Learning, Media and Technology in Arabic Education
Volume 2, Issue 1, 35-45.
e_ISSN: -
https://lmtae.unikhams.ac.id/index.php/lmtae/index

Developing 3D Augmented Reality–Based Arabic Instructional Materials through Contextual Teaching and Learning to Enhance Eighth-Grade Students' Listening Skills

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Article Info

Article history:

Received: Mar 22, 2026
Revised: May 4, 2026
Accepted: Jun 6, 2026

Keywords:

Arabic Listening Skills; Augmented Reality; Contextual Teaching and Learning; Instructional Materials; *Maharah Istima'*.

Abstract

The limited availability of interactive listening materials and the continued reliance on printed worksheets and teacher-centered instruction have constrained the development of Arabic listening skills among junior secondary students. This study aimed to develop 3D Augmented Reality-based Arabic instructional materials through the Contextual Teaching and Learning approach, examine their feasibility, evaluate changes in students' *maharah istima'* achievement, and identify students' responses to their use. The study employed a Research and Development design using the ADDIE model, comprising analysis, design, development, implementation, and evaluation, and incorporated a one-group pretest-posttest design. The participants were Grade 8-E students at MTsN 3 Mojokerto, selected through purposive sampling. Data were collected using expert-validation sheets, listening achievement tests, student-response questionnaires, and implementation documentation, and were analyzed through descriptive statistics, paired-samples testing, the Wilcoxon signed-rank test, and normalized gain analysis. The developed materials were judged feasible for classroom use after revisions based on expert feedback. The paired-samples test showed a statistically significant difference between pretest and posttest scores, $t(26) = -2.450$, $p = .021$, while the Wilcoxon test also indicated a significant difference, $Z = -2.100$, $p = .036$. The mean N-Gain score was .6315, equivalent to 63.15%, and was classified as moderate, while students responded positively to the materials in terms of interactivity, visual appeal, and learning engagement. These findings indicate that integrating 3D AR with contextual pedagogy can provide a feasible and meaningful alternative for supporting Arabic listening instruction, although broader controlled studies are needed to confirm its effectiveness.

To cite this article: Nesti, S. F., Aimmah, D. F., & Zainuddin, A. (2025). Developing 3D augmented reality–based Arabic instructional materials through contextual teaching and learning to enhance eighth-grade students' listening skills. *Learning, Media and Technology in Arabic Education, 2*(1), 25-35.

INTRODUCTION

Listening comprehension is a central component of Arabic language learning because it enables students to recognize sounds, identify vocabulary, interpret sentence structures, and construct meaning from spoken input. In classroom practice, however, listening instruction is often more difficult to develop than reading or vocabulary instruction because spoken language must be processed in real time. Learners are required to connect pronunciation, meaning, and context simultaneously, even when their exposure to Arabic outside the classroom is limited. This challenge becomes more complex when learning materials are dominated by printed texts, teacher explanations, and short audio recordings that provide minimal visual support. Digital and mobile technologies have expanded opportunities to present language through multimodal, interactive, and context-sensitive environments that can make input more accessible to learners (Li et al., 2023; Lai et al., 2022; Tegoan et al., 2021). Accordingly, Arabic listening instruction needs instructional materials that do not merely deliver audio but also help students understand what they hear through meaningful visual and contextual cues.

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The need for such materials is particularly evident in junior secondary madrasahs, where Arabic is taught as a foreign language and students often depend heavily on classroom exposure. At MTsN 3 Mojokerto, preliminary observations indicated that eighth-grade students experienced difficulties in *maharah istima'* because learning activities relied mainly on lectures, printed worksheets, and limited audio resources. These conditions reduced students' opportunities to associate spoken Arabic with concrete objects, actions, and situations from daily life. As a result, listening activities tended to become passive exercises in identifying isolated words rather than meaningful processes of understanding messages. Similar concerns have been reported in technology-supported language learning, where digital tools may fail to improve performance when they are disconnected from pedagogical objectives or learner contexts (Hua & Wang, 2023; De Lima et al., 2022; Iqbal et al., 2022). Therefore, the problem is not only the limited availability of media but also the absence of an instructional design that integrates auditory input, visualization, interaction, and contextual meaning.

Augmented Reality offers a promising response to this problem by combining real-world environments with digital objects, text, animation, and audio through mobile devices. In educational settings, AR can transform abstract content into interactive representations that students can explore directly. Meta-analyses and systematic reviews have generally shown that AR and other immersive technologies can improve learning outcomes, engagement, motivation, and knowledge retention when they are appropriately designed (Garzón & Acevedo, 2019; Garzón et al., 2020; Hamilton et al., 2021; Coban et al., 2022; Villena-Taranilla et al., 2022; Chang et al., 2022). In language education, AR has been associated with improved vocabulary acquisition, reading comprehension, speaking practice, and technology acceptance (Bursali & Yilmaz, 2019; Chang et al., 2020; Gu et al., 2022; Su et al., 2022; Hussein et al., 2023). Broader reviews further indicate that AR can support situated language learning by linking linguistic input with objects, places, and communicative situations (Huang et al., 2021; Wedyan et al., 2022; Chen et al., 2022; Schorr et al., 2024). These findings suggest that 3D AR has considerable potential to support Arabic listening instruction by synchronizing spoken language with visualized contexts.

Despite its promise, AR does not automatically generate effective learning. The presence of three-dimensional objects, animation, and interactive features may increase cognitive demands if students are required to process too many elements at once. Studies on cognitive load and multimedia learning emphasize that poorly organized digital materials can distract learners from essential content and reduce comprehension (Skulmowski & Xu, 2022; Elford et al., 2022; Krüger & Bodemer, 2022; Krieglstein et al., 2022). Similar concerns have been raised regarding the design of AR authoring tools, interface complexity, hardware access, and the need for pedagogically meaningful interaction (Dengel et al., 2022; Iqbal et al., 2022; Batool, 2022). Recent evidence also indicates that the effect of AR on cognitive load depends on how information, interaction, and learning tasks are structured rather than on immersion alone (Zhu et al., 2026; Çelik et al., 2026). For this reason, AR-based Arabic materials require a pedagogical framework that helps students connect digital representations with relevant experiences. Contextual Teaching and Learning is appropriate for this purpose because it organizes learning around meaningful situations, prior knowledge, and practical use of language.

The CTL approach emphasizes that students learn more meaningfully when academic content is related to familiar contexts and authentic problems. In Arabic language learning, this means that listening materials can be organized around everyday themes such as school activities, household objects, routines, places, and social interaction. Context-rich learning environments allow students to infer meaning from the relationship among spoken expressions, visual cues, background knowledge, and communicative intentions. Research on authentic learning has shown that realism and contextual relevance can improve learner participation and knowledge application when tasks are carefully structured (Nachtigall et al., 2022; Xiao, 2022). Technology-supported contextual learning has also been associated with more active and flexible language learning practices (Perales & Ulla, 2025; Jia et al., 2022). In Arabic education specifically, CTL has been reported to support learner participation, communicative ability, and meaningful engagement with language content (Zakiyah & Aditia, 2025). Thus, integrating CTL with 3D AR may enable listening materials to become not only interactive but also pedagogically relevant to students' daily experiences.

Previous studies provide a strong foundation for this integration, yet the dominant patterns of research remain uneven. AR studies in language education have focused mainly on English, vocabulary acquisition, reading comprehension, gamified interaction, and higher education settings (Pinto et al., 2021; Wedyan et al., 2022; Zhang & Hasim, 2023; Zhi & Wu, 2023; Liu et al., 2023). Systematic reviews by Schorr et al. (2024) and Christou et al. (2025) likewise show that AR-based language learning is commonly designed around vocabulary, object recognition, and task engagement, while listening-specific applications receive less attention. In Arabic education, recent studies have begun using AR for sentence structures, vocabulary, and interactive presentation, including a quasi-experimental study on Arabic sentence structures that reported positive learning evidence ("Augmented Reality as a Learning Medium," 2025). These developments demonstrate that AR can support Arabic instruction, but they do not sufficiently explain how synchronized 3D visualization, audio input, and contextual tasks can be combined to improve *maharah istima'*. Moreover, studies of CTL in Arabic learning generally emphasize contextual activities without integrating immersive three-dimensional environments (Zakiyah & Aditia, 2025). The critical gap therefore lies in the limited empirical evidence on AR-based Arabic listening materials that are explicitly structured through CTL principles and evaluated in a junior secondary madrasah context.

To address this gap, the present study develops 3D Augmented Reality-based Arabic instructional materials through the Contextual Teaching and Learning approach for eighth-grade students at MTsN 3 Mojokerto. The study aims to examine the feasibility of the developed materials through expert validation, evaluate changes in students' listening achievement after implementation, and analyze students' responses to the learning experience. The instructional design positions AR as a medium for presenting synchronized Arabic audio, three-dimensional objects, and contextual tasks rather than as a technological novelty used independently of pedagogy. Theoretically, this study contributes to the intersection of multimedia learning, contextual learning, and technology-assisted Arabic education by examining how visual, auditory, and situational elements can support listening comprehension. Practically, it offers Arabic teachers an alternative model for transforming conventional listening materials into interactive resources connected to students' daily lives. The findings are also expected to inform future development of accessible, pedagogically grounded, and context-sensitive digital materials for secondary-level Arabic language learning.

METHOD

This study employed a Research and Development design to develop and evaluate 3D Augmented Reality-based Arabic instructional materials integrated with the Contextual Teaching and Learning approach. The development process followed the ADDIE model, which consists of analysis, design, development, implementation, and evaluation. This model was selected because its systematic stages support the development, validation, classroom testing, and revision of technology-enhanced instructional products (Okpatrioka, 2023). To examine the effectiveness of the developed materials, the study also used a pre-experimental one-group pretest-posttest design. Through this design, students' listening achievement was measured before and after the implementation of the AR-based materials, although the absence of a control group limits strong causal interpretation.

The study was conducted at MTsN 3 Mojokerto, East Java, Indonesia, within the context of Grade 8 Arabic language instruction. The school was selected because Arabic is part of its formal curriculum and preliminary observations indicated limited availability of interactive audiovisual materials for teaching *maharah istima'*. The population comprised all eighth-grade students distributed across ten classes. Class 8-E consisted of 32 registered students. However, the number of valid observations varied across analyses because the available statistical outputs contained 27 complete pretest-posttest pairs for the paired-samples test and 18 valid cases for the normalized gain analysis. Students were included when they attended the learning sessions and completed the required instruments, whereas incomplete data were excluded from the relevant analysis.

Data were collected using expert-validation sheets, a listening achievement test, a student-response questionnaire, and implementation documentation. The validation sheets assessed content accuracy, alignment with learning objectives, quality of Arabic language use, audio clarity, interface design, 3D visualization, technical functionality, and conformity with CTL principles. The

achievement test consisted of ten multiple-choice and picture-matching items that measured students' ability to recognize spoken vocabulary, connect oral input with visual objects, identify information from short utterances, and interpret meaning in contextual situations. Test scores were converted to a scale ranging from 0 to 100. The student-response questionnaire examined perceived usefulness, ease of use, visual attractiveness, audio quality, contextual relevance, engagement, and students' willingness to use the materials in future Arabic lessons.

The validity of the instruments and developed materials was established through expert judgment involving specialists in Arabic language education, instructional design, and educational media. Their evaluations were used to revise the language content, audio presentation, visual elements, instructions, and AR functionality before classroom implementation. The achievement-test items were examined using item-total correlations, with items considered valid when the calculated coefficient exceeded the critical value at the 5% significance level. Internal consistency was assessed using Cronbach's alpha, with a coefficient of at least .70 interpreted as acceptable. The data collection process followed the ADDIE stages, beginning with an analysis of curriculum requirements, classroom practices, students' listening difficulties, and available technological resources. The product was then designed, developed, validated, revised, implemented through pretest, AR-supported learning activities, and posttest, and finally evaluated using expert feedback, student performance, questionnaire responses, and implementation notes.

Quantitative data were analyzed using descriptive and inferential statistics with IBM SPSS Statistics. Expert-validation and student-response scores were converted into percentages by dividing the obtained scores by the maximum possible scores and multiplying the results by 100. Pretest and posttest scores were summarized using means, standard deviations, minimum values, and maximum values. The normality of the difference scores was examined using the Shapiro-Wilk test, after which a paired-samples *t* test was applied when the normality assumption was satisfied, while the Wilcoxon signed-rank test was used when the data were not normally distributed. Statistical significance was determined at $p < .05$, and normalized gain was calculated to classify the magnitude of improvement in students' listening skills. The study was conducted with permission from the school, and students were informed about the purpose and procedures of the research. Participant identities were replaced with codes, all responses were treated confidentially, and the results were reported only in aggregate form.

RESULTS AND DISCUSSION

Results

The study produced 3D Augmented Reality-based Arabic instructional materials integrated with the Contextual Teaching and Learning approach for teaching *maharah istima'*. The effectiveness analysis focused on differences between students' pretest and posttest scores and the magnitude of score improvement after the instructional materials were implemented. Because the available statistical outputs contained different numbers of valid cases, the sample size for each analysis is reported separately. The paired-samples analysis included 27 complete score pairs, whereas the normalized gain analysis was based on 18 valid cases.

The Wilcoxon signed-rank test showed a statistically significant difference between students' pretest and posttest scores. The analysis produced a *Z* value of −2.100 with an asymptotic two-tailed significance value of .036. Since this value was below the significance threshold of .05, students' listening scores differed significantly between the two measurements. The result is presented in Table 1.

Table 1. Wilcoxon Signed-Rank Test Results

Score comparison	Valid cases	Z	p	Decision
Posttest − Pretest	Not reported in the available output	−2.100	.036	Significant

Note. The test statistic was based on negative ranks. Statistical significance was determined at $p < .05$.

The paired-samples *t* test was conducted using 27 complete pretest-posttest pairs, as indicated by the degrees of freedom of 26. The mean difference between the pretest and posttest scores was −12.222, with a standard deviation of 25.919 and a standard error of 4.988. The negative mean difference indicates that the posttest scores were higher because the difference was calculated

as pretest minus posttest. The 95% confidence interval ranged from −22.475 to −1.969. The result was statistically significant, $t(26) = -2.450$, $p = .021$, as shown in Table 2.

Table 2. Paired-Samples *t* Test Results

Comparison	N	Mean difference	SD	SE	95% CI lower	95% CI upper	t	df	p
Pretest – Posttest	27	−12.222	25.919	4.988	−22.475	−1.969	−2.450	26	.021

Note. A negative mean difference indicates that the posttest scores were higher than the pretest scores.

The magnitude of improvement was examined using normalized gain analysis based on 18 valid cases available in the statistical output. The mean N-Gain score was .6315, equivalent to 63.1481%. Individual N-Gain scores ranged from −.67 to 1.00, while the corresponding percentage values ranged from −66.67% to 100.00%. The mean score was classified as moderate. However, the standard deviation of .58304 indicates substantial variation in the level of improvement among the analyzed students.

Table 3. Descriptive Statistics of Normalized Gain Scores

Measure	N	Minimum	Maximum	Mean	SD	Classification
N-Gain score	18	−.67	1.00	.6315	.58304	Moderate
N-Gain percentage	18	−66.67	100.00	63.1481	58.30360	Moderate

Overall, the available analyses showed a statistically significant difference between students' listening scores before and after the implementation of the developed instructional materials. The Wilcoxon signed-rank test yielded $p = .036$, while the paired-samples t test yielded $p = .021$. The normalized gain analysis further indicated an average improvement of .6315, or approximately 63.15%, which was classified as moderate. Nevertheless, these findings should be interpreted according to the number of valid cases included in each analysis because the paired-samples and N-Gain outputs were based on different analytical sample sizes.

Discussion

The statistically significant difference between the pretest and posttest scores indicates that the integration of 3D Augmented Reality with Contextual Teaching and Learning supported improvement in students' Arabic listening achievement. This improvement can be interpreted as the result of combining auditory input with visual and situational cues that helped learners connect spoken expressions with objects, actions, and familiar contexts. In listening activities, such connections reduce the dependence on word-by-word translation because students can infer meaning from several sources of information at the same time. This interpretation is consistent with multimedia learning principles, which suggest that coordinated verbal and visual representations can strengthen comprehension when irrelevant information is minimized (Çeken & Taşkın, 2022). Similar gains have been reported in studies showing that AR-supported learning can improve students' learning experiences and academic outcomes by increasing the accessibility and interactivity of instructional content (Baabdullah et al., 2022; Chang et al., 2022). Nevertheless, the present findings extend this evidence to Arabic *maharah istima'*, a skill that has received less attention than vocabulary, reading, and sentence-structure learning in AR research.

The improvement in listening achievement also suggests that the pedagogical organization of the technology was at least as important as the presence of AR itself. CTL positioned the audio and 3D objects within situations related to students' daily experiences, allowing the technology to function as a medium for contextual meaning rather than merely as an attractive display. This pattern supports the argument that technological affordances produce stronger learning effects when they are guided by explicit pedagogical principles and authentic tasks. Research on CTL has similarly emphasized the value of linking academic concepts with recognizable problems and experiences, although the model has been more frequently applied in mathematics and general classroom instruction than in Arabic listening education ("Research Trends in the Application of the CTL Model," 2025). In language learning, contextual and technology-supported instruction can create more

meaningful interaction when tasks reflect actual communicative purposes rather than decontextualized drills (Perales & Ulla, 2025; Zakiyah & Aditia, 2025). Therefore, this study modifies the conventional use of CTL by showing that contextualization can be embedded directly within AR-based listening materials through synchronized sound, visualization, and task design.

The moderate N-Gain value of 63.15% shows that the developed materials produced meaningful improvement but did not generate uniformly high gains across all learners. This finding is important because it prevents the technology from being interpreted as an automatic solution to listening difficulties. AR-based learning may strengthen attention and motivation, but its effect depends on learners' prior vocabulary, listening readiness, familiarity with mobile devices, and ability to navigate the digital environment. Zhao et al. (2022) similarly found that the motivational and learning benefits of AR vary according to the strategies used by learners during multimedia activities. Continuous learning intention is also shaped by the interaction among motivation, attitude, and cognitive load rather than by technological novelty alone (Wu et al., 2022). The moderate gain in this study therefore suggests that the product was beneficial but still required instructional scaffolding, sufficient exposure time, and adaptation to individual learning differences.

The wide range of N-Gain scores, including negative values, further indicates that students did not benefit from the intervention to the same extent. Some learners may have needed more time to coordinate spoken Arabic, visual objects, written prompts, and device操作 during the learning activities. From a cognitive perspective, AR can either support comprehension or create additional processing demands, depending on how information is segmented, signaled, and synchronized. Although AR has produced positive outcomes across various professional and educational settings, meta-analytic evidence shows that its effectiveness is influenced by intervention design, learner characteristics, and the complexity of the learning task (Baashar et al., 2022; AlMekkawi et al., 2026). Engagement should also not be assumed from observable interaction alone because students may appear active while devoting attention to technical features rather than the intended linguistic content (Karimah & Hasegawa, 2022). Consequently, the variation in gain scores points to the need for simpler navigation, staged listening tasks, repeated audio exposure, and teacher guidance for students who experience difficulty processing several representations simultaneously.

The findings also position 3D AR as a potentially useful bridge between receptive and productive Arabic language learning. Listening comprehension is not an isolated ability because the recognition of sounds, vocabulary, and sentence patterns contributes to later speaking and interaction. Mobile language-learning studies have shown that structured digital environments can support speaking performance when listening input, practice opportunities, and feedback are integrated into a coherent instructional sequence (Criollo-C et al., 2022). In the present study, contextualized listening activities may have helped students build mental representations of how Arabic expressions function in recognizable situations. This interpretation is consistent with broader reviews showing that AR environments can support situated language learning by connecting linguistic forms with spatial and social contexts (Schorr et al., 2024; Christou et al., 2025). The contribution of this study therefore lies not only in improving test performance but also in demonstrating how AR-supported listening can provide a foundation for broader communicative development.

At the same time, the significant pretest-posttest difference must be interpreted cautiously because the study used a one-group design without a comparison class. The observed improvement may have been influenced by repeated testing, teacher assistance, students' increasing familiarity with the test format, or other classroom experiences occurring during the intervention. For this reason, the results demonstrate an association between the implementation of the developed materials and improved scores rather than definitive evidence that AR alone caused the change. Similar methodological concerns have been noted in immersive-learning research, where positive outcomes are sometimes reported despite small samples, short intervention periods, and limited experimental control (Hamilton et al., 2021; Chen et al., 2022). The differences in valid cases across the available statistical analyses also restrict the precision with which the findings can be generalized. Future studies should therefore employ a control or comparison group, maintain consistent analytical samples, and include delayed posttests to determine whether listening gains are retained over time.

Despite these limitations, the study contributes a new perspective to the global literature on technology-assisted language learning by combining AR, CTL, and Arabic listening instruction in a junior secondary madrasah. Most existing AR language studies have concentrated on English, vocabulary learning, reading activities, or higher education, leaving Arabic *maharah istima'* comparatively underrepresented. The present design addresses this gap by treating AR not as an independent innovation but as a contextual learning environment in which sound, three-dimensional visualization, and everyday situations are pedagogically coordinated. Practically, the findings suggest that Arabic teachers can use AR to extend limited textbook and audio resources, provided that the activities remain aligned with learning objectives and are supported by clear instructions and appropriate devices. The product may also be expanded to speaking, reading, and vocabulary learning, but such expansion should preserve the contextual and multimedia principles that shaped the current materials. In this sense, the study offers both a practical model for Arabic teachers and a conceptual basis for future research on context-sensitive immersive language learning.

CONCLUSION

The 3D Augmented Reality-based Arabic instructional materials integrated with the Contextual Teaching and Learning approach were found to be feasible for use in Grade 8 *maharah istima'* instruction after revision based on expert feedback. Their implementation was associated with a statistically significant improvement in students' listening achievement, as indicated by the paired-samples *t* test result of $p = .021$ and a mean N-Gain score of .6315, which was classified as moderate. Students also responded positively to the materials, particularly in terms of interactivity, visual appeal, and learning engagement. These findings indicate that combining contextual pedagogy with immersive digital media can provide a meaningful alternative to conventional listening instruction, although broader testing with more rigorous experimental designs is still required.

ACKNOWLEDGMENT

The authors express their sincere appreciation to the administration, teachers, and staff of MTsN 3 Mojokerto for granting permission and providing support during the implementation of this study. Special thanks are also extended to the Grade 8-E students who participated actively in the research activities. The authors are grateful to colleagues and all parties who contributed constructive feedback and assistance throughout the development of the instructional materials and preparation of the manuscript.

AUTHOR CONTRIBUTIONS STATEMENT

Syofia Fadila Nesti contributed to the conceptualization of the study, research design, product development, data analysis, and preparation of the original manuscript. Diana Fitri Aimmah contributed to field investigation, data collection, classroom implementation, and research documentation. Ammar Zainuddin supervised the research process, provided methodological guidance, and critically reviewed the manuscript. All authors read and approved the final version of the manuscript.

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