. (2024). Systematic literature review: Use of augmented reality as a tool in educational settings. *Learning Technology Journal*.
- Huang, L., & Musah, A. A. (2024). The influence of augmented reality on creativity, student behavior, and pedagogical strategies in technology-infused education management. *Journal of Pedagogical Research*, 8(2), 260–275. <https://doi.org/10.33902/JPR.202425376>
- Ibáñez, M.-B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. *Computers & Education*, 123, 109–123. <https://doi.org/10.1016/j.compedu.2018.05.002>
- Kazlaris, G. C., Keramopoulos, E., Bratsas, C., & Kokkonis, G. (2025). Augmented reality in education through collaborative learning: A systematic literature review. *Multimodal Technologies and Interaction*, 9(9), 94. <https://doi.org/10.3390/mti9090094>

- Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for T-tests and ANOVAs. *Frontiers in Psychology*, 4, 1–12. <https://doi.org/10.3389/fpsyg.2013.00863>
- Li, M., Wang, X.-X., Chen, Y., & Cukurova, M. (2026). Augmented reality and generative learning in K-12 writing: Performance outcomes and the mediating roles of motivation and metacognition. *Computers & Education*, 244, 105538. <https://doi.org/10.1016/j.compedu.2025.105538>
- Lin, H., Wan, S., Gan, W., Chen, J., & Chao, H.-C. (2022). *Metaverse in education: Vision, opportunities, and challenges*. ArXiv pre-print. <https://doi.org/10.1109/BigData55660.2022.10021004>
- Maulana, I. (2024). The impact of virtual and augmented reality on enhancing higher-order thinking skills (HOTS): A study in Indonesian context. *International Conference on Smart Learning Environments*, 3(1). <https://doi.org/10.57142/picsar.v3i1.377>
- McLaren, B. M., Richey, J. E., Nguyen, H., & Hou, X. (2022). How instructional context can impact learning with educational technology: Lessons from a study with a digital learning game. *Computers & Education*, 178, 104366. <https://doi.org/10.1016/j.compedu.2021.104366>
- Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. *Annals of Cardiac Anaesthesia*, 22(1). https://doi.org/10.4103/aca.ACA_157_18
- Niyas, V. K. M., Rahulan, S. D., Arjun, R., & Sasidharan, A. (2021). *ICU-acquired candidemia in covid-19 patients: An experience from a tertiary care hospital in Kerala, South India*. 4–5.
- Novitaningrum, A. (2023). Empowering teachers with augmented reality (AR) tools to enhance students' writing skills. *Journal of Community Service*, 1(2), 66–71.
- Oto-millera, N., Pellicer-ortín, S., & Bustamante, J. C. (2025). Augmented reality in English language acquisition among gifted learners: A systematic scoping review (2020-2025). *Appl. Sci.* 15, 11487. <https://doi.org/10.3390/app152111487>
- Özdemir, E. Ç., & Akyol, H. (2021). Effect of augmented reality-based reading activities on some reading variables and class participation. *International Journal of Progressive Education*, 17(4). <https://doi.org/10.29329/ijpe.2021.366.9>
- _____. (2022). The design of augmented reality-based synectic model device in writing short stories. *Mediasi: Jurnal Komunikasi, Seni, dan Pembelajaran*.
- Puspita, R. (2020). Peningkatan keterampilan menulis cerpen siswa: Studi di Jurnal Sarasvati. *Jurnal Sarasvati*, 79–88.
- Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, 147, 103778. <https://doi.org/10.1016/j.compedu.2019.103778>
- Rahayu, N. I., Muktiarni, M., & Hidayat, Y. (2024). ASEAN journal of science and engineering an application of statistical testing: A guide to basic parametric statistics in educational research using SPSS. *ASJE*, 4(3), 569–582. <https://doi.org/10.17509/ajse.v4i3.76092>
- Rohman, A. N., Mustofa, M., & Heriyawati, D. F. (2024). The use of augmented reality-based learning media: A descriptive qualitative study in English learning. *FTL Journal*, 9(1), 1-18. <https://doi.org/10.18196/ftl.v9i1.18789>
- Sari, N. W. A. P., Sudrajat, Y., Casande, S., Syarif, M., & Monarchi, A. M. (2024). Augmented reality in improving writing skills learning experiences in vocational high school students. *JTP-Jurnal Teknologi Pendidikan*, 26(3), 860-872. <https://doi.org/10.21009/jtp.v26i3.49844>
- Setiawan, A., Yunitasari, I., Pratiwi, D. J., Dela, Y. I., & Jatmiko, W. A. (2025). Developing augmented reality-based flashcards to enhance science literacy in elementary schools. *Pedagogia: Jurnal Ilmiah Pendidikan*, 17(1), 90-103. <https://doi.org/10.55215/pedagogia.v17i1.49>
- Setiawan, J. D., Ihsan, M. S., Saputro, R., Munadi, M., Paryanto, P., & Alimi, S. (2022). Evaluation and development of wireless monitoring systems for an autonomous sailboat. *Journal of Physics: Conference Series*, 2193(1), 012050. IOP Publishing. <https://doi.org/10.1088/1742-6596/2193/1/012050>
- Sugiri, V. E., & Cahyadi, R. (2020). Terapan augmented reality untuk buku cerita “Petualangan Jaka Aksara.” *Jurnal Multimedia dan IT*, 4(2), 18–30. <https://doi.org/10.46961/jommit.v4i2.333>
- Tashakkori, A., & Teddlie, C. (2003). *Handbook of mixed methods in social & behavioral research*.
- Tolibovna, Q. M. (2023). The role of augmented reality in developing writing skills. *International Journal of Future Education*, 7(1), 45–60.
- Trikotama, R. M. A. (2024). Application of augmented reality in education: urgency in Society 5.0 in Indonesia. *Jurnal HIPKIN JER*.
- Usodo, B., & Budhi, E. (2025). Effectiveness of augmented reality application on critical thinking skills of elementary school students based on learning interest. *Jurnal JPSD*, 12(1), 39–49. <https://doi.org/10.26555/jpsd.v12i1.a30760>

- Utama, N. W. (2025). Pengembangan media pembelajaran berbasis flipbook digital untuk kemampuan menulis teks deskripsi. *Jurnal Riset Ilmu Pendidikan, Bahasa, dan Budaya*, 2(3), 244–252. <https://doi.org/10.61132/semantik.v2i3.851>
- Wayan, N., Permata, A., Sudrajat, Y., & Casande, S. (2024). Augmented reality in improving writing skills learning experiences in vocational high school students. *Jurnal Teknologi Pendidikan*, 26(3), 860–872. <https://doi.org/10.21009/jtp.v26i3.49844>