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AUGMENTED REALITY AND SITUATED GRAMMAR LEARNING IN PRIMARY EFL CLASSROOMS: A QUASI-EXPERIMENTAL MIXED-METHODS STUDY

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Abstract: Augmented reality (AR) offers contextual and visual support for primary EFL learners; however, empirical evidence on AR-supported grammar learning in primary classrooms remains limited. This explanatory sequential mixed-methods study examined how AR-supported situated grammar instruction supported second-semester fourth-grade students' learning of the present continuous tense. Sixty students from SD Negeri Topogaro, Morowali, Central Sulawesi, participated in a quasi-experimental pre-test-post-test control group design. Class 4A served as the experimental group (n = 30), and Class 4B served as the control group (n = 30). The experimental group learned through Assemblr Edu AR markers, collaborative sentence construction, and situated task presentation, while the control group received conventional grammar instruction. The experimental group obtained higher post-test scores (M = 87.67, SD = 8.73) than the control group (M = 75.73, SD = 8.48). ANCOVA confirmed a significant group effect after controlling for pre-test scores, $F(1, 57) = 54.70$, $p < .001$, partial eta squared = .490, with an adjusted mean difference of 11.55 points. The questionnaire, administered only to the experimental group after the intervention, showed very positive post-intervention perceptions (M = 4.47/5.00). Qualitative findings indicated that AR supported grammar learning through authentic context, embodied learning, collaboration, and visual anchoring. The findings suggest that AR can function as a complementary scaffold for contextualized grammar learning.
Keywords: *augmented reality; situated learning; grammar instruction; primary EFL learners; present continuous tense.*

INTRODUCTION

Teaching English grammar to young EFL learners remains challenging because grammar is often introduced through rule explanation, memorization, and written exercises. Such practices may help learners recognize sentence patterns, but they do not always support meaningful grammar use in context (Butler, 2026; Pawlak et al., 2025; Purpura, 2004; Sundqvist et al., 2025). For primary learners, especially second-semester fourth-grade students, grammar learning needs to be concrete, visual, interactive, and connected to observable actions. The present continuous tense is therefore an appropriate focus because its meaning can be linked directly to visible ongoing activities.

Recent studies indicate that augmented reality (AR) can enrich language learning by combining digital objects with real-world learning environments. Across language-learning contexts, AR has been reported to support multimodal input, learner engagement, and contextualized practice (Angra & Jangra, 2025; Asadi & Ebadi, 2025; Christou et al., 2025; Koumpouros, 2024; Schorr et al., 2024; Wu, 2025; Zhao & Wang, 2024). However, this body of research also shows that AR is not automatically effective simply because it is technologically novel. Its pedagogical value depends on task design, teacher scaffolding, classroom management, and the extent to which digital representations are connected to meaningful language use (Criollo-C et al., 2024; Li et al., 2025; Mohd Nabil et al., 2024; Pallavicini & Anesa, 2026). Thus, what is known is that AR can enhance engagement and multimodal learning; what remains less clear is how AR can be pedagogically

organized to support grammar use among young EFL learners.

A closer review of AR language-learning studies shows that much of the evidence has focused on vocabulary learning, reading, speaking, general engagement, or secondary and higher-education contexts (Ahmed & Mohamed, 2026; Fernandez-Alcocer & Belda-Medina, 2025; Khodabandeh et al., 2025; Mohd Nabil et al., 2024; Morfidi & Iatraki, 2025; Oto-Millera et al., 2025; Salehi, 2025; Zhang et al., 2025). Compared with these areas, fewer studies have examined grammar learning in authentic primary EFL classrooms. Recent work on AR and grammar among older learners suggests promise, but it does not fully explain how young learners use AR-based visual cues, movement, and collaboration to construct grammar meaning. Therefore, a more specific research gap remains: no previous study has systematically examined AR-supported situated grammar instruction for the present continuous tense with second-semester fourth-grade students in an Indonesian primary EFL classroom using an explanatory sequential mixed-methods design.

Situated Learning Theory provides a suitable framework for addressing this gap. From a situated learning perspective, knowledge is constructed through participation in meaningful activity, social interaction, and context-based practice (Lave & Wenger, 1991; Parlar & Soner, 2025; Vargas et al., 2026; Wang et al., 2025). Grammar, in this view, should not be learned only as isolated forms but also practiced as a resource for describing meaningful situations. AR can support situated grammar learning because it allows students to observe animated actions, discuss them with peers, and produce sentences that describe what they see in the classroom environment.

AR-supported grammar instruction may also be understood through embodied, collaborative, and visual learning perspectives. When learners scan markers, move around the classroom, point to objects, discuss sentence choices, and present answers, they engage physically, socially, cognitively, and affectively with the grammar task (Çelik & Baturay, 2024; Crogman et al., 2025; Fehrmann, 2025; Kazlaris & Keramopoulos, 2025; Stalheim & Somby, 2024; Suo et al., 2026). These mechanisms are also consistent with sociocultural views of peer-supported learning (Vygotsky, 1986) and visual anchoring in language learning (Paivio, 1991; Schorr et al., 2024). Nevertheless, these mechanisms require empirical examination in primary classrooms, where learners' age, attention span, device use, and classroom organization may influence the effectiveness of AR-based grammar tasks.

The novelty of this study lies in three specific aspects. To the authors' knowledge, this study is among the first to focus on AR-supported situated instruction for teaching the present continuous tense to second-semester fourth-grade students in an Indonesian primary EFL context. It also uses Assemblr Edu as the AR platform for presenting animated grammar prompts and employs an explanatory sequential mixed-methods design to explain quantitative grammar outcomes through questionnaire, observation, and interview data. This study is significant for three reasons. Theoretically, it extends Situated Learning Theory to AR-supported grammar instruction. Methodologically, it demonstrates how mixed-methods evidence can explain the effects of AR interventions. Practically, it provides guidance for primary EFL teachers who wish to integrate AR as a complementary scaffold rather than as a replacement for teacher explanation and written practice.

To address the identified gap, the present study investigated AR-supported situated grammar instruction for second-semester fourth-grade students in a primary EFL classroom. The study focused on the present continuous tense and compared students who learned through AR-supported situated activities with students who received conventional grammar instruction. It also examined students' post-intervention perceptions and qualitative learning experiences to explain how AR-supported instruction supported grammar learning: (1) To what extent do second-semester fourth-grade students report satisfaction, willingness/motivation, and enjoyment as integrated dimensions of their post-intervention perceptions after participating in AR-supported situated grammar instruction? (2) How does AR-supported situated grammar instruction affect students' contextualized use of the present continuous tense, operationalized through recognition, limited production, and picture-description tasks, compared with conventional grammar instruction? (3) How do students' classroom engagement and learning experiences explain the effects of AR-supported situated grammar instruction on grammar learning?

METHOD

This study employed an explanatory sequential mixed-methods design. The quantitative phase was conducted first using a quasi-experimental pre-test-post-test control group design, followed by a

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qualitative phase involving classroom observations and semi-structured interviews. The purpose of using this design was to measure the effect of AR-supported situated grammar instruction on students' contextualized grammar use and to explain the quantitative findings through students' learning experiences during the intervention (Christodoulou, 2025; Creswell & Plano Clark, 2018; Haynes-Brown, 2025).

In the quantitative phase, two intact classes were involved. Class 4A served as the experimental group and received AR-supported situated grammar instruction, while Class 4B served as the control group and received conventional grammar instruction. Both groups completed a grammar pre-test before the intervention and a grammar post-test after the intervention.

In addition, a motivation and enjoyment questionnaire was administered only to the experimental group after the AR-supported instruction. Therefore, the questionnaire data were interpreted as post-intervention perceptions of the AR learning experience rather than as evidence of motivational gain compared with the control group.

The qualitative phase was conducted to provide deeper explanations of the quantitative findings. Classroom observations were carried out during the intervention, and semi-structured interviews were conducted with selected students from the experimental group after the intervention.

Table 1. *Overall research design*

Group	Pre-test	Treatment	Post-test	Additional Data
Experimental / Class 4A	Grammar pre-test	AR-supported situated grammar instruction	Grammar post-test	Questionnaire, observation, interviews
Control / Class 4B	Grammar pre-test	Conventional grammar instruction	Grammar post-test	-

The participants of this study were second-semester fourth-grade students at SD Negeri Topogaro, Kecamatan Bungku Barat, Morowali, Central Sulawesi, Indonesia. Purposive sampling was used to select two intact classes that were available at the same grade level, followed the same school English curriculum, were scheduled to learn the same grammar topic, and had comparable prior school-based English learning experience. A total of 60 students aged 9-10 years participated in the study. The participants came from two naturally formed classes, namely Class 4A and Class 4B, each consisting of 30 students. Based on teacher confirmation, the students had previously received basic English lessons at school, but they had not received formal AR-supported grammar instruction before this study.

Class 4A was assigned as the experimental group, while Class 4B was assigned as the control group. The experimental group consisted of 19 female students and 11 male students, whereas the control group consisted of 17 female students and 13 male students. Since the class distribution had already been arranged by the school system and school scheduling did not allow class restructuring, individual random assignment was not possible.

The experimental group received AR-supported situated grammar instruction, while the control group received conventional grammar instruction. Both groups were taught by the same English teacher of SD Negeri Topogaro to maintain instructional consistency and minimize teacher-related bias. Before the intervention, both groups completed a grammar pre-test to examine their initial grammar ability.

Table 2. *Participant characteristics*

Group	Class	Semester	N	Age	Female	Male	Instruction
Experimental	4A	2	30	9-10	19	11	AR-supported situated grammar instruction
Control	4B	2	30	9-10	17	13	Conventional grammar instruction
Total	-	-	60	9-10	36	24	-

A grammar achievement test was used to measure students' ability to understand and use the present continuous tense before and after the intervention. The same test format was administered as the pre-test and post-test to both the experimental and control groups. The test

focused on students' recognition and production of the present continuous tense in sentence-level and contextualized tasks, consistent with the view that grammar assessment should include both knowledge of forms and ability to use forms in context (Purpura, 2004).

The total raw score of the test was 25 points. The multiple-choice section was worth 10 points, with each correct answer receiving 1 point. The gap-fill section was worth 5 points, with each item scored 1 point for a correct answer, 0.5 point for a partially correct answer, and 0 point for an incorrect answer. The picture-description section was worth 10 points, with each item scored using a 0-2 rubric. A sentence with correct present continuous tense structure and appropriate meaning received 2 points; a sentence with partially correct structure or meaning received 1 point; and an incorrect or unclear sentence received 0 point. The raw score was converted into a 100-point scale using the formula: converted score = (raw score / 25) x 100.

The content validity of the grammar achievement test was examined through expert judgment. The instrument was reviewed by a lecturer with a doctoral degree in English language education from Universitas Muhammadiyah Gresik and an English teacher from SD Negeri Topogaro. The reviewers evaluated the clarity of instructions, the appropriateness of the items for second-semester fourth-grade students, the alignment between the test items and the learning objective, and the clarity of the language used in the test. The multiple-choice section was scored using an answer key, while the gap-fill and picture-description sections were scored using structured rubrics. The picture-description section was scored independently by two raters using the same 0-2 rubric. Because the task required students to describe simple and clearly identifiable ongoing actions, the scoring categories were explicit and easy to apply. Inter-rater agreement for the picture-description section was 100%, as both raters assigned the same scores across 300 rated responses. This result should be interpreted as scoring consistency for a simple rubric-based task rather than as evidence that productive grammar assessment is free from subjectivity in more complex tasks.

Table 3. *Grammar achievement test blueprint*

Section	Item Type	Number of Items	Maximum Score	Purpose
A	Multiple choice	10	10	Recognition of present continuous tense forms
B	Gap-fill	5	5	Limited production of am/is/are + verb-ing
C	Picture description	5	10	Contextualized production based on visual prompts
Total	-	20	25	Converted to 100-point scale

Motivation and enjoyment questionnaire

A motivation and enjoyment questionnaire was administered to the experimental group after the intervention to examine students' perceptions of AR-supported situated grammar instruction. The questionnaire consisted of 15 items measuring three sub-constructs: satisfaction, willingness/motivation, and enjoyment, with five items for each sub-construct. These dimensions reflect common affective and usability concerns in AR-supported language learning research (Koumpouros, 2024; Marrahi-Gomez et al., 2024; Parlar & Soner, 2025).

The questionnaire was written in Indonesian to ensure that the second-semester fourth-grade students could understand each statement clearly. A five-point Likert scale supported by emoji icons was used to make the response options more accessible for young learners. The response options ranged from 5 = strongly agree to 1 = strongly disagree.

Examples of questionnaire items included: "Saya senang belajar grammar menggunakan AR" [I enjoy learning grammar using AR] for satisfaction, "Saya ingin belajar bahasa Inggris lagi dengan AR" [I want to learn English again using AR] for willingness/motivation, and "Saya suka bergerak dan bekerja sama dengan teman saat belajar menggunakan AR" [I like moving and working with friends when learning with AR] for enjoyment. These examples show that the statements were written in simple Indonesian and adjusted to the students' age level.

The content validity of the questionnaire was examined through expert judgment by the same validators who reviewed the grammar achievement test. The validators reviewed the clarity of the statements, the appropriateness of the language for fourth-grade students, the relevance of the items to

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the measured constructs, and the suitability of the emoji-supported Likert scale for young learners. The reliability of the questionnaire was examined using Cronbach's Alpha. The overall questionnaire demonstrated excellent internal consistency (alpha = .968). The reliability coefficients for the three sub-constructs were also high: satisfaction (alpha = .922), willingness/motivation (alpha = .927), and enjoyment (alpha = .848). These results indicate that the questionnaire had strong internal consistency for measuring students' post-intervention perceptions of AR-supported grammar learning.

Table 4. *Questionnaire structure and reliability*

Sub-construct	Number of Items	Focus	Cronbach's Alpha
Satisfaction	5	Perceived ease, usefulness, and interest in AR grammar learning	.922
Willingness/ Motivation	5	Willingness to use AR again and in other English lessons	.927
Enjoyment	5	Enjoyment of movement, collaboration, and AR-based challenges	.848
Overall	15	Overall perception of AR-supported grammar learning	.968

Classroom observation

Classroom observation was used to document students' learning behaviors during the implementation of AR-supported situated grammar instruction. The observation was conducted only in the experimental group because the purpose was to examine how students engaged with AR-supported grammar activities during the intervention. Classroom observations were conducted live by the first researcher during all five instructional sessions. Field notes were taken using an observation sheet, and no video recording was used in order to minimize disruption and protect young learners' privacy. The observation dimensions were informed by studies emphasizing physical, social, cognitive, and affective engagement in immersive and embodied learning environments (Chang & Aberash, 2026; Crogman et al., 2025; Stalheim & Somby, 2024).

An observation sheet was used to record students' learning behaviors during the activities. The observation focused on four dimensions: physical engagement, social interaction, cognitive engagement, and affective engagement. Since the observation was conducted generally throughout each session, no fixed time-interval coding was used.

Table 5. *Observation dimensions*

Dimension	Indicators Observed	Focus of Observation
Physical engagement	Movement, gestures, device use, scanning AR markers	Physical interaction with AR tasks
Social interaction	Collaboration, discussion, turn-taking, peer assistance	Peer interaction during AR activities
Cognitive engagement	Focus, problem-solving, verbal responses, sentence construction	Application of the present continuous tense
Affective engagement	Enjoyment, enthusiasm, confidence, low anxiety	Emotional response to AR grammar learning

Semi-structured interview

Semi-structured interviews were conducted to obtain deeper insights into students' experiences after participating in AR-supported situated grammar instruction. Six students from the experimental group were selected based on variation in students' learning outcomes, so that the interview data could represent students with different levels of grammar achievement after the intervention.

The interviews were conducted after the AR learning sessions and post-test had been completed. The interview setting was arranged in a small-group format, where students sat together to create a comfortable atmosphere, but the questions were addressed to each student individually. The interviews were conducted in Indonesian and were audio-recorded with permission.

Treatment / intervention procedure

The intervention was conducted over three weeks and consisted of five instructional sessions. Each session lasted 60 minutes. Both the experimental and control groups learned the same grammar topic, namely the present continuous tense. The same English teacher taught both groups to maintain instructional consistency.

The experimental group received AR-supported situated grammar instruction using Assemblr Edu, an AR education platform that supports interactive 3D/AR learning content for teachers and students (Assemblr Team, 2023). The AR learning materials were designed in the form of picture cards or markers. When the students scanned the markers using smartphones, animated activity objects appeared on the screen. These animations represented actions such as reading, eating, dancing, running, drinking, and cooking.

During the AR sessions, students worked collaboratively in small groups of five. Smartphones were provided by the researcher in cooperation with the teachers at the school. The learning process in the experimental group followed five stages: opening, explanation, AR scanning, group sentence construction, presentation, and feedback.

In contrast, the control group received conventional grammar instruction. The teacher explained the present continuous tense pattern on the whiteboard, provided examples, asked students to write the grammar pattern in their notebooks, gave worksheet-based exercises, and reviewed the answers together with the class.

Table 6. *Overview of the intervention procedure*

Session	Grammar Focus	Experimental Group	Control Group	Situated Output / Task
1	Introduction	Pattern introduction, AR scanning, and affirmative sentence construction	Whiteboard explanation and basic written exercises	Students identify visible ongoing actions and produce simple affirmative sentences.
2	To be: am, is, are	Students scan AR animations and identify the correct to be	Teacher explanation and gap-fill exercises	Students match AR actions with the correct form of to be (am/is/are).
3	Verb-ing forms	Students construct sentences using verb-ing forms from AR animations	Worksheet-based sentence construction	Students write verb-ing phrases from animated actions shown through AR markers.
4	Contextual construction	Groups write complete sentences describing AR animations	Students write sentences based on worksheet prompts	Groups compose contextualized present continuous sentences from AR scenes.
5	Review and presentation	Groups present sentences and receive feedback	Review, written practice, and class correction	Groups present completed sentences orally and receive teacher/peer feedback.

The data were analyzed using both quantitative and qualitative techniques. Quantitative data were processed using SPSS. Before conducting inferential statistical tests, assumption testing was carried out. Normality was tested using the Shapiro-Wilk test, while homogeneity of variance was examined using Levene's test.

Grammar achievement data were analyzed using descriptive statistics, paired-sample t-tests, independent-samples t-tests, and Analysis of Covariance (ANCOVA). An independent-samples t-test was conducted on pre-test scores to examine baseline equivalence between the experimental and control groups. Paired-sample t-tests were used to examine within-group improvement from pre-test to post-test. Independent-samples t-tests were used to compare post-test and gain scores between the two groups. ANCOVA was conducted to examine the effect of instructional group on students' post-test grammar achievement after controlling for their pre-test scores. The homogeneity of regression slopes assumption was examined before interpreting the ANCOVA results. Effect size was reported using Cohen's d for t-test results and partial eta squared for ANCOVA results.

The motivation and enjoyment questionnaire data were analyzed descriptively because the questionnaire was administered only to the experimental group after the intervention. The analysis included frequency, percentage, mean, and standard deviation for each sub-construct and for the overall questionnaire score. Qualitative data

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from classroom observations and semi-structured interviews were analyzed using thematic analysis following Braun and Clarke's (2006) procedure. The analysis involved familiarization with observation notes and interview recordings, generation of initial codes, grouping related codes into potential themes, reviewing the themes against the data, naming the final themes, and reporting the themes with supporting evidence. Initial coding was conducted by the first researcher. To improve trustworthiness, the second researcher independently coded 20% of the interview transcripts, and inter-coder agreement was 92%. Disagreements were resolved through discussion, and the emerging themes were checked against classroom observation notes, interview responses, and quantitative findings.

This study was conducted by following ethical principles for research involving young learners. Permission was obtained from SD Negeri Topogaro, Kecamatan Bungku Barat, Morowali, Central Sulawesi. Parental consent was also secured before students participated in the research. The students were given a simple explanation in age-appropriate language and were informed that they could choose whether or not to participate.

Participation was voluntary, and students' involvement did not affect their regular English scores at school. To protect confidentiality, students' real names were not used in the research report. Instead, codes such as S1, S2, and S3 were used when presenting interview excerpts. The data and audio recordings were used only for research purposes. During AR-supported grammar instruction, smartphone use was supervised by the researcher and the teacher. Any photo or video documentation involving children was limited, used only with school and parental permission, and was not presented in the report in a way that could identify individual students.

RESULTS AND DISCUSSION

Students' satisfaction, motivation, and enjoyment after AR-supported grammar instruction

To answer the first research question, a motivation and enjoyment questionnaire was administered to the experimental group after the students completed the AR-supported situated grammar instruction. Since the questionnaire was given only to the experimental group, the results were interpreted as students' post-intervention perceptions rather than as evidence of motivational improvement compared with the control group.

The questionnaire measured three sub-constructs: satisfaction, willingness/motivation, and enjoyment. As shown in Table 7, the overall mean score was very high (M = 4.47, SD = 0.42). Enjoyment received the highest mean score (M = 4.61, SD = 0.36), followed by willingness/motivation (M = 4.43, SD = 0.46), and satisfaction (M = 4.37, SD = 0.47). These findings suggest that students perceived AR-supported situated grammar instruction positively, particularly in terms of enjoyment.

Table 7. *Descriptive statistics of students' motivation and enjoyment*

Sub-construct	Mean	SD	Interpretation
Satisfaction	4.37	0.47	Very High
Willingness/ Motivation	4.43	0.46	Very High
Enjoyment	4.61	0.36	Very High
Overall	4.47	0.42	Very High

The distribution of students' overall perception categories showed that all students responded positively to AR-supported grammar learning. As presented in Table 8, 15 students (50.0%) were categorized as having very positive perceptions, while the remaining 15 students (50.0%) were categorized as having positive perceptions. No students were categorized as neutral, negative, or very negative. At the item level, the highest-rated item was related to movement during AR activities (M = 4.90), followed by collaboration with peers (M = 4.83). The lowest-rated items were still in the very high category (M = 4.30), indicating that students generally responded favorably across all questionnaire items.

Table 8. *Distribution of students' overall perception categories*

Category	Score Range	Frequency	Percentage
Very Positive	4.21-5.00	15	50.0%
Positive	3.41-4.20	15	50.0%
Neutral	2.61-3.40	0	0%
Negative	1.81-2.60	0	0%
Very Negative	1.00-1.80	0	0%

Students' grammar achievement

To answer the second research question, grammar achievement was measured using pre-test and post-test scores from both the experimental and control groups. The grammar test assessed students' ability

to understand and use the present continuous tense in sentence-level and contextualized tasks. Before comparing post-test achievement, an independent-samples t-test was conducted to examine the baseline equivalence of the two groups. The result showed no significant difference in pre-test scores between the experimental group (M = 48.93, SD = 12.46) and the control group (M = 48.13, SD = 13.18), t(58) = 0.24, p = .810. This indicates that the two groups had comparable initial grammar ability before the intervention.

As shown in Table 9, both groups improved from pre-test to post-test. The experimental group increased from a pre-test mean score of 48.93 (SD = 12.46) to a post-test mean score of 87.67 (SD = 8.73). The control group increased from a pre-test mean score of 48.13 (SD = 13.18) to a post-test mean score of 75.73 (SD = 8.48). The experimental group also obtained a higher gain score (M = 38.73, SD = 8.76) than the control group (M = 27.60, SD = 9.13).

Table 9. *Descriptive statistics of pre-test and post-test performance*

Group	N	Pre-test Mean	SD	Post-test Mean	SD	Gain Score Mean	SD
Experimental	30	48.93	12.46	87.67	8.73	38.73	8.76
Control	30	48.13	13.18	75.73	8.48	27.60	9.13

Paired-sample t-tests showed that both groups improved significantly from pre-test to post-test. The experimental group showed a significant improvement, t(29) = 24.20, p < .001, and the control group also showed a significant improvement, t(29) = 16.55, p < .001. Independent-samples t-tests showed that the experimental group achieved significantly higher post-test scores than the control group, t(58) = 5.37, p < .001, Cohen's d = 1.39. The gain score comparison also showed a significant difference in favor of the experimental group, t(58) = 4.82, p < .001, Cohen's d = 1.24. These results indicate large effects of AR-supported situated grammar instruction on students' grammar achievement.

Table 10. *Independent samples t-test results*

Variable	t-value	Df	p-value	Cohen's d	Interpretation
Pre-test	0.24	58	.810	-	Comparable baseline
Post-test	5.37	58	< .001	1.39	Large effect
Gain score	4.82	58	< .001	1.24	Large effect

To provide a more rigorous comparison, ANCOVA was conducted with post-test scores as the dependent variable, instructional group as the independent variable, and pre-test scores as the covariate. Prior to the analysis, the assumption of homogeneity of regression slopes was examined. The interaction between group and pre-test was not significant, F(1, 56) = 0.06, p = .805, indicating that the assumption was met. Levene's test also showed that the homogeneity of variance assumption was satisfied, F(1, 58) = 0.03, p = .874. The ANCOVA results showed a significant effect of instructional group on post-test grammar achievement after controlling for pre-test scores, F(1, 57) = 54.70, p < .001, partial eta squared = .490. The covariate, pre-test score, was also significant, F(1, 57) = 60.56, p < .001, partial eta squared = .515.

Table 11. *ANCOVA results for post-test grammar achievement*

Source	F	Sig.	Partial Eta Squared
Pre-test	60.56	< .001	.515
Group	54.70	< .001	.490

The adjusted post-test mean was higher for the experimental group (Madj = 87.47) than for the control group (Madj = 75.93). The adjusted mean difference was 11.55 points, SE = 1.56, p < .001, 95% CI [8.42, 14.67], favoring the experimental group.

Table 12. *Adjusted post-test means and pairwise comparison*

Group	Adjusted Mean	Mean Difference	SE	95% CI
Experimental	87.47	11.55	1.56	[8.42, 14.67]
Control	75.93	-	-	-

The distribution of gain scores further supports the quantitative findings. Most students in the experimental group achieved gain scores of 30 points or higher, while the control group showed a more modest distribution.

Table 13. *Distribution of gain scores*

Gain Score Range	Experimental Frequency	Experimental %	Control Frequency	Control %
50-60	3	10.0%	0	0%
40-49	11	36.7%	2	6.7%
30-39	10	33.3%	12	40.0%
20-29	6	20.0%	12	40.0%
10-19	0	0%	2	6.7%
0-9	0	0%	2	6.7%

Qualitative findings from student interviews

Semi-structured interviews were conducted with six selected students from the experimental group after the AR-supported grammar instruction and post-test had been completed. Thematic analysis generated five themes: enjoyment and fun, embodied learning, collaboration, challenges, and grammar understanding.

Table 14. *Thematic summary of student interviews*

Theme	Sub-themes	Frequency	Sample Quotation
Enjoyment and fun	Excitement, not boring, wanting to repeat	6/6	"Learning with AR makes me not bored" (S3)
Embodied learning	Moving, using body to learn, not sleepy	5/6	"I can move around looking for objects, so I don't get sleepy" (S2)
Collaboration	Helping friends, discussing answers, checking together	6/6	"I like working with friends because they help when I forget" (S1)
Challenges	Technical issues, physical fatigue, lighting problems	3/6	"Sometimes AR objects are hard to appear when the light is dim" (S1)
Grammar understanding	Easier to remember, visual help, sentence patterns	5/6	"AR helps me remember sentence patterns because I see directly" (S4)

The interview findings support the questionnaire and grammar test results. Students described AR learning as fun, less boring, and easier to remember. They also explained that movement, peer collaboration, and visual animations helped them connect sentence patterns with visible actions. However, some students reported technical issues, lighting problems, and physical fatigue, indicating that AR activities need careful classroom preparation.

Classroom observation findings

Classroom observations were conducted in the experimental group during the AR-supported grammar learning sessions. The observations focused on four dimensions: physical engagement, social interaction, cognitive engagement, and affective engagement. Rather than reporting only general frequency labels, the observation summary presents concrete field-note evidence from the learning sessions.

Table 15. *Summary of observation findings*

Dimension	Indicators Observed	Frequency / Field-note Evidence
Physical engagement	Body movement, gestures, device manipulation, moving to different AR markers	Observed in 5/5 sessions; students moved between markers, adjusted smartphone positions, pointed at AR objects, and used gestures to represent actions.
Social interaction	Collaboration, discussion, turn-taking, showing peers, helping with device operation	Observed in 4/5 sessions, especially Sessions 2-5; students took turns scanning markers, showed AR objects to peers, discussed sentence choices, and helped friends operate the device.
Cognitive engagement	Focus, problem-solving, verbal responses, asking clarifying questions	Observed in 4/5 sessions, especially Sessions 2-5; students selected the correct to be, corrected verb-ing forms, asked clarifying questions, and revised sentences after teacher feedback.

Affective engagement	Joy, enthusiasm, low anxiety, smiling, voluntary task continuation	Observed in 5/5 sessions; students smiled, volunteered to continue tasks, expressed excitement, and showed lower hesitation when presenting group sentences.

Overall, the interview and observation findings provide qualitative support for the quantitative results. The observation notes showed that students did not merely watch AR animations; they used the animations as prompts for movement, discussion, sentence construction, peer correction, and oral presentation. Some implementation challenges were also noted, especially when lighting conditions made AR objects difficult to display or when students needed reminders to take turns using the smartphones. These findings suggest that AR-supported situated grammar instruction was positively experienced by students and supported learning through enjoyment, movement, collaboration, and visualized grammar use, while still requiring careful teacher guidance.

AR-supported grammar learning and students' positive perceptions

The findings of this study provide evidence that AR-supported situated grammar instruction can support second-semester fourth-grade students' learning of the present continuous tense. This result is consistent with recent AR language-learning studies suggesting that AR can strengthen engagement and language performance when paired with meaningful learning tasks (Marrahi-Gomez et al., 2024; Parlar & Soner, 2025; Schorr et al., 2024; Tian & Ironsi, 2025).

However, the findings should be interpreted carefully. Since the questionnaire was administered only to the experimental group after the intervention, the results do not directly prove that AR increased motivation more than conventional instruction. Rather, they show that students who experienced AR-supported grammar activities perceived the learning process positively.

The high enjoyment score may be related to the interactive and collaborative nature of the learning activities. Students did not only receive grammar explanations but also moved, scanned AR markers, observed animated actions, discussed sentence construction with peers, and presented their answers. Such active, multisensory, and low-stakes learning conditions may support motivation and reduce anxiety in language learning (Fehrmann, 2025; Krashen, 1982; Nguyen et al., 2025; Ryan & Deci, 2000; Salehi, 2025).

Improvement in contextualized grammar use

The grammar achievement results showed that the experimental group achieved higher post-test and gain scores than the control group. The independent-samples t-test indicated a significant difference with a large effect size. More importantly, the ANCOVA results showed that the effect of instructional group remained significant after controlling for pre-test scores. This supports the argument that contextualized grammar practice can strengthen both form recognition and productive use (Pawlak et al., 2025; Purpura, 2004).

The improvement may be explained by the way AR connected grammatical forms with visible and contextualized actions. In conventional grammar instruction, students usually learn the present continuous tense through rules, examples, and written exercises. In contrast, the experimental group observed animated actions through AR markers and constructed sentences based on what they saw. This visual-contextual link is consistent with AR language-learning research emphasizing multimodal input and context-rich representation (Fernandez-Alcocer & Belda-Medina, 2025; Khodabandeh et al., 2025; Oto-Millera et al., 2025).

Authentic context as a situated learning mechanism

One important mechanism identified in this study is authentic context. AR-supported activities allowed students to learn grammar through simulated real-world actions embedded in their classroom environment. When students scanned AR markers and saw animated activities, they were not merely memorizing rules but using grammar to describe meaningful actions. This interpretation is aligned with situated learning perspectives and recent work on immersive context-based learning (Lave & Wenger, 1991; Parlar & Soner, 2025; Vargas et al., 2026; Wang et al., 2025).

Embodied learning through movement and interaction

A second mechanism is embodied learning. The observation data showed that students moved around, scanned markers, adjusted smartphone positions, pointed to objects, and used gestures while discussing sentences. Interview responses also indicated that movement helped students stay

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focused and remember sentence patterns. These findings are consistent with embodied cognition and AR learning studies that connect bodily movement, perception, and learning outcomes (Chang & Aberash, 2026; Crogman et al., 2025; Stalheim & Somby, 2024; Suo et al., 2026; Varela et al., 1991).

Collaborative knowledge construction

The third mechanism is collaborative knowledge construction. Students worked in small groups of five during the AR activities, helped one another, discussed answers, took turns using smartphones, and checked sentence forms together. This pattern reflects sociocultural and collaborative learning perspectives, in which interaction supports meaning-making and peer-assisted learning (Butler, 2026; Kazlaris & Keramopoulos, 2025; Nagpal et al., 2025; Vygotsky, 1986). This finding is also consistent with Aziz et al. (2023), who reported that students' perceptions of collaborative writing and self-efficacy were positively related to writing achievement in the information technology era, suggesting that collaborative language activities can be strengthened when learners feel confident and perceive the learning process positively.

Visual anchoring of grammar forms

The fourth mechanism is visual anchoring. Students reported that AR helped them remember sentence patterns because they could see the actions directly. This suggests that AR helped anchor abstract grammatical forms to visual representations. The present continuous tense can be difficult for young EFL learners when it is taught only as a rule. However, when students see a boy running, a girl eating, or students dancing, the meaning of is running, is eating, or are dancing becomes easier to understand. This interpretation is consistent with dual coding theory and AR studies that emphasize visual support for language learning (Paivio, 1991; Schorr et al., 2024; Zhao & Wang, 2024).

Pedagogical implications

The findings suggest that AR-supported situated grammar instruction can be used as a complementary strategy for teaching grammar to young EFL learners. AR activities should combine visual support, movement, collaboration, and sentence production. This recommendation is consistent with Pratama et al. (2024), who emphasize that educational technology should be integrated through appropriate instructional design, digital media use, and technology-supported assessment rather than treated merely as a tool. Teachers should provide clear scaffolding before, during, and after AR activities, and practical classroom conditions such as lighting, device stability, marker clarity, group organization, and time management should be considered (Fernandez-Herrero et al., 2026; Harvey & Cope, 2025; Mirza et al., 2025; Okumuş & Savaş, 2024; S. Zhang & Yao, 2025).

CONCLUSION

This study provides evidence that AR-supported situated grammar instruction can support second-semester fourth-grade students' learning of the present continuous tense in a primary EFL classroom. The questionnaire findings showed that students in the experimental group perceived AR-supported grammar learning very positively, particularly in terms of enjoyment, willingness/motivation, and satisfaction. However, because the questionnaire was administered only after the intervention and only to the experimental group, these findings should be interpreted as students' favorable post-intervention perceptions rather than as direct evidence of motivational improvement compared with conventional instruction.

The grammar achievement results showed that students who received AR-supported situated grammar instruction achieved higher post-test scores and gain scores than those who received conventional grammar instruction. The ANCOVA results further confirmed that the difference between the experimental and control groups remained significant after controlling for pre-test scores. These findings suggest that AR-supported situated grammar instruction can help young EFL learners use the present continuous tense more effectively in contextualized tasks.

The qualitative findings indicate that AR supported grammar learning through authentic context, embodied learning, collaborative knowledge construction, and visual anchoring. AR should not be viewed as a replacement for teacher explanation, textbook practice, or written reinforcement. Instead, it can enrich grammar instruction when combined with clear scaffolding, collaborative tasks, teacher feedback, and opportunities for non-AR practice.

Future studies should involve larger samples, longer intervention periods, delayed post-tests, and different grammar topics to examine the broader applicability and long-term impact of AR-

supported situated grammar instruction in primary EFL classrooms.

LIMITATIONS AND FUTURE RESEARCH

This study has several limitations. First, the participants were limited to 60 second-semester fourth-grade students from one elementary school. Therefore, the findings cannot be generalized broadly to all primary EFL learners in different school contexts.

Second, the study used naturally formed intact classes. Although pre-test scores were used to examine baseline comparability and ANCOVA was conducted to control for initial grammar ability, individual random assignment was not possible. Therefore, causal claims should be made with caution.

Third, the intervention was relatively short, consisting of five 60-minute sessions over three weeks. This duration was sufficient to examine immediate grammar achievement and perceptions, but it did not allow the researcher to examine long-term retention. Future studies should include delayed post-tests.

Fourth, the study focused only on one grammatical structure, namely the present continuous tense. Future research should examine whether AR-supported situated instruction is also effective for different grammatical features.

Fifth, the motivation and enjoyment questionnaire was administered only to the experimental group after the intervention. Therefore, the questionnaire results indicate students' positive perceptions of AR-supported grammar learning, but they do not provide direct comparative evidence of motivational change between the experimental and control groups.

Sixth, the positive responses to AR may partly reflect a novelty effect because many students were experiencing AR-supported grammar activities for the first time. Therefore, students' enthusiasm may have been influenced not only by the pedagogical quality of the tasks but also by the newness of the technology. Finally, several practical issues were identified during implementation, including lighting problems, difficulty scanning AR markers, and students' physical fatigue. Future research should involve larger samples, multiple schools, longer intervention periods, more diverse grammar topics, delayed post-tests, and comparisons with other technology-enhanced approaches.

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