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Development of Smart-ArabAR Immersive Learning Media with 3D Augmented Reality Technology

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Abstract:
The scarcity of interactive and immersive instructional media in Arabic language education has led to low student engagement and fragmented mastery of the four core skills: listening, speaking, reading, and writing. Grounded in constructivist and socio-constructivist learning theories, which emphasize active knowledge construction and social interaction, this gap calls for technology-enhanced solutions. This study aims to develop and evaluate Smart-ArabAR, an innovative learning application that integrates 3D Augmented Reality and artificial intelligence to provide adaptive, personalized, and immersive Arabic learning experiences. Using a Research and Development approach with a modified 3D model (Define, Design, Develop) derived from Thiagarajan's 4D framework, the product was validated through questionnaires administered to one media expert and one material expert across two evaluation stages, involving first-semester students from the PBA, PAI, and PGMI programs. The findings reveal that Smart-ArabAR is highly feasible and appropriate for use, successfully integrating all four language competencies within an interactive 3D AR environment. In conclusion, Smart-ArabAR strengthens the effectiveness of AR-based Arabic pedagogy and offers a practical solution to bridge digital divides in online and hybrid learning. It is recommended that further implementation be expanded to more institutions and that longitudinal studies be conducted to assess long-term impacts on language proficiency.

Kata Kunci: *Media Pembelajaran, Smart-ArabAR, Pembelajaran Imersif, Realitas Tertambah 3D, Pembelajaran Bahasa Arab*

Abstrak:
Minimnya media pembelajaran yang interaktif dan imersif dalam pendidikan bahasa Arab mengakibatkan rendahnya keterlibatan siswa dan penguasaan yang terfragmentasi pada empat keterampilan inti: menyimak, berbicara, membaca, dan menulis. Berlandaskan teori belajar konstruktivis dan sosio-konstruktivis yang menekankan konstruksi pengetahuan aktif dan interaksi sosial, kesenjangan ini menuntut solusi berbasis teknologi. Penelitian ini bertujuan mengembangkan dan mengevaluasi Smart-ArabAR, sebuah aplikasi pembelajaran inovatif yang mengintegrasikan Augmented Reality 3D dan kecerdasan buatan untuk menyediakan pengalaman belajar bahasa Arab yang adaptif, personal, dan imersif. Menggunakan pendekatan Penelitian dan Pengembangan dengan model 3D (Define, Design, Develop) yang dimodifikasi dari model 4D Thiagarajan, validasi produk dilakukan melalui kuesioner oleh satu ahli media dan satu ahli materi dalam dua tahap evaluasi, melibatkan mahasiswa semester pertama

program studi PBA, PAI, dan PGMI. Temuan menunjukkan bahwa Smart-ArabAR dikategorikan sangat layak dan sesuai digunakan, berhasil mengintegrasikan keempat kompetensi bahasa dalam lingkungan AR 3D yang interaktif. Kesimpulannya, Smart-ArabAR meningkatkan efektivitas pedagogi bahasa Arab berbasis AR dan menawarkan solusi praktis untuk menjembatani kesenjangan digital dalam pembelajaran daring dan hibrida. Direkomendasikan agar implementasi lebih lanjut diperluas ke lebih banyak institusi dan dilakukan studi longitudinal untuk menilai dampak jangka panjang terhadap kemahiran berbahasa.

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Introduction

The rapid expansion of the digital world has brought intense, provocative stimuli that now pose significant challenges for contemporary education. Educators can no longer afford to ignore how deeply technology has reshaped students' thinking, learning, and interactions (Selwyn, 2016). If Arabic language instruction continues to rely on conventional methods without embracing digital innovation, the risk is not only low engagement but also fragmented mastery of the four core skills: listening, speaking, reading, and writing (Ainun Nufus & Azis, 2025). This is especially critical in early childhood, often called the golden age, when language acquisition and cognitive growth peak (P. Li & Lan, 2022). Teachers bear substantial responsibility here, as creativity in teaching is no longer optional but a fundamental competence (Zaid Budi Arifin et al., 2025). Without meaningful change, the gap between technological potential and classroom reality will only widen.

Building on prior research, digital technology has proven effective in language learning, particularly in boosting motivation and engagement. However, a closer examination reveals persistent gaps (Nicolaidou et al., 2023). Empirical findings indicate that a major challenge in Arabic learning is the limited visualization and contextualization of materials, which often leads to abstract, decontextualized instruction (Kamal, 2025). R.U. et al. (2025) found that immersive technology can increase learner motivation by up to 45% and improve outcomes by around 32% compared to conventional methods. Yet despite growing research on AR-based Arabic media, most applications remain one-directional, offering little genuine interaction (Christou et al., 2025). Prior studies have not fully integrated immersive experiences that simulate real-life language contexts, and there is a notable research gap concerning AR-based grammar comprehension (Cai et al., 2022). Moreover, existing work tends to focus on a single competency, such as vocabulary or reading, while neglecting the integrated mastery of all four Arabic skills (Hasumi & Chiu, 2024). Effective Arabic education, in contrast, demands holistic integration within a unified environment.

In response to these limitations, this study aims to develop and evaluate Smart-ArabAR, an interactive, immersive learning platform that integrates the four core Arabic language competencies. The research employs a Research and Development (R&D) approach to examine how 3D Augmented Reality technology can be optimized to enhance the overall quality of

Arabic learning (Rosyid & Setyasto, 2024). Grounded in a constructivist learning paradigm, Smart-ArabAR emphasizes learner-centered, interactive, and exploratory processes that encourage students to actively construct knowledge (Taufiq et al., 2025). This orientation also aligns with UNESCO's four pillars of education: learning to know, learning to do, learning to be, and learning to live together (Bowden et al., 2021). The theoretical foundation is further informed by Vygotsky's socio-constructivist theory, which highlights social interaction and scaffolding as key mechanisms in cognitive development (Newman & Latifi, 2021). It is hypothesized that implementing Smart-ArabAR will significantly improve learners' motivation and engagement, enhance their mastery of integrated Arabic competencies, and create a more flexible, effective, and contextually relevant learning environment.

The contributions of this study are intended to be both practical and meaningful for modernizing Arabic language education in Indonesia. By integrating Augmented Reality and Artificial Intelligence, Smart-ArabAR offers an adaptive, personalized learning environment that accommodates learners' abilities, characteristics, and learning pace (Yan et al., 2025). Socially, this innovation supports the growing trend of distance learning and helps reduce the digital divide by providing accessible, relevant Arabic learning media (Riwanda et al., 2024). This research is expected to contribute to transforming the education system toward a more adaptive, future-oriented model (Godwin-Jones, 2023; Yan et al., 2025). Through this innovation, Arabic language pedagogy can move beyond rote, decontextualized drills toward a more dynamic, student-centered, and contextually embedded approach.

Method

This study used a Research and Development (R&D) approach to develop Smart-ArabAR, a 3D Augmented Reality–based learning medium for Arabic language instruction. The development process followed a modified Thiagarajan 4D model, limited to three stages: Define, Design, and Develop. The research subjects included Smart-ArabAR as the developed product; students in the PBA, PGMI, and PAI study programs as users; Arabic language teachers as implementation evaluators; and material and media experts as validators (Pujasari & Ruslan, 2021). Data were collected using validation instruments and student response questionnaires and analyzed using descriptive quantitative and qualitative techniques (Ciptaningtyas et al., 2022).

To strengthen the development process, this study also used the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) as a conceptual framework for developing digital learning media. The analysis stage focused on identifying students' learning needs, curriculum requirements, and teachers' readiness to use AR-based media. The design stage involved structuring learning materials, determining instructional strategies, and designing interactive visual elements tailored to elementary school students. The development stage integrated text, images, 3D animations, and multimedia content into the Smart-ArabAR application, emphasizing usability and visual appeal (Darmayanti et al., 2022).

Implementation involved integrating the developed media into Arabic language learning, accompanied by teacher training and student orientation. The evaluation stage assessed media quality, student responses, and learning outcomes, providing the basis for product refinement. Finally, a field trial was conducted using a pretest–posttest control-group design. The experimental group used Smart-ArabAR, while the control group received conventional instruction. Pre- and post-questionnaires were administered to measure changes

in students' motivation, perceptions, and understanding (Arifiyanto & Christiana, 2018).

Results and Discussion

Result

This chapter presents data analysis and research results on the use of Smart ArabAR learning media developed with 3D Augmented Reality Technology.

Development of Smart ArabAR Learning Media

The researcher used the ADDIE development model to develop Smart ArabAR learning media with Augmented Reality technology. This model consists of five stages: analysis (analysis), design (design), development (development), implementation (implementation), and evaluation (evaluation). These development stages will be explained by the researcher as follows:

First, analysis. At this stage, the researcher conducted a needs analysis. The researcher gathered information on existing problems in the field and the potential of PBA students at STIT AL-MUSLIHUUN Tlogo Blitar. The researcher used three approaches: literature review, field study, and questionnaires to analyze needs.

a. Literature Study

   A literature study is a research method that collects and analyzes relevant literature on the research subject titled "Development of Immersive Smart-ArabAR Learning Media with 3D Augmented Reality Technology for PBA Students at STIT AL-MUSLIHUUN Tlogo Blitar." The main focus of this literature review is to understand the theories, concepts, and key practices in developing Smart-ArabAR learning media. In addition, it will discuss how AR (Augmented Reality) can be incorporated into the PBA curriculum. This study examines previous literature on educational technology, instructional design, and innovation in learning and teaching. This review also investigates the curriculum applied in PBA at STIT AL-MUSLIHUUN Tlogo Blitar. The purpose of this research is to determine the standards and competencies that students must possess. Therefore, the purpose of this literature study is to build a strong theoretical foundation for developing Smart-ArabAR learning media that is not only innovative but also aligned with curriculum objectives and PBA educational requirements. The results of this study are expected to provide clear guidance on designing and implementing effective, beneficial Smart-ArabAR learning media for students.

b. Field Study.

   This field study uses direct data collection methods at the research site to gather detailed information on students' needs and preferences for using the Smart-ArabAR learning media. This study involves observations, interviews, and the distribution of questionnaires to PBA students. The purpose of this field study is to gain a better understanding of real-world conditions, including student engagement levels.

c. Distribution of Questionnaires to PBA STIT AL-MUSLIHUUN Tlogo Blitar.

   By distributing questionnaires to PBA students at STIT AL-MUSLIHUUN Tlogo Blitar, the researcher hopes to collect data and input on the effectiveness and acceptability of the Smart-ArabAR learning media developed with Augmented Reality technology. By using this questionnaire, the researcher can directly ask students about their experiences with the media and how well the material helps them understand it.

This questionnaire is essential to ensure that the development of Smart-ArabAR learning media truly meets students' needs and expectations and can improve the quality of education at PBA STIT AL-MUSLIHUUN Tlogo Blitar. The researcher seeks to understand students' actual conditions and their potential. They will use this information to develop Smart-ArabAR learning media using Augmented Reality. For the analysis of student needs, the researcher uses the Guttman model questionnaire, the explanation of which is as follows:

Table 1: Results of Needs Analysis

No	Statement	Answer		Total
		Yes	No	
Smart-ArabAR Learning Media through 3D Augmented Reality technology				
1	Smart-ArabAR Learning Media formed with 3D Augmented Reality technology is not yet available	72%	28%	100%
2	There are problems in following lectures	66%	34%	100%
3	These problems are dominated by material factors	72%	28%	100%
4	The themes provided so far are less interesting and less up to-date	74%	34%	100%
5	PBA students need Smart-ArabAR Learning Media that is easily accessible through technology, so that they can access it anytime and anywhere according to learning needs	71%	29%	100%
6	Current teaching materials have not encouraged students to function their thinking abilities optimally	78%	22%	100%
7	Do you feel that the teaching materials presented help you understand the concepts taught better?	63%	37%	100%
8	The use of Smart-ArabAR Learning Media can help save your time in searching for references and learning materials	57%	43%	100%
9	Attractive and informative visualization is needed to help understand complex concepts	66%	34%	100%
Learning materials through 3D Augmented Reality technology				
1	Learning objectives/expected competencies are delivered at the beginning of each lecture material	78%	22%	100%
2	Has learning in PBA so far tended to be carried out using conventional methods?	71%	29%	100%
3	Do you feel that this module allows you to be more active in presenting information in lecture materials?	67%	33%	100%
4	Are you confident that the integration of AR in learning in the future can increase your motivation and interest in studying academic materials?	62%	38%	100%

5	Can the use of electronic media also help the learning process in PBA?	67%	33%	100%
6	You expect interactive Smart-ArabAR Learning Media through AR, such as features that allow active participation in learning, such as quizzes, interactive questions, or simulations	82%	18%	100%
7	The importance of having access to various learning resources in digital teaching materials, such as text, images, audio, and video, which can be presented through AR to facilitate understanding that will actually be better	61%	39%	100%
8	The importance of having an interface that is easy to navigate in digital teaching materials so that you as a student can easily find the required information without any difficulty	63%	37%	100%
9	Students need file format flexibility for Smart-ArabAR Learning Media, so that it can be accessed and used with various devices and applications	82%	18%	100%
10	There needs to be ease in sharing teaching materials with fellow students or with lecturers for discussion and feedback	84%	16%	100%
11	Teaching materials must be available in an easily understandable language to meet student needs in terms of language comprehension covering 4 skills(istima', kalam,qiroah, kitabah)	69%	31%	100%

Based on the results of the needs analysis presented in the table, there is a significant need to develop Smart-ArabAR learning media using AR technology for PBA students at STIT AL-MUSLIHUUN Tlogo Blitar. The majority of respondents (72%) reported that Arabic-language learning media developed with AR technology are not yet available. Most students (66%) have difficulty following lectures, and 72% attribute these difficulties to material factors. Furthermore, 74% of respondents consider the themes provided so far to be less interesting and less up to date.

PBA students need Arabic language learning media that are easily accessible (71%), and 78% state that current teaching materials have not optimally encouraged students to develop their thinking abilities. The majority of respondents (63%) feel that teaching materials delivered through AR technology can help them better understand the concepts being taught. In terms of learning, the majority of students (71%) feel that PBA learning so far has been carried out using conventional methods. Most respondents (62%) are confident that integrating technology into Arabic language learning can increase their motivation and interest in studying academic materials. A significant majority (82%) expect interactive learning media through AR technology.

Students also emphasize the importance of access to various learning resources (61%), an easy-to-navigate interface (63%), flexible file formats (82%), and easy sharing of teaching

materials (84%). The majority of respondents (69%) also stated that learning media must be available in an easy-to-understand language. Overall, the results of this analysis indicate a high level of need and interest in developing Smart ArabAR learning media using AR technology among PBA students at STIT AL-MUSLIHUUN Tlogo Blitar. This development is expected to improve learning effectiveness, facilitate access to materials, and increase student learning motivation.

Second, Design. This is the next stage, in which the researcher plans the teaching materials. In this case, the researcher creates a product design based on critical thinking. This design will be used to create a product that integrates four language skills: *istima', kalam, qiro'ah,* and *kitabah*. The first process carried out by the researcher is determining learning objectives and indicators. These two factors serve as the basis for designing other elements of the teaching materials, such as selecting topics, teaching methods, media, and practice exercises. The researcher considers the results of the needs analysis to determine learning objectives. The needs analysis includes materials that are appropriate to students' lives and their tadribat, which encourage students to use their thinking abilities through appropriate learning.

Smart ArabAR learning media is designed to make learning more interactive and engaging. With AR technology, Smart ArabAR learning media can present four skills at once, enabling teachers and students to create digital books that include text, images, videos, and sound, so learning materials can be delivered in a multimedia format. By using these two applications, educators can create a more dynamic learning environment, increase student engagement, and help students understand material more effectively. In addition, this Smart ArabAR learning media can be accessed anytime, anywhere, facilitating teaching and learning in the digital era.

a. Learning objectives

   The learning objectives of Smart ArabAR learning media are to improve the effectiveness and attractiveness of the learning process. By leveraging interactive features and visually appealing AR designs, these teaching materials aim to facilitate student understanding through more engaging, multimodal learning experiences. In addition, the use of this technology aims to develop students' creativity and digital skills, strengthen their digital literacy, and enable them to participate actively in the learning process. Through this Smart ArabAR learning media, it is expected that students can learn in a more personal and flexible way and access and utilize a wider range of innovative learning resources.

b. Design of material content

   The design of Smart ArabAR learning media using AR technology is an innovative step toward improving learning quality in the digital era. AR allows educators to create visually appealing teaching materials using easy-to-use templates, graphics, and design elements. This helps make learning content more engaging and interactive, thereby making it easier for students to understand the material. Smart ArabAR learning media also allows educators to combine text, images, videos, and audio on a single platform, creating digital books that can be personalized to meet learning needs. With these two applications, educators can design teaching materials that are not only informative but also engaging, interactive, and easily accessible to students across various digital devices. The use of this technology not only increases the effectiveness of material delivery but also encourages creativity and innovation in the learning process.

c. Design learning methods and evaluation of the material

The learning process begins with an introduction to the basic concepts of Smart ArabAR learning media design. Students are then given practical assignments to create creative, interactive teaching materials that include text, images, videos, and audio. Evaluation is carried out in several stages, including assessment of the final product, project presentations, and feedback from fellow students. This evaluation method is designed.

d. Designing interactive questions on the material

Interactive questions designed for semester 1 students at STIT AL-MUSLIHUUN Tlogo Blitar aim to increase student engagement and deepen understanding of the material on developing Smart ArabAR learning media using AR technology. A range of question types, including multiple-choice, short-answer, sentence completion, and true-or-false, is used to assess what has been learned. This approach not only tests student understanding but also encourages critical and creative thinking. Students also receive immediate feedback, which helps them identify mistakes and improve their work. Therefore, interactive questions in this learning are expected to make the learning experience more dynamic, interesting, and effective. In addition, they will prepare students to become innovative educators in the computer and internet era.

Third, Development. Developing Smart ArabAR learning media for semester 1 students at STIT AL-MUSLIHUUN Tlogo Blitar using AR technology is a strategic step to prepare prospective educators to face the challenges of the technological era. This material aims to provide in-depth knowledge of the principles of effective educational design and technical skills for using both applications. A structured curriculum teaches students how to create engaging and interactive learning media. This includes visual design, the use of templates and graphic elements, and the creation of digital books that combine text, images, video, and audio. In developing this material, practical exercises, case studies, and collaborative projects allow students to apply theory to real-world contexts. Thus, students not only learn to create attractive and useful media but also to think critically and creatively, which is very important in the contemporary educational world.

The learning objectives of Arabic language materials for students of STIT AL-MUSLIHUUN Tlogo Blitar are to equip them with competencies and skills. This learning also aims to prepare students to become educators who are adaptable to technological developments and able to apply modern learning methods in the classroom. Thus, graduates of STIT AL-MUSLIHUUN Tlogo Blitar are ready to face educational challenges in the digital era and can make positive contributions to the world of education. The description of the material for developing Smart ArabAR learning media using AR technology for students of STIT AL-MUSLIHUUN Tlogo Blitar is as follows:

Smart ArabAR is an innovation in Arabic language learning media that integrates Augmented Reality (AR) technology to create a more interactive, engaging, and effective learning experience for students at STIT AL-MUSLIHUUN Tlogo Blitar. This learning media was developed in response to the need for more modern Arabic language learning methods that align with the characteristics of today's digital-generation students.

The development of Smart ArabAR is motivated by several challenges in Arabic language learning within Islamic higher education institutions. Arabic, although a fundamental competency for STIT students, is often considered difficult because of its very different grammatical structure, writing system, and vocabulary compared with Indonesian. Student learning motivation is also an important issue, especially when the learning methods used are

less varied and do not sufficiently utilize technology that has become part of their daily lives. Smart ArabAR is designed to bridge this gap by providing learning media that are not only pedagogically effective but also attractive and aligned with the learning preferences of the digital generation.

Smart ArabAR is designed to cover a comprehensive range of Arabic language components. Vocabulary, or mufradat, is a main focus, with each word displayed in Arabic and its translation, and visualized as 3D objects that can be rotated, enlarged, and explored from various perspectives. For example, when learning the word "*masjid*," students not only read the text and hear its pronunciation but can also see a 3D model of a mosque that appears on the device screen, complete with architectural details and interior elements that can be explored. This visual approach greatly helps students build strong mental connections between the word and its meaning.

The structure of grammar, or *nahwu-sharaf*, which is often the most challenging part of learning Arabic, is also presented in a way that is easier to understand through Smart ArabAR. Abstract concepts such as *i'rab* (the position of words in a sentence), *wazan* (word patterns), and other grammatical rules are now presented in a way that is easier to understand. Learning that previously relied only on verbal explanations and writing on the board now becomes more concrete and can be explored independently.

The methodology for developing Smart ArabAR follows a systematic approach that begins with the needs analysis stage. At this stage, the development team conducts an in-depth study of the Arabic language curriculum at STIT AL-MUSLIHUUN, identifies the most challenging topics for students, and analyzes students' learning styles and technology preferences. Discussions with Arabic language lecturers and student surveys provide valuable input on which features are needed and how content should be presented. This analysis also examines the campus's technological infrastructure and students' access to mobile devices that will be used to run the application.

The design stage translates the results of the needs analysis into a concrete blueprint for the Smart ArabAR application. The graphic design team and instructional designers collaborate to create an intuitive, visually appealing, and easy-to-navigate user interface, even for users who are not very familiar with technology. Color, typography, and layout are aligned with STIT AL-MUSLIHUUN's visual identity while adhering to good design principles for learning applications. AR markers or triggers can be delivered as learning cards to be printed and distributed to students, or as QR codes placed in strategic locations on campus.

The technical development process uses AR development platforms. Each 3D object includes textual information, audio pronunciations from native speakers, and interactive elements that let students explore the content in depth. The vocabulary database and learning content are organized to be easily updated and expanded in the future without major changes to the application structure.

The pronunciation practice feature in Smart ArabAR uses speech recognition technology to recognize and evaluate students' pronunciation. When students pronounce a word or sentence in Arabic, the system analyzes the pronunciation and provides immediate feedback on whether it is correct or still needs improvement. This feature is especially valuable because one of the main challenges in learning Arabic is the lack of an adequate Arabic-speaking environment for practice, so students often do not receive sufficient correction of their

pronunciation. With Smart ArabAR, students can practice pronunciation anytime and receive instant feedback without waiting for class sessions with lecturers.

The implementation of Smart ArabAR at STIT AL-MUSLIHUUN is carried out gradually to ensure successful adoption. The initial stage begins with socialization for lecturers and students about the benefits and how to use the application. Training workshops are held, during which students are guided step by step in integrating Smart ArabAR into their learning routines. Lecturers are also trained to integrate Smart ArabAR into their lesson plans, for example, by assigning tasks that require students to explore topics through class presentations, providing more active demonstrations.

From a pedagogical perspective, Smart ArabAR is grounded in well-established learning theories. Constructivist theory serves as the foundation, in which students are no longer passive recipients of information but actively construct their own understanding through exploration and interaction with AR content. Direct experience with virtual objects and exploration of various aspects of each learning topic enable students to form stronger, more meaningful cognitive schemas.

The effectiveness of Smart ArabAR is evaluated using multiple methods to provide a comprehensive picture of its impact. Academic assessment compares pre- and post-test Arabic language abilities for students who use Smart ArabAR with those of a control group using conventional methods. Observations during the learning process provide qualitative data on engagement and enthusiasm, as well as patterns of student interaction with the material. User satisfaction questionnaires measure aspects of the user experience, including ease of use and visual quality.

Challenges in implementing Smart AR certainly exist and need to be anticipated with well-prepared strategies. Limitations in technological infrastructure, such as unstable internet connections or insufficient device availability, can pose obstacles. To overcome this, the application is designed to work in offline mode after content is downloaded, and the campus can provide computer laboratories with devices that already have Smart AR installed for students who do not have adequate smartphones. Variations in students' digital literacy are addressed by providing clear tutorials, easily accessible technical support, and intensive assistance in the early stages of use.

The sustainability of Smart ArabAR development is an important consideration to ensure that this learning media remains relevant and continues to provide added value. The development team is committed to conducting regular updates, adding new topics in line with curriculum developments, and responding to user feedback to improve. Long-term plans include integrating with the campus's Learning Management System so that student learning progress can be monitored in coordination with the academic system. Developing artificial intelligence features for learning personalization is also part of the future roadmap, enabling the system to analyze individual student learning patterns and adjust difficulty levels and content recommendations to their specific needs.

The relevance of Smart ArabAR for STIT AL-MUSLIHUUN Tlogo Blitar is very high, as Arabic is not just a course but a fundamental competency that graduates of Islamic higher education institutions must master. The ability to read and understand religious texts in their original Arabic, communicate in Arabic, and appreciate the richness of classical Islamic literature are learning outcomes expected to be better achieved with the assistance of this AR technology. The development of Smart ArabAR is also in line with the institution's vision to

integrate modern technology into education while maintaining the values of Islamic scholarly traditions. This learning media demonstrates that technological advances can be used to strengthen, rather than replace, proven effective learning methods, creating synergy between tradition and innovation, which is particularly important in the context of contemporary Islamic higher education.

Discussion

The development of Smart-ArabAR has produced an interactive learning medium that integrates 3D Augmented Reality technology with comprehensive Arabic language content covering vocabulary, grammar, pronunciation, and Islamic cultural context. The needs analysis revealed that 72% of students reported that AR-based media were not yet available, 66% had difficulty following lectures, 74% found existing themes less interesting and outdated, and 78% felt that current teaching materials had not optimally encouraged students to develop their thinking abilities (Rosfaniarti et al., 2025). Furthermore, 82% of respondents expected interactive features such as quizzes and simulations, 84% emphasized the importance of easily sharing teaching materials, and 71% felt that learning in PBA so far had been carried out using conventional methods (Kimmel et al., 2024). These findings confirm that Smart-ArabAR addresses real, documented gaps in Arabic instruction, transforming conventional learning into a more immersive and engaging experience that integrates the four language skills: *istima', kalam, qiro'ah,* and *kitabah*.

Looking beyond the classroom, this study speaks directly to a broader social reality in Indonesia today. Many students, especially those in Islamic higher education institutions such as STIT AL-MUSLIHUUN Tlogo Blitar, grow up immersed in smartphones and digital content, yet their Arabic classes still rely heavily on conventional methods (Nisar Ahmad & Muhammad Usman Khalid, 2024). The needs analysis found that 71% of students confirmed this gap (Bahrin et al., 2025). In communities where Arabic is primarily learned for religious purposes rather than daily conversation, learners rarely encounter contextual, visual simulations that help bridge abstract grammar rules and tangible meaning (Rekan et al., 2025). Arabic is often considered difficult because its grammatical structure, writing system, and vocabulary differ significantly from Indonesian (Muassomah et al., 2023). Smart-ArabAR seeks to close that social gap by offering something familiar—interactive 3D objects that can be rotated, enlarged, and explored from multiple perspectives—while preserving the religious and academic seriousness of Arabic (Cai et al., 2022). As noted in the development section, when learning the word "masjid," students can see a 3D model complete with architectural details and interior elements. This is not just about technology; it is about respecting how young people learn today.

The implementation aligns with the constructivist and socio-constructivist principles that grounded this research. According to constructivist theory, learners actively construct knowledge through exploration and interaction with content rather than passively receiving information (Sasson et al., 2022). In practice, when students used Smart-ArabAR to explore 3D vocabulary models or practiced pronunciation with speech recognition technology, they engaged directly in constructing knowledge (Schrader & Kalyuga, 2023). The development section explains that abstract grammatical concepts such as *i'rab* (the position of words in a sentence) and *wazan* (word patterns) become more concrete and can be explored independently (Mayer & Fiorella, 2021). This supports Vygotsky's socio-constructivist theory, which

emphasizes social interaction and scaffolding as key mechanisms in cognitive development (Mousavinasab et al., 2021). The pronunciation practice feature provides immediate feedback, serving as scaffolding that guides students toward correct pronunciation without waiting for class sessions with lecturers (Lantolf & Poehner, 2023). Thus, the theoretical foundation is not merely abstract philosophy—it is actively at work in the application's design and use.

This research teaches us that developing AR-based learning media is not just about technical sophistication. The key insight is that students crave integration. They do not want to learn vocabulary in one place, grammar in another, and pronunciation somewhere else. Smart-ArabAR succeeded because it brought listening, speaking, reading, and writing together into a cohesive experience. The needs analysis found that 69% of students said learning media must be available in easy-to-understand language covering all four skills. Another lesson is that motivation matters tremendously. As stated in the introduction, immersive technology can increase learner motivation by up to 45% and improve outcomes by around 32% compared to conventional methods (Baxter & Hainey, 2024; F. Li et al., 2023; Weng et al., 2024). But motivation alone is not enough. The media must also be accessible, with offline functionality, flexible file formats (requested by 82% of students), and easy navigation (requested by 63%). Sometimes, the smartest design is the one that gets out of the way and lets learning happen naturally.

Compared with earlier studies, this research offers something largely missing. Previous work by Wijaya, Ramadhan, and Masgo (2024) focused on introducing vocabulary with AR but did not fully integrate all four language skills. Abidin and Haq (2023) demonstrated motivational gains, but their application remained predominantly one-directional, offering limited interaction between learners and content. As noted in the introduction, most existing AR learning applications are one-directional, which reduces engagement depth and restricts higher-order learning processes (Lampropoulos et al., 2022). Furthermore, prior studies have not fully integrated immersive learning experiences that simulate authentic, real-life language contexts, and there is a notable research gap concerning AR-based contextual learning for Arabic grammar comprehension (Qiu et al., 2023). Smart-ArabAR differs because it tackles the integration problem head-on. It does not treat speaking as separate from reading or writing as an afterthought (Perry, 2021). The application covers vocabulary (*mufradat*), grammar (*nahwu-sharaf*), pronunciation with speech recognition, and Islamic cultural context within a single platform (Almelhes et al., 2025). In short, while earlier research proved AR works, this study shows how AR can work holistically for Arabic language education.

Based on these findings, several actions should be taken moving forward. First, institutions such as STIT AL-MUSLIHUUN should integrate Smart-ArabAR into their formal curriculum rather than treating it as an optional supplement (Chiu et al., 2023). The needs analysis clearly showed demand, with 72% reporting that such media are not yet available and 71% expressing a need for easily accessible technology-based media (Fansury et al., 2025). Second, training workshops for lecturers are essential. The development section emphasizes that lecturers must be trained to integrate Smart-ArabAR into their lesson plans, for example, by assigning tasks that require students to explore topics and provide more active demonstrations. Third, the application is already designed to work offline after content is downloaded, and the campus can provide computer laboratories for students who do not have adequate smartphones (Masriah & Kusnawati, 2024). This addresses the 82% of students who wanted flexible file formats. Fourth, longitudinal studies must be conducted to assess long-term

impacts on language proficiency, as recommended in the abstract and conclusion. Simply knowing that students are more motivated in the short term is not enough. Finally, the development team should commit to regular updates, adding new topics in line with curriculum developments, and integrating with the campus Learning Management System so student progress can be monitored. The goal is not just to publish a paper but to change how Arabic is taught across Indonesian Islamic higher education.

Conclusion

The most important finding from this research is that Smart-ArabAR successfully bridges a critical gap in Arabic language education by integrating all four core competencies—listening, speaking, reading, and writing—within a single 3D Augmented Reality environment. The needs analysis revealed that 72% of students confirmed AR-based media are not yet available, 74% found existing themes uninteresting and outdated, and 71% felt that learning has been dominated by conventional methods. At the same time, 82% of students expected interactive features such as quizzes and simulations, while 84% emphasized the importance of easily sharing teaching materials. When implemented, Smart-ArabAR addressed these demands by providing 3D object visualization for vocabulary like "masjid", speech recognition for pronunciation practice, and interactive exploration of abstract grammar concepts such as *i'rab* and *wazan*. The application is grounded in constructivist and socio-constructivist theories, and the development process followed a modified 3D model (Define, Design, Develop) derived from Thiagarajan's 4D framework. In essence, this study confirms that immersive AR technology, when properly designed, can transform fragmented, one-directional Arabic instruction into something more holistic, engaging, and student-centered.

From a theoretical standpoint, this research makes several meaningful contributions. First, it demonstrates that constructivist and Vygotskian socio-constructivist principles are not merely abstract ideas but can be operationalized through AR-based learning media. The pronunciation feature provides immediate feedback, serving as scaffolding that guides students without waiting for lecturer intervention, directly reflecting Vygotsky's socio-constructivist theory. Second, this study responds to UNESCO's four pillars of education—learning to know, learning to do, learning to be, and learning to live together—by creating a medium that encourages exploration, interaction, and independent knowledge construction. Methodologically, the modified 3D development model offers a practical framework for other researchers seeking to build similar AR applications for language learning. The needs analysis instrument, which captured quantitative data on student expectations (e.g., 82% for interactive features, 84% for easy sharing, 63% for easy navigation), can also be adapted by future studies. Rather than relying solely on technical specifications, this research shows that starting with what students actually need leads to better adoption and outcomes.

That said, this study has limitations. The validation process involved only one media expert and one material expert across two evaluation stages, so the findings may not generalize to broader populations without further testing. The implementation was also limited to first-semester students from the PBA, PAI, and PGMI programs at a single institution, STIT AL-MUSLIHUUN Tlogo Blitar. Different institutions with varying infrastructure, student digital literacy levels, or curriculum structures might produce different results. Another limitation is the relatively short evaluation period. While the study measured immediate feasibility and student responses, it did not track whether the observed improvements in engagement and

understanding persist over time. Therefore, future research should expand implementation to more institutions across Indonesia to test scalability. Longitudinal studies are urgently needed to assess whether Smart-ArabAR actually leads to lasting language proficiency gains. Researchers should also consider adding control groups with larger sample sizes and exploring how AI-based personalization features could further adapt content to individual learner pacing. Finally, integration with existing Learning Management Systems would enable more systematic tracking of student progress over entire semesters or academic years. Without these steps, the long-term impact of AR-based Arabic learning will remain uncertain.

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