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Development of a Markerless Augmented Reality Application for Teaching Prayer Procedures to Young Children

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Abstract. *Learning prayer procedures to young children requires instructional media that can present movement sequences clearly and attractively. This community service project developed an Android-based markerless Augmented Reality (AR) application, named AR Shalat, to visualize the movements of the five daily prayers as three-dimensional animations without printed markers. The application was developed using the Waterfall model through requirements analysis, system design, implementation, and functional testing. Markerless plane detection was implemented using ARCore in Unity, while the three-dimensional character and movement animations were created in Blender. Functional black-box testing showed that the main application functions, including camera initialization, plane detection, 3D character placement, animation playback, and menu navigation, operated as intended. Under the tested conditions, plane detection was completed in less than 3 seconds on textured surfaces with adequate lighting. The application was also directly tried by young children as the intended users to observe its ease of use and their responses to the three-dimensional visualizations. However, learning effectiveness was not quantitatively evaluated. These results indicate that the application is technically feasible as an interactive visual aid for introducing prayer procedures to young children. Further evaluation using standardized usability and learning-outcome instruments is required before conclusions regarding educational effectiveness can be made.*

Keywords: *Markerless augmented reality, prayer procedures, interactive learning media, young children, spatial visualization*

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INTRODUCTION

Prayer (salat) is an obligatory act of worship performed five times daily by Muslims and is an important part of Islamic religious education (Hayati et al., 2025). Introducing the correct sequence and body positions of salat from an early age can help children become familiar with its procedures (Gumelar et al., 2025). In practice, however, teaching young children often relies on verbal explanations, books, and static two-dimensional (2D) illustrations (Saputra et al., 2024; Amelia, 2024). Such media provide limited visual information about changes in body position and movement transitions. Previous studies have therefore explored interactive and Augmented Reality (AR)-based media as complementary tools for presenting prayer procedures (Madani et al., 2025; Nasution, 2025; Mahendra et al., 2025).

AR technology integrates virtual three-dimensional (3D) objects with the real environment in real time and can provide concrete visual representations of objects or movements that are difficult to convey through static illustrations (Adlani et al., 2023; Uriawan et al., 2025). In educational settings, AR has been associated with opportunities to support visualization, engagement, and spatial understanding, although its educational benefits depend on the learning design, target users, and evaluation context (Ruzakki et al., 2024; Koumpouros, 2024). For young children, interactive visual representations may be particularly useful because learning at this developmental stage benefits from concrete and perceptually accessible experiences (Atikah et al., 2023).

Markerless AR offers practical advantages because virtual objects can be placed on detected surfaces without requiring users to print or carry physical markers (Rizkaini, n.d.; Irawati et al., 2023). In the context of prayer instruction, this approach allows a 3D character to be displayed directly on a floor or other suitable flat surface and viewed from different angles. Based on these considerations, this community service project aimed to develop and functionally evaluate an interactive learning medium for the five daily prayers using markerless AR. The application was intended for young children and was designed as a supplementary visual aid that can be used with guidance from educators or parents.

METHODS

The community service activities were conducted through four main stages: needs identification, development of the AR learning media, implementation with target users, and evaluation. The AR Shalat application was developed using the Waterfall approach as part of the media-development stage.The maintenance stage was not implemented during the reported period and is therefore presented as a plan for future development (Romisa et al., 2023; Saravanos & Curinga, 2023).

The Waterfall approach was selected because the main functional requirements could be defined before implementation, including markerless plane detection, 3D visualization of prayer movements, and simple navigation for young users. The sequential structure also facilitated documentation of the development and testing process. Figure 1 summarizes the development workflow used in this project.

System Design

The system design stage translated the identified requirements into the application workflow and interface. Use-case diagrams were prepared to describe interactions between users and the system, including opening the application, directing the camera toward a flat surface, placing the 3D character on the detected plane, and selecting the desired prayer animation. Interface storyboards were also prepared to maintain a simple and consistent navigation flow for young users (Lai & Cheong, 2022).

The AR architecture used a markerless plane-detection approach in which the device camera identifies feature points and estimates suitable flat surfaces for placing virtual objects (Irawati et al., 2023). This approach was selected to avoid dependence on printed marker cards. The 3D character and prayer-movement animations were created in Blender through modeling, rigging, and keyframe animation (Lubis et al., 2024)and were subsequently prepared for integration into Unity. The sequence and body positions represented in the animations were based on the prayer-procedure references used by the development team, including the fiqh-oriented movement reference in (Hayati et al., 2025). No independent validation by a fiqh expert was conducted; this should therefore be considered when interpreting claims regarding movement accuracy.

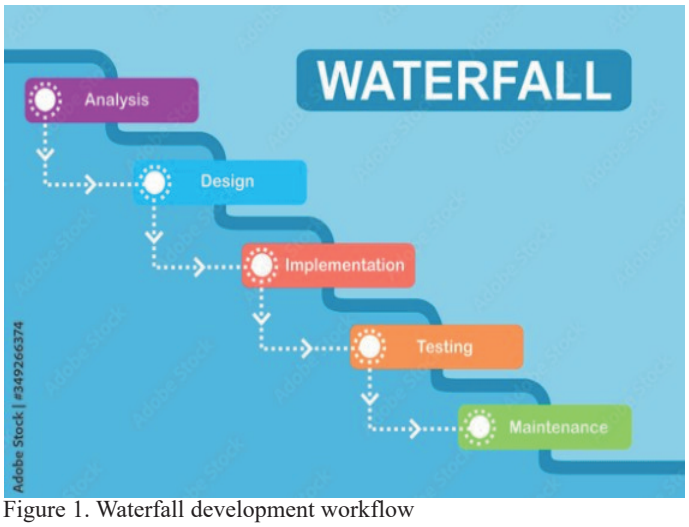

Figure 1. Waterfall development workflow

Implementation

During implementation, the system design was converted into a functional Android application using Unity 3D. ARCore was integrated into Unity to provide motion tracking and markerless plane detection (Putra et al., 2023). The device camera detects environmental feature points and uses them to estimate flat surfaces on which the 3D character can be anchored.

The 3D character and animation sequences created in Blender, including takbiratul ihram, ruku', i'tidal, sujud, sitting between two prostrations, final tasyahud, and salam, were imported into Unity and synchronized with the plane-detection framework. C# scripts were used to control interface interactions, navigation, animation triggers, and sequential playback. Text-based guidance was provided for the prayer positions. Audio narration was not included in the version evaluated in this project. After integration, the application was compiled as an Android Package Kit (APK) for functional testing on physical Android devices.

System Testing

System testing was conducted using black-box testing to determine whether the main application functions operated according to the specified requirements (Romisa et al., 2023). The test items included camera initialization, plane detection on different surface types and lighting conditions, 3D character placement, prayer-animation playback, and menu navigation. The sequence of the displayed prayer movements was also checked against the movement references used during development (Hayati et al., 2025).

Testing scenarios were documented in a table containing the test item, input, expected output, actual result, and test category. Functional testing examined camera initialization, plane detection under different surface and lighting conditions, 3D character placement, animation playback, and menu navigation. In addition to functional testing, the application was directly tried by young children as the intended users. The trial was used to observe whether the children

could interact with the application interface and view the three-dimensional prayer movement animations. Because no standardized usability questionnaire or controlled pre-post learning assessment was administered, observations from the trial were used only as descriptive feedback and were not interpreted as evidence of learning effectiveness.

Maintenance

Maintenance was not carried out within the implementation period reported in this article. It is planned as a subsequent development stage after broader deployment. Future maintenance will focus on compatibility with Android operating-system updates and ARCore revisions, correction of technical problems identified by users, and refinement of the interface based on feedback from educators and parents.

Future development may also include additional instructional content, multilingual guidance, and audio support for prayer recitations. These additions are proposed as subsequent improvements and were not part of the application version evaluated in the present project.

RESULTS AND DISCUSSION

Implementation of the Community Service Activity

The community service activity began with the identification of learning needs through informal observations and discussions with educators and parents. Their input was used to guide the development of AR Shalat as a supplementary visual medium for introducing prayer procedures to young children. After development and functional testing, the application was introduced directly to young children. During the trial, the children interacted with the application and viewed the three-dimensional prayer movement animations, while educators and parents provided assistance when needed.

Interface and 3D Object Implementation

The implementation stage produced an Android-based prayer-learning application named "AR Shalat," integrating a rigged 3D character created in Blender with the Unity 3D engine. The character was developed as a low-poly model with a digital skeletal structure for animation. Character coloring and texturing were managed in Unity using Standard Materials to maintain visual consistency across the movement sequences. Animation development was divided among four team members, after which the individual animation clips were combined into a single application workflow.

The animation sequence covered the principal body positions from standing to the final salam. The standing sequence included the initial standing position and takbiratul ihram; the transition sequence included ruku', i'tidal, and movement from standing to the floor; the floor sequence included the first sujud, sitting between two prostrations (iftirasy), the second sujud, and the resting sitting position (jilsah al-istirahah); and the final sequence included returning to standing, final tasyahud, and salam. Intention (niat) was treated as part of the instructional context rather than as a physical movement. Animation data were exported from Blender as .fbx files with the Bake Animation option enabled and were integrated into a single Animator Controller in Unity for sequential playback through interface buttons.

Markerless Plane Detection Functional Testing Results

Black-box testing showed that the main markerless AR functions operated under the tested conditions. The camera initialized correctly, textured flat surfaces could be detected, the 3D character could be placed on the detected plane, prayer animations could be played sequentially, and the navigation buttons opened the intended pages. During testing, the plane grid appeared in less than 3 seconds on textured surfaces under adequate room lighting. Detection was less stable on very plain surfaces and under low-light conditions, where object drifting was

observed. Table 1 summarizes the functional test results.

Figure 2. Animator Controller workflow for the prayer-animation sequence

Table 1. Markerless plane detection functional test performance

Functional Test Item	Input	Expected Output	Actual Result	Category
Camera Initialization	Open AR Menu	The camera is active and starts scanning the environment	Camera active and scanning	Successful
Plane Detection	Point the camera at the textured floor	Grid visualization appears on the device screen	Plane grid appears < 3 seconds	Successful
3D Character Spawn	Tap on the grid area	3D prayer characters appear precisely at the tap coordinates	The character appears precisely	Successful
Prayer Animation Playback	Press the prayer animation navigation button	Animation runs sequentially in the correct prayer order	Animation runs smoothly without lag	Successful
Menu Navigation Button	Press the Home, Start AR, and About buttons	Navigation changes pages according to the button pressed	All pages accessible	Successful

Potential of 3D Spatial Visualization as a Learning Aid

The markerless AR application provides a dynamic 3D representation of prayer movements that can be viewed from different angles. This feature may help young users observe body positions and movement transitions that are difficult to represent fully in static 2D illustrations. In addition, plane detection removes the need for printed marker cards and allows the virtual character to be placed on a suitable flat surface in the user's environment. These characteristics demonstrate the application's potential as a practical supplementary visual aid. However, the present project did not compare the application with conventional learning media and did not measure cognitive load or learning outcomes; therefore, no conclusion can be drawn regarding superiority, improved retention, or reduced cognitive load.

Previous studies have reported potential educational benefits of AR, particularly for visualization and interactive learning (Ruzakki et al., 2024; Lai & Cheong, 2022; Koumpouros, 2024). Markerless implementation may also reduce practical dependence on physical markers (Irawati et al., 2023). The present application extends these technical features to the visualization of salat procedures for young children. Nevertheless, the contribution demonstrated in this project is primarily functional: the application successfully integrates plane detection, 3D object placement, and sequential prayer animations. Controlled educational evaluation is still required to

determine whether these features improve children's understanding or performance of prayer procedures.

Comparison with Previous Studies and Limitations

The use of AR in Islamic religious education has expanded in recent years. Ruzakki et al. (Ruzakki et al., 2024) reviewed trends in the use of AR and virtual reality in Islamic religious education in Indonesia, while other studies have developed AR applications for prayer-related learning (Hayati et al., 2025; Gumelar et al., 2025; Adlani et al., 2023; Darmanto et al., 2021). In the present project, markerless plane detection was combined with a sequence of 3D prayer animations, including jilsah al-istirahah. The inclusion of this movement reflects the procedural reference adopted by the development team; however, the application was not independently validated by a fiqh expert. Accordingly, the term 'fiqh-validated' is not used in this article.

Several limitations should be acknowledged. First, functional testing was conducted on a limited number of Android devices, and broader compatibility testing is required. Second, the user trial was observational and did not employ a standardized usability instrument, such as the System Usability Scale (SUS), or a controlled pre-post assessment of learning outcomes. Third, the evaluated version did not include audio guidance, which may limit independent use by children who cannot yet read. Fourth, the accuracy of the prayer movements was based on the references adopted by the development team and was not independently reviewed by a fiqh expert. Future work should include broader device testing, standardized usability assessment, controlled educational evaluation, expert validation of prayer procedures, and development of audio guidance and posture-feedback features.

Figure 3. Example of 3D prayer-movement visualization on a detected flat surface

CONCLUSION

This community service project produced a functional Android-based markerless AR application for visualizing the procedures of the five daily prayers for young children. Black-box testing confirmed that the main functions-camera initialization, plane detection, 3D character placement, sequential animation playback, and menu navigation-operated as intended under the tested conditions. Plane detection was faster and more stable on textured surfaces with adequate lighting than on plain surfaces or under low-light conditions. The application therefore demonstrates technical feasibility as a supplementary interactive visual aid for prayer instruction. Because learning outcomes and usability were not evaluated using standardized instruments or a controlled design, the present results do not establish an improvement in children's learning. Further work should focus on broader user testing, learning-effectiveness evaluation, fiqh-expert validation, audio guidance, and compatibility across a wider range of Android devices.

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