EDUKASIA: Jurnal Pendidikan dan Pembelajaran
Vol. 6, 2 (December, 2025), pp. 1067-1080
ISSN: 2721-1150; EISSN: 2721-1169; DOI: 10.62775/edukasia.v6i2.1693

Augmented Reality as a Learning Medium for Arabic Sentence Structures: Evidence from a Quasi-Experimental Study

Muhammad Nasrullah[1], Achmad Baihaqi[2], Ahmad Zubaidi[3], Jepri Nugrawiyati[4]

[1] UIN Kiai Ageng Muhammad Besari Ponorogo, Indonesia; nasrullah752001@gmail.com
[2] UIN Kiai Ageng Muhammad Besari Ponorogo, Indonesia; abayhaque.qie@gmail.com
[3] UIN Kiai Ageng Muhammad Besari Ponorogo, Indonesia; zubaidiahmad716@gmail.com
[4] UIN Walisongo Semarang, Indonesia; jepri.n@walisongo.ac.id

ARTICLE INFO

Keywords:

augmented reality;
arabic language learning;
sentence structures;
students' understanding;
educational technology.

Article history:

Received 2025-08-30
Revised 2025-10-22
Accepted 2025-11-29

ABSTRACT

This study investigates the potential of Augmented Reality (AR) as a learning medium to improve students' comprehension of Arabic sentence structures. Employing a quasi-experimental pretest–posttest control group design, the research involved 60 fourth-semester students of the Arabic education program, divided into experimental and control classes. Data were obtained from achievement tests and perception questionnaires. The findings showed that students in the AR class achieved significantly higher gains in syntactic comprehension than those in the control class, with a large effect size indicating the strong pedagogical impact of AR. In addition, students expressed highly positive attitudes toward AR, perceiving it as motivating, easy to use, and effective in visualizing grammatical structures. These results suggest that AR not only strengthens the cognitive processes of dual coding and spatial visualization but also contributes to the pedagogical development of Arabic language instruction. The study highlights the novelty of applying AR in Arabic syntax learning and offers theoretical implications for computer-assisted language learning and applied linguistics.

Corresponding Author:
Muhammad Nasrullah
UIN Kiai Ageng Muhammad Besari Ponorogo, Indonesia; nasrullah752001@gmail.com

1. INTRODUCTION

Arabic language education at the tertiary level faces persistent challenges in fostering students' comprehension of complex sentence structures, such as *i'rab*, *jumlah ismiyyah,* and *jumlah fi'liyyah*. Many learners struggle to apply syntactic rules accurately, which often results in grammatical errors and hinders their ability to construct meaningful communication (Fitrianto, 2024; Rani et al., 2023). Conventional teaching methods, relying on textbooks, lectures, and rote exercises, tend to emphasize rule memorization rather than active construction of knowledge, leading to low engagement and limited mastery of syntax (Arifin et al., 2024; Ritonga et al., 2024). Preliminary assessments in several cohorts have shown that average scores in Arabic sentence structure remain below satisfactory levels,

reflecting the urgent need for innovative approaches that can promote deeper understanding and sustained motivation.

Previous research has shown that Augmented Reality (AR) is effective in enhancing learning across various domains, particularly in STEM education and vocabulary acquisition (Al Rajab et al., 2023; Hasaniyah et al., 2023; Safitri & Farirahma, 2024). In STEM contexts, AR helps students visualize abstract and spatially complex scientific concepts, thereby improving comprehension and problem-solving skills (Arifin et al., 2024; Faiqoh et al., 2025). In language learning, most AR applications have concentrated on vocabulary, where learners benefit from multimodal exposure, contextual interaction, and increased motivation (Haq et al., 2024; Rani et al., 2023). While these studies demonstrate the motivational and cognitive affordances of AR, they are primarily limited to discrete knowledge units such as terms or scientific objects (Huda, 2024; Nasrullah, et al., 2024; Shaharudin et al., 2021). By contrast, Arabic syntax presents unique challenges that go beyond memorization, requiring mastery of hierarchical grammatical relationships such as i'rab, jumlah ismiyyah, and jumlah fi'liyyah. These structures demand dynamic visualization of grammatical roles and contextual functions within sentences. Despite the growing body of literature on AR, few studies in CALL have addressed the complexity of syntax acquisition, particularly in Arabic. This gap highlights the novelty of the present study, which extends the application of AR from vocabulary-focused learning to the more demanding domain of Arabic sentence structure comprehension (Bessadok & Hersi, 2023; Park & Son, 2022; Stockwell & Ito, 2022).

The learning of Arabic sentence structures at the university level often remains challenging, as many students demonstrate low comprehension and frequent errors in syntactic construction (Haq et al., 2024). Conventional instructional methods, such as lecture-based teaching and textbook exercises, have shown limited effectiveness in addressing these difficulties. Evidence from preliminary assessments indicates a significant gap in students' understanding; for instance, pretest scores from prior cohorts averaged below 60%, reflecting a need for innovative interventions (Afrianingsih et al., 2025; Faiqoh et al., 2025). In addition, students report low engagement and motivation when learning grammar through traditional media. This learning gap highlights the necessity of integrating interactive and technology-enhanced tools that can support conceptual visualization and active learning (Arifin et al., 2024; Rani et al., 2023). Therefore, the study addresses the urgent need to explore solutions that improve both comprehension and engagement in Arabic sentence structure learning.

The primary objective of this study is to examine the effectiveness of AR-based learning media in enhancing university students' understanding of Arabic sentence structures (Faiqoh et al., 2025; Susiawati et al., 2024). In addition, the study aims to identify students' perceptions and attitudes toward the use of AR as a learning tool, particularly regarding engagement and motivation. This investigation seeks to determine whether the integration of AR can lead to measurable improvements in syntactic comprehension compared to conventional learning methods (Auliya et al., 2025; Lazuardi & Syaheed, 2025). Another goal is to assess the potential of AR to foster deeper cognitive processing and interactive learning experiences, which are often lacking in traditional instruction (Huda, 2024; S. Wahyuni, 2021). Furthermore, the study intends to provide empirical evidence that can guide educators in adopting innovative strategies for Arabic language teaching. Ultimately, these objectives align with the broader aim of enhancing learning outcomes and student satisfaction in higher education language programs.

This study addresses two main research questions: first, does the use of AR-based learning media significantly improve students' understanding of Arabic sentence structures? Second, what are students' perceptions and experiences in using AR technology for Arabic language learning? Based on these questions, the study hypothesizes that students in the AR-based experimental group will demonstrate higher posttest scores than those in the control group using conventional media. Additionally, it is expected that students will report positive perceptions regarding engagement, interactivity, and cognitive support provided by AR tools. These hypotheses are grounded in prior research suggesting that immersive digital media can enhance learning outcomes and motivation, particularly in language acquisition (Lazuardi & Syaheed, 2025; Ritonga et al., 2024). The investigation

of these questions aims to provide both empirical evidence and practical guidance for integrating AR into higher education Arabic courses.

The study offers both theoretical and practical contributions. Theoretically, it contributes to applied linguistics and CALL by extending the application of AR from vocabulary learning and STEM visualization to the more demanding domain of Arabic syntax acquisition. It demonstrates how AR supports dual coding and spatial reasoning, thereby offering insights into cognitive mechanisms underlying grammar learning. Practically, the findings can guide teachers and lecturers in adopting AR tools to enhance syntax instruction, improve student engagement, and foster motivation in learning Arabic. Furthermore, the research provides evidence for curriculum developers and policymakers regarding the integration of emerging technologies into higher education language programs. By bridging theory and practice, the study highlights the novelty of employing AR in Arabic syntax learning and underscores its potential to enrich both pedagogical strategies and future research in technology-mediated language education.

2. METHODS

2.1. Research Design

This study employed a quasi-experimental design with a pretest–posttest control group to evaluate the effectiveness of Augmented Reality (AR)-based Arabic language learning media in enhancing students' understanding of sentence structures (Booyoesen, 2023; Zuniari et al., 2022). The quasi-experimental design was chosen because the participants could not be fully randomized due to limitations in class schedules and student enrollment, yet this design still allows a systematic comparison of the intervention (AR media) effects on the experimental and control groups (Çelik & Yangın Ersanlı, 2022). The pretest–posttest design was used to measure students' initial ability to comprehend sentence structures before the treatment and compare it with the post-intervention outcomes, allowing for a quantitative assessment of any improvement. The experimental group received instruction using AR-based media, while the control group followed conventional teaching methods. This approach enables the researcher not only to assess the effectiveness of AR but also to control for other variables that might affect sentence structure comprehension, such as language background, prior learning experiences, and learning motivation. Table 1 presents information related to the experimental design of the study.

Table 1. Experimental design.

Group	Pretest (O_1)	Treatment (X)	Posttest (O_2)
Experimental	O_1	X_1: AR-Based Learning Media	O_2
Control	O_1	X_2: Conventional Learning Method	O_2

Notes:

- **O_1** = Pretest score on sentence structure comprehension;
- **X_1** = AR-based learning intervention;
- **X_2** = Conventional learning intervention;
- **O_2** = Posttest score on sentence structure comprehension.

2.2. Participants

The population of this study comprised all fourth-semester students enrolled in the Arabic Language Education program at UIN Ponorogo. A purposive sampling technique was employed to select participants who met specific inclusion criteria, such as regular attendance and consent to participate in the study. A total of 60 students were selected, divided into 33 students in the experimental group (Class A), which received instruction using AR-based learning media, and 27 students in the control group (Class B), which followed conventional teaching methods. The participants were selected through purposive sampling because the classes had already been

administratively assigned at the university. Random assignment was therefore not feasible due to scheduling and curriculum constraints. The characteristics of the research respondents are shown in Table 2.

Table 2. Characteristics of respondents.

Variable / Category	Experimental Group (AR) — Class A (n = 33)	Control Group — Class B (n = 27)	Total (N = 60)
Gender – Male	13 (39.4%)	9 (33.3%)	22 (36.7%)
Gender – Female	20 (60.6%)	18 (66.7%)	38 (63.3%)
Age – Mean (SD)	20.3 (±0.62) years	20.1 (±0.57) years	20.2 (±0.60)
Age Range	19–22 years	19–22 years	19–22 years
Semester	4 (all participants)	4 (all participants)	4 (all participants)
Experience with AR – Yes	6 (18.2%)	5 (18.5%)	11 (18.3%)
Experience with AR – No	27 (81.8%)	22 (81.5%)	49 (81.7%)

Table 1 summarizes the demographic characteristics of the respondents involved in this study. The majority of participants were female (63.3%), while males accounted for 36.7%. The average age of the students was 20.2 years (SD = 0.60), with an age range of 19 to 22 years, and all participants were enrolled in the fourth semester. Regarding prior exposure to Augmented Reality (AR), only 18.3% of students reported having previous experience, while the vast majority (81.7%) had no prior AR experience, indicating relatively homogeneous baseline exposure across groups. The sampling procedure employed intact class selection (quasi-experimental design) due to administrative considerations and to minimize disruption to ongoing lectures. Two intact classes from the same semester were purposively assigned: one designated as the experimental group, which received AR-based instructional media, and the other as the control group, which received conventional instruction. Inclusion criteria required that students be officially enrolled in the fourth semester, provide informed consent to participate, and attend at least 80% of the sessions. In contrast, students who did not meet these criteria were excluded from the analysis.

2.3. Procedures

The research procedures were systematically designed to evaluate the effectiveness of AR-based learning media in improving students' understanding of Arabic sentence structures. Initially, both the experimental and control groups underwent a pretest to assess their baseline knowledge of sentence structures. Each instructional session lasted approximately 90 minutes, covering key topics such as nominal and verbal sentences, word order, and syntactic functions. After the completion of the treatment, a posttest was administered to both groups to measure learning gains and identify differences in comprehension between AR-assisted and traditional methods. Throughout the procedure, all instructional materials were aligned with the course syllabus, and the sequence of activities ensured consistency across groups while allowing the AR intervention to provide a richer, more engaging learning experience. The structured implementation of pretest → treatment → posttest enabled a clear comparison of outcomes and supported the investigation of AR's pedagogical impact.

2.4. Data Collection and Research Instruments

Data for this study were collected using a combination of pretest–posttest assessments, student perception questionnaires, and classroom observations to obtain quantitative evidence of learning outcomes and engagement. The pretest and posttest, administered before and after the intervention respectively, measured students' understanding of Arabic sentence structures through multiple-choice questions that assessed both lower-order and higher-order thinking skills (HOTS). In addition, the student perception questionnaire, using a five-point Likert scale, captured students' attitudes,

satisfaction, and perceived usefulness of the AR-based learning media. Classroom observations were conducted during the treatment phase to monitor students' participation, interaction with AR materials, and engagement levels, providing supplementary qualitative data to support the quantitative findings. Data collection occurred over a four-week period, coinciding with the instructional sessions, ensuring that all measurements were timely and reflective of the immediate impact of the AR intervention. The test instrument consisted of 10 multiple-choice items assessing basic comprehension of Arabic sentence structures. While reliable for measuring core syntactic understanding, the instrument remains limited in scope as it does not fully capture the complexity of advanced syntactic features. Table 3 presents information related to the pretest–posttest multiple choice instrument.

Table 3. Pretest–posttest multiple choice instrument (arabic sentence structure, experimental & control).

No	Pretest Instrument	Posttest Instrument	Cognitive Level	Score
1	Identify the subject in: المعلمُ يشرح الدرس	Identify the subject in: الطالبُ يذاكر الدرس	LOTS – Knowledge	1
2	Identify the verb in: الطالبةُ تكتب الواجب	Identify the verb in: المعلمةُ تشرح الدرس	LOTS – Knowledge	1
3	Which sentence is grammatically correct? 1) الولدُ (تكتب الواجب 2 (الولدُ يكتب الواجب 3 الولدُ كتابة الواجب 4 (يكتب الولدُ الواجب	Which sentence is grammatically correct? 1) البنتُ (البنتُ يقرأ الكتاب 2 تقرأ الكتاب 3 (الولدُ تقرأ الكتاب 4 (يقرأ الولدُ الكتاب	HOTS – Analysis	2
4	Rearrange: (محمد، يذهب، إلى المدرسة)	Rearrange: (يذهب، أحمد، إلى السوق)	HOTS – Creation	2
5	Identify the object: قرأ الطالبُ الدرس	Identify the object: كتب الطالبُ الواجب	LOTS – Comprehension	1
6	Which sentence shows correct gender agreement? 1) البنتُ (يكتب 2 (البنتُ تكتب 3 (الولدُ تكتب 4 الولدُ تدرس	Which sentence shows correct gender agreement? 1) البنتُ يذهب 2) البنتُ تذهب 3 (الولدُ تذهب 4 (الولدُ يذهب	HOTS – Analysis	2
7	Select correct sentence: 1) المعلمُ (يعلّم الطلاب 2 (المعلم تعلم الطلاب 3 المعلمُ تعلم الطلاب 4 (المعلم الطلاب يعلّم	Select correct sentence: 1) المعلمُ يعلّم الطالبات 2 (المعلم تعلم الطالبات 3 (المعلمُ تعلم الطالبات 4 (المعلم الطالبات يعلّم	LOTS – Knowledge	1
8	Translate: "The boy reads a book"	Translate: "The girl reads a book"	LOTS – Comprehension	1
9	Detect the error: البنتُ يكتب الرسالة بسرعة	Detect the error: الولدُ يكتب الدرس بسرعة	HOTS – Evaluation	2
10	Combine: (الولدُ، يدرس، الدرس، في الفصل)	Combine: (البنتُ، تكتب، الواجب، في المدرسة)	HOTS – Creation	2

Both tests were developed with equivalent difficulty levels and cognitive domains, ensuring isomorphic assessment while avoiding identical items to minimize memory effects. The tests included a combination of lower-order thinking skills (LOTS), such as knowledge and comprehension, and higher-order thinking skills (HOTS), such as analysis, evaluation, and creation, in accordance with Bloom's taxonomy. Each test contained 10 multiple-choice questions, with LOTS items scored 1 point and HOTS items scored 2 points, allowing a total maximum score of 14 points. The pretest was administered before the intervention to assess baseline competencies, while the posttest was conducted after the AR-based learning sessions to determine the effectiveness of the media.

The students' perceptions of the AR-based Arabic learning media were measured using a structured questionnaire developed on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire consisted of 15 items divided into three dimensions: (1) usability

and accessibility of the AR media, (2) engagement and motivation during learning, and (3) perceived improvement in understanding sentence structures. This instrument aimed to capture students' subjective experiences and satisfaction with the AR-based learning process. The questionnaire was validated through expert review to ensure content relevance and clarity, and its reliability was confirmed using Cronbach's alpha, which yielded a value of 0.87, indicating high internal consistency. The results from this questionnaire provided important insights into how AR technology supports student learning and engagement in Arabic sentence structure comprehension. Table 4 presents information related to the student perception questionnaire on AR-based arabic learning media.

Table 4. Student perception questionnaire on AR-based arabic learning media.

No	Dimension	Items
1	Learning Effectiveness	The AR-based learning media helped me understand Arabic sentence structures more easily.
2	Motivation	Using AR increased my motivation to study Arabic sentence structures.
3	Usability	The instructions in the AR media were clear and easy to follow.
4	Learning Effectiveness	The AR media allowed me to visualize sentence structures more clearly.
5	Learning Outcomes	I felt more confident in constructing Arabic sentences after using the AR media.
6	Engagement	The AR media provided interactive activities that enhanced my learning.
7	Engagement	I enjoyed learning Arabic using AR compared to traditional methods.
8	Usability	The media was user-friendly and easy to navigate.
9	Learning Effectiveness	The AR media helped me correct my mistakes effectively.
10	Motivation	I would like to use AR-based learning media in other Arabic language topics.
11	Multimedia Learning	The visual and auditory elements in AR supported my understanding.
12	Usability	The pace of AR activities was suitable for my learning needs.
13	Engagement	Using AR enhanced my focus and attention during learning.
14	Learning Outcomes	The media encouraged me to practice constructing sentences independently.
15	Motivation / Attitude	I feel that AR-based learning should be integrated into regular Arabic courses.

2.5. Data Analysis

The collected data were analyzed using both descriptive and inferential statistical techniques. Initially, assumptions of normality and homogeneity of variance were tested to ensure the suitability of parametric tests (Daryono et al., 2020; Purwanto et al., 2023). For the main analysis, a paired-sample t-test was conducted to compare pretest and posttest scores within each group, determining the improvement in students' understanding of Arabic sentence structures (Hidayanthi et al., 2022; Zuniari et al., 2022). Additionally, an independent-sample t-test was employed to compare the posttest scores between the experimental group (AR-based learning) and the control group (conventional learning), assessing the effectiveness of the AR intervention. To quantify the magnitude of the intervention's effect, Cohen's d was calculated, providing an interpretation of practical significance. For the student perception questionnaire, descriptive statistics, including mean scores and standard deviations, were computed to summarize students' attitudes, satisfaction, and perceived usefulness of the AR-based media. This comprehensive analysis approach ensured that both statistical significance and educational relevance were thoroughly evaluated. Future studies are recommended to employ larger and more diverse samples across multiple institutions and to develop more comprehensive assessment tools that cover a wider range of syntactic competencies.

3. FINDINGS AND DISCUSSION

3.1. Findings

Table 5 presents the descriptive statistics of students' pretest, posttest, and gain scores in both groups. The experimental group (n = 33), which received instruction using Augmented Reality (AR)-based learning media, achieved a higher mean score at posttest (M = 82.18, SD = 5.91) compared to their pretest score (M = 62.42, SD = 6.85), yielding a substantial mean gain of 19.76 (SD = 5.12). Meanwhile, the control group (n = 27), which followed conventional learning, also showed improvement from pretest (M = 61.89, SD = 7.02) to posttest (M = 71.15, SD = 6.43), with a smaller mean gain of 9.26 (SD = 4.87). These descriptive results indicate that although both groups improved after the intervention, the experimental group demonstrated a markedly greater increase in sentence structure understanding compared to the control group, suggesting the potential effectiveness of AR-based media in enhancing students' learning outcomes.

Table 5. Descriptive statistics of pretest, posttest, and gain scores by group.

Group	n	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Gain Score (Mean ± SD)
Experimental (AR)	33	62.42 ± 6.85	82.18 ± 5.91	19.76 ± 5.12
Control	27	61.89 ± 7.02	71.15 ± 6.43	9.26 ± 4.87

Figure 1 presents a comparison of the mean pretest and posttest scores between the experimental group (AR-based instruction) and the control group. The experimental group showed a substantial increase from pretest (M = 62.42) to posttest (M = 82.18), while the control group also improved from pretest (M = 61.89) to posttest (M = 71.15), although with a smaller gain. These results visually illustrate that the AR-based learning media produced greater improvement in students' comprehension of Arabic sentence structures compared to conventional instruction.

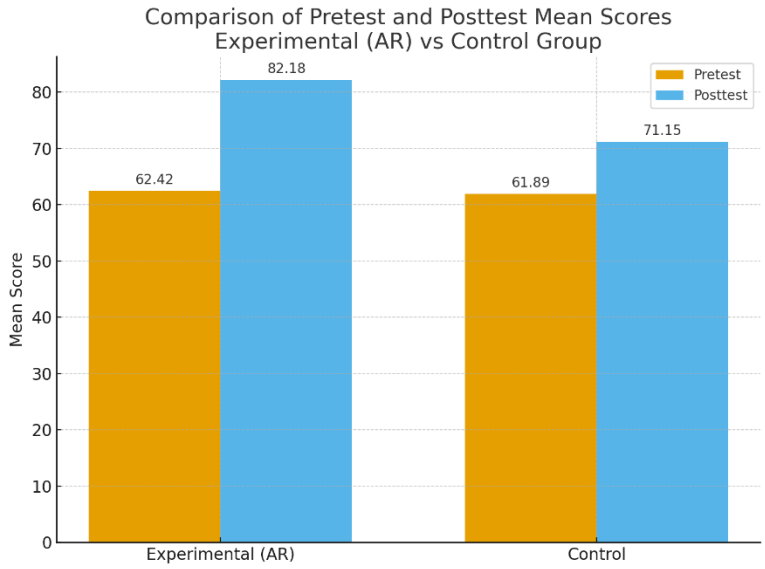

Figure 1. Comparison of pretest and posttest mean scores between experimental (ar) and control groups.

The results of the normality tests (Table 6) using both Kolmogorov-Smirnov and Shapiro-Wilk indicated that the distribution of scores in each group met the assumption of normality. For the experimental group, the pretest scores (K-S = .112, p = .200; S-W = .973, p = .543) and posttest scores (K-S = .106, p = .200; S-W = .968, p = .422) were normally distributed. Similarly, for the control group, the pretest scores (K-S = .115, p = .200; S-W = .971, p = .611) and posttest scores (K-S = .102, p = .200; S-W = .979, p = .771) also showed no deviation from normality. In addition, Levene's Test of Equality of Error

Variances confirmed the homogeneity of variances across groups (F(1,58) = 1.247, p = .269). These results demonstrate that the data met the assumptions required for parametric testing, thereby allowing the use of paired-sample t-tests and independent-sample t-tests to examine the effectiveness of Augmented Reality (AR)-based learning media in enhancing students' understanding of Arabic sentence structures.

Table 6. Paired samples test.

Group	Mean Difference (Post–Pre)	SD Difference	t_{value}	df	Sig. (2-tailed)
Experimental (AR)	19.76	5.12	21.34	32	.000
Control	9.26	4.87	10.01	26	.000

The paired-sample t-test was conducted to examine within-group improvements in students' understanding of Arabic sentence structures before and after the intervention. As shown in Table 3, the experimental group (n = 33), which received instruction through AR-based learning media, demonstrated a significant increase from pretest (M = 62.42, SD = 6.85) to posttest (M = 82.18, SD = 5.91), with a mean difference of 19.76 (SD = 5.12), $t(32) = 21.34$, $p < .001$. Similarly, the control group (n = 27), which received conventional instruction, also showed improvement from pretest (M = 61.89, SD = 7.02) to posttest (M = 71.15, SD = 6.43), with a mean difference of 9.26 (SD = 4.87), $t(26) = 10.01$, $p < .001$. Although both groups achieved statistically significant gains, the experimental group exhibited a markedly greater increase in posttest performance, suggesting that the use of AR-based instructional media was more effective in enhancing students' comprehension of Arabic sentence structures compared to traditional teaching methods.

Table 7. Independent samples test

Levene's Test	t-test for Equality of Means	t_{value}	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval
F = 1.247, Sig. = .269	Equal variances assumed	7.24	58	.000	11.03	1.52	Lower = 7.98, Upper = 14.08
	Equal variances not assumed	7.19	54.7	.000	11.03	1.53	Lower = 7.96, Upper = 14.10

The independent-sample t-test was performed to compare the posttest scores of the experimental and control groups. As shown in Table 8, the experimental group (M = 82.18, SD = 5.91, n = 33) scored significantly higher than the control group (M = 71.15, SD = 6.43, n = 27). Levene's test indicated that the assumption of equal variances was met, F(1,58) = 1.247, $p = .269$. Under this condition, the independent t-test revealed a statistically significant difference between groups, $t(58) = 7.24$, $p < .001$, with a mean difference of 11.03 (SE = 1.52, 95% CI [7.98, 14.08]). This result demonstrates that the experimental group achieved markedly better outcomes than the control group, supporting the effectiveness of Augmented Reality (AR)-based learning media in enhancing students' comprehension of Arabic sentence structures compared to conventional methods.

Table 8. Effect size (Cohen's *d*)

Comparison	Mean Difference	Pooled SD	Cohen's *d*	Effect Size Interpretation
Experimental (AR): Pretest → Posttest	19.76	6.40	3.09	Very Large
Control: Pretest → Posttest	9.26	6.74	1.37	Large
Experimental vs Control (Posttest)	11.03	6.16	1.79	Very Large

To further examine the magnitude of the observed differences, Cohen's *d* was calculated as a measure of effect size. As presented in Table 5, the experimental group demonstrated a very large effect from pretest to posttest (*d* = 3.09), while the control group showed a large effect (*d* = 1.37). Moreover, the comparison of posttest scores between the experimental and control groups yielded a very large effect size (*d* = 1.79), indicating that the AR-based instructional media produced not only statistically significant but also practically meaningful improvements in students' comprehension of Arabic sentence structures. These findings highlight the substantial educational impact of integrating AR technology into Arabic language instruction.

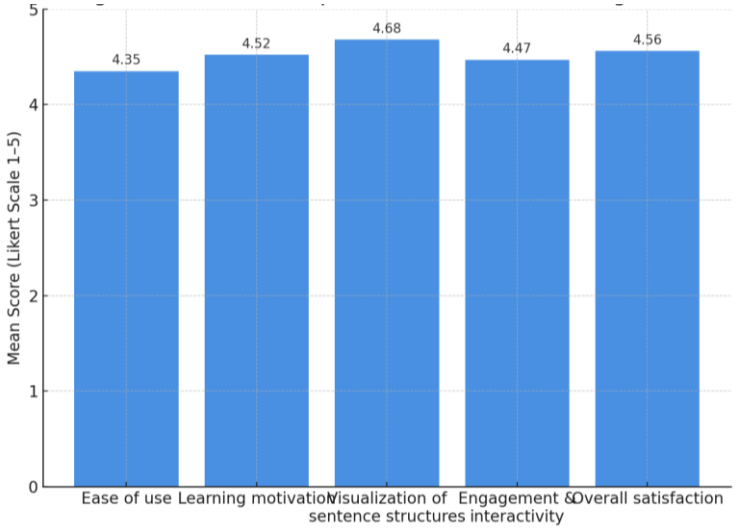

Figure 2. Students' responses to AR-based learning media

The highest ratings were obtained for visualization of sentence structures (M = 4.68) and overall satisfaction (M = 4.56), followed by learning motivation (M = 4.52) and engagement (M = 4.47). Ease of use was also rated positively (M = 4.35). Overall, students expressed strong agreement that AR media enhanced their learning experience and facilitated understanding of Arabic sentence structures.

3.2. Discussion

The findings of this study revealed that the experimental group taught using Augmented Reality (AR) media experienced a significantly greater improvement in sentence structure comprehension compared to the control group. The mean gain score of the experimental class (19.76 ± 6.54) was more than double that of the control class (9.26 ± 5.87), and the paired-sample *t*-test confirmed this difference as highly significant ($p < .001$). Furthermore, the effect size calculated using Cohen's *d* was greater than 1.7, indicating a very large magnitude of impact, far beyond what is typically considered educationally meaningful. These results strongly support the effectiveness of AR as a pedagogical tool in enhancing syntactic understanding in Arabic language learning. Similar outcomes were reported by Şimşek (2024), who demonstrated that AR-based tools improved learners' conceptual grasp in STEM education, and by Martín-Valero et al. (2025), who found that AR significantly enhanced vocabulary acquisition and learner motivation in Arabic sentence structures. However, while previous studies focused on STEM or vocabulary learning, the present study extends the evidence to the domain of Arabic syntax, a more abstract and challenging area (Al khresheh et al., 2024; Booyoesen, 2023). This contextual variation highlights that AR is not only effective in concrete or visual domains but can also support complex grammatical learning by bridging abstract structures with immersive visualization.

The results of this study can also be interpreted through the lens of established learning theories. According to Akram & Abdelrady (2025) and Esiyok et al (2024), students learn more effectively when information is presented through both visual and verbal channels, a process known as dual coding. By

integrating interactive 3D visualization with textual explanations, AR supports this dual processing and reduces the cognitive load associated with understanding abstract sentence structures. From a constructivist perspective, AR creates opportunities for learners to actively engage with the material, manipulate visual representations, and build their own understanding of grammatical relations rather than passively receiving information. This aligns with prior studies showing that immersive environments foster deeper engagement and higher-order thinking (Roudi & Reza, 2020; Sukatiman et al., 2020). Moreover, the findings resonate with the theory of spatial visualization, which emphasizes that learners of foreign languages benefit from spatially mapping syntactic structures to improve comprehension. Thus, AR does not merely enhance motivation but provides a theoretically grounded mechanism for improving complex cognitive processes involved in Arabic syntax learning.

When compared with prior research, the present study extends the evidence base for the effectiveness of AR in language learning. Previous studies, such as Casteleiro-Pitrez (2021), have demonstrated that AR enhances vocabulary acquisition and learner engagement in foreign language, while Pujiastuti & Haryadi (2024) highlighted its potential in promoting situated and experiential learning across STEM domains. However, much of the AR literature remains concentrated in science, technology, and mathematics, with relatively limited exploration in the area of Arabic sentence structures. The current findings contribute a novel perspective by showing that AR is not only useful for vocabulary or cultural learning, but also highly effective in supporting syntactic understanding, a domain traditionally perceived as abstract and difficult to master through conventional text or audio-based methods. This underscores the contribution of AR in making invisible grammatical relations more concrete and accessible, offering a fresh pathway for improving the teaching of Arabic sentence structures (Al Rajab et al., 2023; Hasaniyah et al., 2023).

Student perceptions further reinforce the effectiveness of AR-based learning media. The questionnaire results (M = 4.35–4.68) indicate that students regarded AR as easy to use, motivating, and particularly helpful in visualizing sentence structures that are often abstract in traditional instruction. Such positive responses are critical, as learner acceptance strongly influences the sustainability of technology integration in higher education classrooms. This finding aligns with the Technology Acceptance Model (TAM), which posits that perceived ease of use and perceived usefulness are key predictors of user adoption (Al-Adwan et al., 2024; Alfadda & Mahdi, 2021; Han & Sa, 2022). Similar results have been reported in AR-related studies in education, where favorable student attitudes were shown to correlate with higher engagement and learning outcomes (Çelik & Yangın Ersanlı, 2022; K. Wahyuni et al., 2025). The consistently high ratings in this study suggest that beyond cognitive gains, AR also fosters an affective dimension of learning, which is vital for the long-term implementation of technology-enhanced Arabic language instruction.

The results of the student perception survey (M = 4.35–4.68) demonstrate that learners found the AR-based media to be easy to use, motivating, and particularly effective in visualizing Arabic sentence structures, which are often challenging to grasp through text or audio alone. Such positive attitudes are crucial, as learner acceptance plays a key role in determining the sustainability of instructional technology integration. This finding is consistent with the Technology Acceptance Model (TAM), which emphasizes that perceived ease of use and perceived usefulness significantly influence user adoption and continued use of technology in learning contexts (Al Rajab et al., 2023; Hasaniyah et al., 2023). Similar studies have also reported that favorable student perceptions of AR positively affect engagement and language learning outcomes (Syarofah et al., 2024; Yasin, 2025). Therefore, the positive reception in this study not only validates the cognitive effectiveness of AR but also highlights its affective impact, reinforcing its potential for long-term adoption in Arabic language instruction (Auliya et al., 2025; Lazuardi & Syaheed, 2025; Syarifah, 2024).

The findings confirm that students in the AR-based class demonstrated significantly higher gains in syntactic comprehension compared to the control class. These results align with the principles of multimedia learning and dual coding theory, which suggest that multimodal visualization supports deeper processing of abstract information. AR facilitated students' ability to visualize and manipulate

sentence structures, thereby enhancing their grammatical understanding and engagement. Nevertheless, several limitations must be acknowledged. First, the participants were relatively homogeneous, consisting of students from the same academic program and semester, which restricts the generalizability of the results to broader populations. Second, the intervention was carried out within a limited timeframe, providing only a short-term view of the learning process. Longer-term studies are needed to examine whether AR produces sustained improvements in syntactic competence. Third, the strong positive results observed may in part reflect a novelty effect, as students could have been motivated by the excitement of using new technology rather than solely by its pedagogical affordances. Future research should therefore investigate whether the benefits of AR persist after the novelty has diminished.

These limitations point to important directions for future inquiry. Expanding the sample to include students from multiple institutions and diverse academic backgrounds would increase external validity. Developing more comprehensive assessment instruments that capture both basic and advanced syntactic features could also provide a more nuanced understanding of AR's impact. In addition, longitudinal research designs are needed to explore the durability of AR's effects on grammar acquisition over time. By addressing these issues, future studies can build on the present findings and further clarify the role of AR in advancing technology-enhanced language learning.

4. CONCLUSION

The findings of this study provide strong evidence that Augmented Reality (AR) is an effective medium to enhance students' understanding of Arabic sentence structures. The experimental group that employed AR-based learning media achieved significantly higher gains compared to the control group, with a large effect size indicating substantial pedagogical impact. Students also reported highly positive perceptions of AR, particularly in terms of its ease of use, motivational appeal, and ability to visualize abstract syntactic concepts. These outcomes highlight the novelty of applying AR to Arabic syntax learning, a domain that has traditionally been difficult to master through conventional text-based or lecture-driven methods.

Beyond its immediate results, this research offers both theoretical and practical contributions. Theoretically, the study extends the scope of Computer-Assisted Language Learning (CALL) by moving from the widely studied domains of vocabulary and STEM education to the more complex area of Arabic syntax acquisition. It supports applied linguistics and Arabic pedagogy by demonstrating how AR facilitates dual coding, spatial reasoning, and active construction of grammatical knowledge. This provides a theoretical basis for developing CALL models specifically tailored to Arabic grammar learning. Practically, the findings suggest that language instructors and curriculum designers can integrate AR to create interactive, learner-centered approaches that make grammar instruction more engaging and comprehensible.

Future research should build on these findings by adopting multi-site designs across diverse institutions, expanding the range of syntactic features assessed, and incorporating longitudinal approaches to evaluate the sustainability of AR's effects. In addition, exploring AR's potential in other language skills such as listening and speaking can broaden its pedagogical contributions. By bridging theoretical insights and classroom practice, this study underscores the role of AR not only as a motivational tool but also as a substantive contribution to the development of technology-mediated Arabic language education.

Acknowledgments: This research was conducted with financial support from the Directorate of Islamic Higher Education, Directorate General of Islamic Education, Ministry of Religious Affairs through the Recipient of Applied Research Assistance for National Development Number 6010 of 2022.

REFERENCES

Afrianingsih, B. I., Naifah, Azizah, N. L., Sanah, S., & Ramadlan, M. A. A. (2025). Characteristics of Arabic Language Learning in Indonesia Era 4.0. *Mantiqu Tayr: Journal of Arabic Language*, *5*(1), 1–23. https://doi.org/10.25217/mantiqutayr.v5i1.5098

Akram, H., & Abdelrady, A. H. (2025). Examining the role of ClassPoint tool in shaping EFL students' perceived E-learning experiences: A social cognitive theory perspective. *Acta Psychologica*, *254*, 104775. https://doi.org/10.1016/j.actpsy.2025.104775

Al khresheh, M. H., Mohamed, A. M., & Shaaban, T. S. (2024). A quasi-experimental study on the effectiveness of augmented reality technology on english vocabulary learning among early childhood pupils with learning disabilities. *Innoeduca: International Journal of Technology and Educational Innovation*, *10*(2), 5–26. https://dialnet.unirioja.es/servlet/articulo?codigo=9886747

Al Rajab, M., Odeh, S., Hazboun, S., & Alheeh, E. (2023). AI-Powered Smart Book: Enhancing Arabic Education in Palestine with Augmented Reality. In P. Novais, V. Julián Inglada, M. J. Hornos, I. Satoh, D. Carneiro, J. Carneiro, & R. S. Alonso (Eds.), *Ambient Intelligence – Software and Applications – 14th International Symposium on Ambient Intelligence* (pp. 167–178). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-43461-7_17

Al-Adwan, A. S., Meet, R. K., Anand, S., Shukla, G. P., Alsharif, R., & Dabbaghia, M. (2024). Understanding continuous use intention of technology among higher education teachers in emerging economy: Evidence from integrated TAM, TPACK, and UTAUT model. *Studies in Higher Education*, *49*(6), 1–20. https://doi.org/10.1080/03075079.2024.2343955

Alfadda, H. A., & Mahdi, H. S. (2021). Measuring Students' Use of Zoom Application in Language Course Based on the Technology Acceptance Model (TAM). *Journal of Psycholinguistic Research*, *50*(4), 883–900. https://doi.org/10.1007/s10936-020-09752-1

Arifin, Z., Lubis, T., Ath-Thukhi, A. M., Alsokari, T., Ainin, M., & Taufan, M. (2024). Analyzing the Problems of Arabic Language Learning in Higher Education. *International Journal of Islamic Studies Higher Education*, *3*(3), 1–15. https://doi.org/10.24036/insight.v3i3.193

Auliya, A., Aljanah, D. S., Sagala, R., Hijriyah, U., & Ghazi, F. (2025). The Digital Revolution in Arabic Language Learning: An Analysis of Trends, Results, and the Future of Language Education in the Digital Age. *RADEN INTAN: Proceedings on Family and Humanity*, *2*(1), 194–203. https://doi.org/10.47352/3032-503x.69

Bessadok, A., & Hersi, M. (2023). A structural equation model analysis of English for specific purposes students' attitudes regarding computer-assisted language learning: UTAUT2 model. *Library Hi Tech*, *43*(1), 36–55. https://doi.org/10.1108/LHT-03-2023-0124

Booyoesen, T. (2023). Exploring the Impact of Augmented Reality on Student Engagement and Learning Outcomes in Science Education. *Journal Educational Verkenning*, *4*(4), 25–32. https://doi.org/10.48173/jev.v4i4.183

Casteleiro-Pitrez, J. (2021). Augmented Reality Textbook: A Classroom Quasi-Experimental Study. *IEEE Revista Iberoamericana de Tecnologias Del Aprendizaje*, *16*(3), 258–266. https://doi.org/10.1109/RITA.2021.3122887

Çelik, F., & Yangın Ersanlı, C. (2022). The use of augmented reality in a gamified CLIL lesson and students' achievements and attitudes: A quasi-experimental study. *Smart Learning Environments*, *9*(1), 1–30. https://doi.org/10.1186/s40561-022-00211-z

Daryono, R. W., Hariyanto, V. L., Usman, H., & Sutarto, S. (2020). Factor analysis: Competency framework for measuring student achievements of architectural engineering education in Indonesia. *REID (Research and Evaluation in Education)*, *6*(2), Article 2. https://doi.org/10.21831/reid.v6i2.32743

Esiyok, E., Gokcearslan, S., & Kucukergin, K. G. (2024). Acceptance of Educational Use of AI Chatbots in the Context of Self-Directed Learning with Technology and ICT Self-Efficacy of Undergraduate Students. *International Journal of Human–Computer Interaction*, *40*(1), 1–10. https://doi.org/10.1080/10447318.2024.2303557

Faiqoh, P. K., Gadoum, H., & Baity, A. N. (2025). Digital Media and Technology in Arabic Language Learning. *Journal of Arabic Language Teaching*, *5*(1), 121–132. https://doi.org/10.35719/arkhas.v5i1.2263

Fitrianto, I. (2024). Innovation and Technology in Arabic Language Learning in Indonesia: Trends and Implications. *International Journal of Post Axial: Futuristic Teaching and Learning*, 134–150. https://doi.org/10.59944/postaxial.v2i3.375

Han, J.-H., & Sa, H. J. (2022). Acceptance of and satisfaction with online educational classes through the technology acceptance model (TAM): The COVID-19 situation in Korea. *Asia Pacific Education Review*, *23*(3), 403–415. https://doi.org/10.1007/s12564-021-09716-7

Haq, A. Z., Akmansyah, M., Erlina, E., & Koderi, K. (2024). Technology integration in arabic language learning: A literature review on the effectiveness of e-learning and mobile applications. *JISTECH: Journal of Information Science and Technology*, *4*(2), 481–494. https://doi.org/10.30862/jri.v4i2.473

Hasaniyah, N., Arsyad, B., & Hasan, A. A. (2023). Development of augmented reality-based Arabic uslub materials to improve daily language expressing ability. *Eloquence: Journal of Foreign Language*, *2*(1), 241–254. https://ejournal.iaingorontalo.ac.id/index.php/ELOQUENCE/article/view/672

Hidayanthi, R., Fitria, Y., Syarifuddin, H., & Miaz, Y. (2022). Elementary School Students' Mathematical Disposition Ability Oriented with STEAM Approach. *International Journal of Elementary Education*, *6*(4), Article 4. https://doi.org/10.23887/ijee.v6i4.54086

Huda, M. (2024). Teaching Arabic Vocabulary Using Augmented Reality: A Classroom Experiment. *IJAS: International Journal of Arabic Studies*, *1*(2 Desember), 41–50. https://ojs.bustanilmu.com/index.php/IJAS/article/view/45

Lazuardi, A. M., & Syaheed, S. M. (2025). Enhancing Arabic Language Proficiency through Interactive Learning Programs. *Lahjatuna: Jurnal Pendidikan Bahasa Arab*, *4*(2), 89–102. https://doi.org/10.38073/lahjatuna.v4i2.2584

Martín-Valero, R., Sr, A. V.-M., Martín-Vega, F. J., Rodriguez-Huguet, M., Rodríguez-Martínez, M. C., & Vinolo-Gil, M. J. (2025). Effectiveness of Augmented Reality in the Teaching of Health University Students: Quasi-Experimental Study. *JMIR Serious Games*, *13*(1), e54312. https://doi.org/10.2196/54312

Nasrullah, M., Ulfa, S., & Rochmahwati, P. (2024). Gagne's Nine Events in Mobile-Assisted Vocabulary Learning for Higher Education. *Al-Hayat: Journal of Islamic Education*, *8*(4), 1366–1382. https://doi.org/10.35723/ajie.v8i4.69

Park, M., & Son, J.-B. (2022). Pre-service EFL teachers' readiness in computer-assisted language learning and teaching. *Asia Pacific Journal of Education*, *42*(2), 320–334. https://doi.org/10.1080/02188791.2020.1815649

Pujiastuti, H., & Haryadi, R. (2024). The Effectiveness of Using Augmented Reality on the Geometry Thinking Ability of Junior High School Students. *Procedia Computer Science*, *234*, 1738–1745. https://doi.org/10.1016/j.procs.2024.03.180

Purwanto, Hidayah, N., & Wagistina, S. (2023). The Effect of Gersmehl's Spatial Learning on Students' Disaster Spatial Literacy. *International Journal of Educational Methodology*, *9*(2), 345–354. https://doi.org/10.12973/ijem.9.2.345

Rani, S. A., Zikriati, Z., Muhammady, A., Syukran, S., & Ali, B. (2023). Arabic Language Learning Based on Technology (Opportunities and Challenges in the Digital Era). *International Journal of Education, Language, and Social Science*, *1*(1), 1–11. https://doi.org/10.62612/ijelass.v1i1.4

Ritonga, M., Mudinillah, A., Wasehudin, W., Julhadi, J., Amrina, A., & Shidqi, M. H. (2024). The effect of technology on Arabic language learning in higher education. *Journal of Education and Learning (EduLearn)*, *18*(1), 116–127. https://doi.org/10.11591/edulearn.v18i1.20867

Roudi, E., & Reza, A. (2020). The Effectiveness of Flipped Learning in a Testing University Classroom: Students' Perceptions, the Role of Personality Traits, and Successful Intelligence. *Applied Research on English Language*, *9*(3), 349–364. https://doi.org/10.22108/are.2020.119039.1494

Safitri, R., & Farirahma, N. M. (2024). Development of Falabic: An Interactive Arabic Learning Application using Augmented Reality. *2024 Ninth International Conference on Informatics and Computing (ICIC)*, 1–6. https://doi.org/10.1109/ICIC64337.2024.10957137

Shaharudin, M. D. D., Zakaria, M. F., & Aziz, A. M. A. (2021). Augmented Reality as Educational Tools to Raise Students' Motivation in Learning Arabic. *Jurnal Maw'izah*, *4*(1), 75–80. https://www.unimel.edu.my/journal/index.php/JMAW/article/view/931

Şimşek, E. E. (2024). The Use of Augmented Reality-Supported Activities in Environmental Education for Early Childhood: A Quasi-Experimental Study. *Sustainability*, *16*(23), 10374. https://doi.org/10.3390/su162310374

Stockwell, G., & Ito, Y. (2022). Computer-assisted language learning and communicative competence. In *Communicative Competence in a Second Language*. Routledge.Sukatiman, Akhyar, M., Siswandari, & Roemintoyo. (2020). Enhancing Higher-Order Thinking Skills in Vocational Education through Scaffolding-Problem Based Learning. *Open Engineering*, *10*(1), 612–619. https://doi.org/10.1515/eng-2020-0070

Susiawati, I., Mardani, D., & Alhaq, M. F. (2024). The Role and Strategy of Digital Technology in Improving the Arabic Language Learning Process. *HUNAFA Jurnal Studia Islamika*, *21*(2), 209–232. https://doi.org/10.24239/jsi.v21i2.783

Syarifah, S. (2024). Interactive Multimedia-Based Arabic Language Learning: A Systematic Literature Review. *Jurnal Sustainable*, *7*(2), 247–259. https://doi.org/10.32923/kjmp.v7i2.4922

Syarofah, A., Sutiah, S., Taufiqurrohman, R., & Sari, R. R. (2024). Design and Development of the Game "Kitabah For Kids" Augmented Reality Technology for Arabic language learning. *Kilmatuna: Journal Of Arabic Education*, *4*(2), 104–116. https://doi.org/10.55352/pba.v4i2.983

Wahyuni, K., Habiburrahman, Assapari, M., & Satriawan. (2025). Technology As A Modern Arabic Language Learning Medium. *Al-Afkar, Journal For Islamic Studies*, *8*(2), 43–54. https://doi.org/10.31943/afkarjournal.v8i2.1392

Wahyuni, S. (2021). Efforts to Increase Studentsâ€™ Islamic Religious Learning Outcomes Through Nasyid in Elementary School. *Jurnal Basicedu*, *5*(6), Article 6. https://doi.org/10.31004/basicedu.v5i6.1786

Yasin, R. (2025). Dynamics of Arabic Language Learning in the Gen Z Era: Challenges and Opportunities. *Multidisciplinary Indonesian Center Journal (MICJO)*, *2*(3), 3840–3847. https://doi.org/10.62567/micjo.v2i3.1182

Zuniari, N. I., Ridlo, Z. R., Wahyuni, S., Ulfa, E. M., & Dharmawan, M. K. S. (2022). The Effectiveness of Implementation Learning Media Based on Augmented Reality in Elementary School in Improving Critical Thinking Skills in Solar System Course. *Journal of Physics: Conference Series*, *2392*(1), 1–10. https://doi.org/10.1088/1742-6596/2392/1/012010