

Adaptive AI Scaffolding within Gamified Reading Missions: Effects on Grade 10 Students Reading Comprehension in South Sulawesi

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ABSTRACT

Background. Reading comprehension remains a critical challenge in secondary education, while conventional instruction often provides limited opportunities for adaptive feedback and sustained student engagement.

Purpose. This study examined the effectiveness of an AI assisted gamified learning strategy in improving the reading comprehension of Grade 10 students at SMA Negeri 4 Sidrap, South Sulawesi, Indonesia.

Method. A quantitative quasi experimental method with a nonequivalent pretest posttest control group design was employed. The participants were 54 students divided into an experimental group (n = 29) and a control group (n = 25). Reading comprehension was measured using a 30 item test, and the data were analyzed using descriptive statistics and ANCOVA. was then processed using descriptive statistics in the form of percentages.

Novelty. The study integrates AI generated adaptive scaffolding with structured gamification elements, including reading missions, progress indicators, achievement badges, and immediate feedback, within a unified reading instruction design.

Results. The experimental group achieved a higher adjusted posttest mean than the control group (82.03 vs. 73.97). ANCOVA revealed a significant instructional effect, $F(1, 51) = 15.00$, $p < .001$, partial $\eta^2 = .227$.

Conclusion. AI assisted gamified learning effectively improved students' reading comprehension and offers a promising adaptive approach for secondary school literacy instruction.

KEYWORDS

Artificial Intelligence, Gamification, Reading Comprehension, Secondary Education, Instructional Strategy

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INTRODUCTION

Over the past five years, the global learning paradigm has undergone a transformation from a teacher centered knowledge transmission model toward learning that is more learner centered, competency based, adaptive, collaborative, and integrated with digital technology. This transformation has been driven not only by technological advancement but also by a global learning crisis indicating that the expansion of access to education has not always



been accompanied by adequate mastery of foundational skills. The State of Global Learning Poverty report estimates that approximately 70% of ten year old children in low and middle income countries are unable to read and a simple text, revealing a serious gap between school participation and actual learning outcomes (Akmal & Pritchett, 2021). At the same time, the expansion of digital learning ecosystems, learning analytics, and artificial intelligence has opened opportunities for more interactive, personalized, and responsive learning experiences tailored to learners' needs (Sajja et al., 2024).

Nevertheless, global evidence also indicates that the availability of technology does not automatically enhance learning quality, as its effectiveness depends on pedagogical design, teacher competence, equitable access, data protection, and active learner engagement (Díaz Suárez et al., 2025). These conditions underscore that the paradigm shift in global education must be directed not merely toward the digitalization of learning tools, but toward a reconstruction of the learning process capable of sustainably enhancing learners' participation, motivation, autonomy, and depth of understanding (Chen, 2022; Zhou et al., 2024).

Within the Indonesian regional context, Sulawesi cannot be treated as a homogeneous educational region, given that each province exhibits distinct social conditions, learning infrastructure, access to reading resources, and literacy ecosystems. Data from the 2024 Community Literacy Development Index reveal a considerable disparity across regions; South Sulawesi recorded a score of 88.24, the highest attainment nationally, whereas Central Sulawesi recorded a score of 71.70, despite an improvement over its previous year's achievement (Abduh et al., 2024). However, this index primarily reflects the support provided by the literacy ecosystem such as the availability of library services and public access to knowledge resources and therefore cannot be directly equated with a measure of students' reading comprehension ability.

Empirical evidence at the secondary school level in Central Sulawesi further indicates that a considerable proportion of tenth grade students continue to experience difficulties in identifying main ideas, locating detailed information, understanding vocabulary, making inferences, and summarizing text content. Several studies conducted at SMA Negeri 1 Sojol, SMK Negeri 1 Dampal Selatan, and SMA Lab School Untad Palu have shown that these abilities can be improved through reading strategies that are more active, structured, and collaborative compared with conventional instruction (Erniwati et al., 2025). These findings suggest that the literacy challenges in Sulawesi are not solely attributable to the availability of learning resources, but also to the quality of pedagogical design capable of sustaining student engagement and facilitating the process of meaning construction when learners encounter complex texts.

Although various innovative strategies have been implemented to improve reading comprehension, prior research still reveals a number of conceptual, methodological, and contextual gaps. Studies on gamification indicate that the use of game elements can enhance students' motivation, engagement, and learning outcomes; however, its effectiveness is influenced by educational level, treatment duration, learning environment, and the alignment between game elements and learning objectives (Alsawaier, 2018; Erwin et al., 2026; Gyedu et al., 2026). Research on gamification in reading instruction in Indonesia also remains limited to the use of points, rewards, quizzes, or simple competitions, and has generally not yet leveraged artificial intelligence to adjust text difficulty levels, generate comprehension questions, provide immediate feedback, or support students' individual learning needs (Alqahtani et al., 2023; Erwin & Kuswandi, 2024).

Meanwhile, research on AI in language learning has been conducted predominantly among university students or has focused on user acceptance and perception, whereas experimental

evidence involving secondary school students remains relatively limited (El Fathi et al., 2025). Studies on reading comprehension among tenth grade students in Sulawesi tend to examine specific reading strategies, such as DRTA, Jigsaw, SQ3R, and QAR, with several employing a single class design without a comparison group and none integrating gamification and AI within a single, systematic pedagogical design (Gifarini et al., 2025). Therefore, a two group experimental study is still needed to examine the effectiveness of an AI assisted gamification learning strategy on the reading comprehension ability of tenth grade students in Sulawesi, so as to generate stronger empirical evidence regarding the difference in learning outcomes between innovative and conventional instruction.

In response to this gap, the present study implements an AI assisted gamification learning strategy designed as a structured pedagogical ecosystem, rather than the mere addition of game elements or the isolated use of AI. This approach integrates the pre reading, while reading, and post reading stages into tiered learning missions equipped with objectives, challenges, points, achievement badges, progress visualization, feedback, and collaborative activities. In the initial stage, students' abilities are mapped through a diagnostic test to determine an appropriate level of text complexity and comprehension task difficulty. Students then read the text independently, identify main ideas, locate detailed information, interpret vocabulary based on context, make inferences, and formulate conclusions before receiving AI assistance. Artificial intelligence is positioned as an adaptive pedagogical scaffold that provides guiding questions, gradual explanations, differentiated exercises, and feedback on students' responses, rather than as a tool that directly generates final answers.

This design is consistent with evidence indicating that self regulation based gamification can strengthen reading comprehension, motivation, and students' strategic engagement, while AI can support personalization and adaptive feedback in language learning (Nguyen Viet & Doan Ngoc Minh, 2025; Yang et al., 2025). Every AI response remains verified against textual evidence and is mediated by the teacher to prevent overreliance, inaccurate information, and the use of technology as a substitute for students' thinking processes (Abdi Tabari et al., 2025; Nygren et al., 2026). The effectiveness of this approach is subsequently examined through a quasi experimental pretest–posttest control group design involving two classes, allowing changes in reading comprehension ability in the experimental group to be systematically compared with those of the group receiving regular instruction.

This study contributes to the existing literature by integrating gamification and artificial intelligence into a single, systematic pedagogical design, an approach that remains underexplored in reading comprehension research, particularly in the context of secondary education in Indonesia. By empirically testing this integrated strategy through a quasi experimental design, this study is expected to provide both theoretical and practical contributions: theoretically, by expanding understanding of how self regulation based gamification and AI assisted scaffolding jointly influence reading comprehension processes; and practically, by providing an evidence based learning model that teachers and policymakers can adapt to strengthen literacy outcomes in under resourced regional contexts.

RESEARCH METHODOLOGY

Research Design

This study employed a quantitative approach using a nonequivalent pretest posttest control group quasi experimental design. This design was selected because the study involved two pre existing classes, precluding random assignment of participants to groups. A quasi experimental

design allows researchers to examine the effect of a treatment within an authentic classroom setting while retaining a comparison group and pre and post intervention measurements (Sinha, 2026).

One class was assigned as the experimental group, receiving the AI assisted gamification learning strategy, while the other served as the control group, receiving regular instruction. Both groups completed a pretest to measure initial reading comprehension ability and a posttest to measure comprehension ability following the treatment. The difference in score change between the two groups was used to determine the effectiveness of the implemented learning strategy. The research design is structured as follows:

Table 1. Nonequivalent Pretest–Posttest Control Group Design

Group	Pretest	Treatment	Posttest
Experimental Group	O ₁	X	O ₂
Control Group	O ₃	C	O ₄

Research Location and Subjects

The accessible population consisted of 54 Grade 10 students enrolled in two intact classes at a public senior high school in South Sulawesi Province, Indonesia. Given that the population was relatively small and fully accessible, this study employed a total population sampling approach, in which all members of the defined population were included. Census sampling refers to a complete enumeration in which data are collected from every unit within the identified population, thereby eliminating sampling error within that specific population (Lohr, 2021). Nevertheless, as the participants were drawn from a single school context, the findings should not be generalized to all Grade 10 students in South Sulawesi without further evidence from multiple schools and locations.

The two intact classes were retained as pre existing groups, as individual random assignment was not feasible within the school's administrative structure. One class was designated as the experimental group and received the AI assisted gamified learning strategy, while the other served as the control group and received regular reading instruction. The use of comparable intact groups is consistent with a nonequivalent pretest posttest control group design, particularly in authentic educational settings where restructuring established classes is often impractical (Eti, 2015). To examine potential baseline differences between the groups, pretest scores on reading comprehension were compared prior to the intervention.

Table 2. Demographic Profile and Group Distribution of the Study Participants

Class	Study Group	Male, <i>n</i> (%)	Female, <i>n</i> (%)	Total, <i>n</i>	Percentage of Total Sample (%)
	Class A Experimental group	11 (37.9)	18 (62.1)	29	53.7
	Class B Control group	10 (40.0)	15 (60.0)	25	46.3
Total	-	21 (38.9)	33 (61.1)	54	100.0

Percentages for male and female students in each class were calculated based on the total number of students within the respective class. The percentages in the final column were calculated based on the total study sample (*N* = 54). All Grade 10 students from the two intact classes were included using a total population or census sampling approach. Class A was assigned as the experimental group and received the AI assisted gamified learning strategy, whereas Class B served as the control group and received regular reading instruction.

Instrument and Data Analysis

Students reading comprehension was measured using two parallel forms of a researcher developed multiple choice test, administered as a pretest and posttest. Each form consisted of 30 items based on six reading passages representing narrative, expository, and informative texts appropriate for 10th grade students. The instrument was developed by adapting the reading processes described in the PISA assessment framework, specifically finding information, understanding and integrating textual meaning, and evaluating or reflecting on textual content (Marcq & Braeken, 2025; Sun et al., 2022). These processes were operationalized into five measurable indicators: identifying main ideas, finding explicit information, interpreting vocabulary in context, making inferences, and drawing conclusions. The inclusion of textual complexity and task difficulty was considered because reading test performance is influenced by the characteristics of the reading passage and the cognitive demands of the questions (Anggia & Habók, 2023; Ferrara et al., 2022; Spencer et al., 2019).

Table 3. Blueprint of the Reading Comprehension Test

Reading Comprehension Indicator	Operational Description	Number of Items	Percentage (%)
Identifying main ideas	Identifying the central idea, topic, or communicative purpose of a passage or paragraph	6	20.0
Locating explicit information	Retrieving facts, details, sequences, and directly stated information	6	20.0
Interpreting vocabulary in context	Determining the meaning of words or expressions using textual context	6	20.0
Making inferences	Deriving implicit meanings, causal relationships, intentions, and logical implications	6	20.0
Drawing conclusions	Integrating information to formulate summaries, conclusions, or overall interpretations	6	20.0
Total		30	100.0

Data were first summarized using means, standard deviations, and minimum–maximum scores for both groups. The intervention’s primary effect was examined using analysis of covariance (ANCOVA), with posttest score as the dependent variable, instructional group as the fixed factor, and pretest score as the covariate, as ANCOVA statistically controls baseline differences in a nonequivalent pretest posttest design (Köhler et al., 2021).

Prior to hypothesis testing, assumptions of normality of residuals, homogeneity of variance, linearity, and homogeneity of regression slopes were examined. Adjusted posttest means, F statistic, p value, partial eta squared, and 95% confidence intervals were reported, with significance set at $\alpha = .05$. Descriptive pretest to posttest changes were also reported for each group, though the ANCOVA result served as the principal basis for determining the strategy’s effectiveness.

Research Procedures

The study was conducted through four sequential stages: preparation, pretesting, intervention, and posttesting. During the preparation stage, the researchers obtained institutional permission, finalized the reading materials and research instruments, configured the AI assisted gamification activities, and briefed the teacher and students on the study procedures. The use of AI was supervised by the teacher to ensure data privacy, age appropriate access, and human centred pedagogical implementation (Urmeneta & Romero, 2024).

Both groups completed an equivalent reading comprehension pretest before the intervention. Class A, comprising 29 students, received the AI assisted gamified learning strategy, while Class B,

comprising 25 students, received regular reading instruction. The intervention was conducted over eight 90 minute sessions within four weeks. Both groups studied equivalent reading materials, learning objectives, and comprehension indicators, whereas only the experimental group received reading missions, points, achievement badges, progress indicators, AI generated prompts, and formative feedback. Treatment implementation was monitored using a fidelity checklist. After the intervention, both groups completed a parallel posttest under equivalent conditions. This procedure is consistent with a nonequivalent pretest–posttest control group design involving intact classroom groups.

Table 4. Research Procedure

Stage	Experimental Group: Class A (<i>n</i> = 29)	Control Group: Class B (<i>n</i> = 25)	Research Output
Preparation	Preparation of AI assisted gamification activities, reading materials, instruments, and student orientation	Preparation of equivalent reading materials, instruments, and student orientation	Validated instructional materials and instruments
Pretest	Completion of the reading comprehension pretest	Completion of the same reading comprehension pretest	Baseline reading comprehension scores
Intervention	Eight 90 minute sessions using reading missions, points, badges, progress indicators, AI scaffolding, and feedback	Eight 90 minute sessions using regular reading instruction without gamification or AI assistance	Treatment implementation and fidelity records
Posttest	Completion of the parallel reading comprehension posttest	Completion of the same parallel posttest	Post intervention reading comprehension scores

Both groups received equivalent text genres, learning objectives, reading indicators, instructional duration, and testing conditions. AI generated support was verified through textual evidence and teacher supervision.

RESULT AND DISCUSSION

Descriptive statistics were calculated to examine changes in students' reading comprehension scores before and after the intervention. As presented in Table 5, the experimental and control groups demonstrated relatively similar pretest scores. The experimental group obtained a mean pretest score of 61.09 (*SD* = 8.26), while the control group obtained a mean score of 61.34 (*SD* = 7.56). An independent samples *t* test confirmed that the initial difference between the groups was not statistically significant, $t(52) = 0.12, p = .907$.

Following the intervention, the experimental group achieved a mean posttest score of 81.97 (*SD* = 6.85), compared with 74.04 (*SD* = 9.90) in the control group. The mean score improvement was 20.88 points for the experimental group and 12.69 points for the control group.

Table 5. Descriptive Statistics of Students' Reading Comprehension Scores

Group	<i>n</i>	Pretest, <i>M</i> (<i>SD</i>)	Posttest, <i>M</i> (<i>SD</i>)	Mean Gain, <i>M</i> (<i>SD</i>)
Experimental group	29	61.09 (8.26)	81.97 (6.85)	20.88 (7.92)
Control group	25	61.34 (7.56)	74.04 (9.90)	12.69 (9.46)
Total	54	-	-	-

Scores were converted to a scale ranging from 0 to 100. Mean gain was calculated by subtracting the pretest score from the posttest score.

Before conducting ANCOVA, the statistical assumptions were examined. The Shapiro–Wilk test indicated that the model residuals were normally distributed, $W = .963, p = .089$. Levene's test showed that the variance of posttest scores was homogeneous across the groups, $F(1, 52) = 3.32, p = .074$. The interaction between the pretest score and instructional group was not statistically significant, $F(1, 50) = 0.50, p = .483$, confirming the homogeneity of regression slopes. Inspection of scatterplots and residual plots also supported linearity between the pretest and posttest scores.

Table 6. Results of the ANCOVA Assumption Tests

Statistical Assumption	Test or Examination	Statistic	<i>p</i>	Decision
Normality of residuals	Shapiro–Wilk test	$W = .963$	.089	Satisfied
Homogeneity of variance	Levene’s test	$F = 3.32$	.074	Satisfied
Homogeneity of regression slopes	Pretest $\times$ group interaction	$F = 0.50$	.483	Satisfied
Linearity	Scatterplot and residual inspection	-	-	Satisfied

ANCOVA was conducted with the posttest score as the dependent variable, instructional group as the fixed factor, and pretest score as the covariate. After controlling for students’ initial reading comprehension scores, the analysis revealed a statistically significant effect of instructional group on posttest performance, $F(1, 51) = 15.00$, $p < .001$, partial $\eta^2 = .227$. This effect size indicates that approximately 22.7% of the adjusted variance in posttest reading comprehension scores was associated with the instructional treatment.

The pretest score was also a significant covariate, $F(1, 51) = 12.16$, $p = .001$, partial $\eta^2 = .193$, indicating that students’ initial reading ability contributed to their post intervention performance.

Table 7. ANCOVA Results for Students’ Reading Comprehension Posttest Scores

Source	Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	<i>p</i>	Partial η^2
Pretest score	705.58	1	705.58	12.16	.001	.193
Instructional group	870.34	1	870.34	15.00	< .001	.227
Error	2,959.16	51	58.02	-	-	-

The adjusted posttest mean for the experimental group was 82.03, with a 95% confidence interval ranging from 79.19 to 84.87. The adjusted mean for the control group was 73.97, with a 95% confidence interval ranging from 70.91 to 77.03. The adjusted mean difference was 8.05 points, 95% CI [3.88, 12.23], in favour of the experimental group.

Table 8. Adjusted Posttest Means by Instructional Group

Group	Adjusted Mean	Standard Error	95% Confidence Interval
Experimental group	82.03	1.41	[79.19, 84.87]
Control group	73.97	1.52	[70.91, 77.03]
Adjusted mean difference	8.05	-	[3.88, 12.23]

Descriptive analysis across the five reading comprehension indicators showed that the experimental group obtained higher posttest scores than the control group on all measured dimensions. The largest difference was found in identifying main ideas, followed by making inferences. Because each indicator consisted of only six items, these indicator level findings were interpreted descriptively rather than as separate inferential tests.

Table 9. Posttest Performance across Reading Comprehension Indicators

Reading Comprehension Indicator	Experimental Group (%)	Control Group (%)	Mean Difference
Identifying main ideas	84.5	76.0	8.5
Locating explicit information	83.1	75.2	7.9
Interpreting vocabulary in context	80.2	73.1	7.1
Making inferences	80.8	72.4	8.4
Drawing conclusions	81.3	73.5	7.8
Overall mean	81.98	74.04	7.94

Overall, the descriptive and inferential findings demonstrate that students who participated in the AI assisted gamified learning strategy achieved greater improvement in reading comprehension

than students who received regular reading instruction. The difference remained statistically significant after students' initial reading comprehension scores were controlled.

The findings indicate that the AI assisted gamified learning strategy produced a meaningful improvement in students' reading comprehension. After controlling for initial ability, the experimental group achieved a significantly higher adjusted posttest score than the control group, with the intervention accounting for 22.7% of the adjusted outcome variance. This improvement may be associated with the structured combination of reading missions, progressive challenges, achievement feedback, and visible learning progress, which encouraged students to interact repeatedly and purposefully with the texts. The result supports previous experimental evidence showing that gamified instruction can improve reading comprehension performance compared with conventional teaching and is consistent with a systematic review reporting generally positive effects of gamification on reading engagement, accuracy, and comprehension (Cheng et al., 2025; Mudinillah et al., 2024).

AI supported scaffolding may have further strengthened comprehension by providing differentiated questions, contextual vocabulary explanations, and immediate formative feedback. The higher performance of the experimental group in identifying main ideas and making inferences suggests that AI support was particularly useful for cognitive processes requiring students to connect explicit information with broader textual meaning. This interpretation corresponds with evidence that proficiency aligned AI adaptation can improve inference making and information retrieval, especially among learners who experience difficulty accessing the original text (Aldamen et al., 2026). Nevertheless, the benefits of AI should not be interpreted as universal because its effectiveness may differ according to students' proficiency, task complexity, and the quality of teacher supervision. AI generated explanations may also introduce inaccuracies or alter textual meaning; therefore, human verification remains essential (Lermann Henestrosa & Kimmerle, 2025).

A critical interpretation is that the observed effect cannot be attributed separately to gamification or AI because both components were implemented as a single intervention. Increased scores may also reflect novelty, additional feedback, or stronger teacher attention rather than a durable improvement in independent reading strategies. Moreover, the four week intervention, small sample, and single school context limit the generalizability and long term interpretation of the findings. Future research should employ a factorial design comparing gamification only, AI only, combined, and conventional conditions, include delayed posttests, and involve schools with different geographical and socioeconomic characteristics. This direction is important because current gamified reading research remains dominated by relatively short interventions and still requires stronger longitudinal and contextually diverse evidence (Wang et al., 2024).

CONCLUSION

This study indicates that the AI assisted gamified learning strategy was more effective than regular instruction in improving the reading comprehension of Grade 10 students at a public senior high school in South Sulawesi. After controlling for initial reading ability, students in the experimental group achieved higher posttest scores across the measured indicators, particularly in identifying main ideas and making inferences. The integration of structured reading missions, gamification elements, adaptive AI scaffolding, and teacher supervised feedback appears to support more active, differentiated, and meaningful engagement with texts. Nevertheless, the findings should be interpreted within the limitations of the small sample, short intervention period, single school setting, and combined treatment design, which did not isolate the individual effects of AI and gamification. Further research should involve multiple schools, longer interventions, delayed posttests, and separate comparison conditions to examine the sustainability and specific contribution of each instructional component.

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DECLARATION OF GENERATIVE AI USE

ChatGPT was used to support language refinement and manuscript organization. All AI assisted content was critically reviewed, verified, and revised by the authors, who take full responsibility for the accuracy, originality, and integrity of the manuscript.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization, methodology, investigation, data analysis, and writing original draft.

Author 2: Instrument development, data collection, validation, and writing, review and editing.

Author 3: English translation, language editing, cross cultural review, and writing, review and editing.

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