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SIMULATING HALAL SLAUGHTERING THROUGH VIRTUAL REALITY: A 3D INTERACTIVE APPLICATION GROUNDED IN ISLAMIC PRINCIPLES

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Abstract: *Traditional training methods for halal slaughtering often depend on live demonstrations, which can be costly, inconsistent, and raise ethical concerns related to animal welfare. These challenges hinder the effective dissemination of standardized procedures and religious principles essential to the halal meat industry. A 3D interactive, Virtual Reality (VR)-compatible application was developed to accurately model the halal slaughtering process in a realistic and educational format. The application integrates realistic 3D livestock models, anatomical animations, and instructional content grounded in Quranic teachings and Hadith. Built using Unity and Blender this study adopts a research methodology based on the waterfall model, providing a systematic framework to guide the development process while ensuring a structured and methodical approach from design to implementation. Functionality testing confirmed that all components performed successfully, while usability and clarity assessments demonstrated improved user comprehension, engagement, and confidence. Scoring features are based on Malaysia's MS1500:2009 standards to ensure alignment with the general requirements for halal food preparation, handling, and slaughtering. This development highlights the potential of interactive media to modernize religious education and support ethical, standardized halal practices worldwide.*

Keywords: *Virtual Reality, Halal Slaughtering, Education Tools, Religious Education*

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Introduction

3D interactive media is a powerful tool that offers unique solutions for areas that are otherwise inaccessible or require more comprehensive processing. Especially compared to traditional media formats such as 2D images, videos, or audio. Tools like these are particularly beneficial in hands-on professions as they bolster practical skills while reducing costs and resource usage (Dancsa et al., 2023; Piovesan et al., 2012). For instance, the halal meat industry relies heavily on practical skills, coupled with ethical and religious understandings, which play a core role in ensuring that halal products are suitable for consumption by the Muslim population(Azam & Abdullah, 2021; Latif et al., 2014). Recent studies have shown that 3D interactive tools can significantly enhance learning outcomes in specialized fields, such as hajj pilgrims (Munshi, 2022) and halal forensics (Baharuddin et al., 2021), by providing immersive and engaging training environments. Besides, the tools can benefits for traceability of halal supply chain (Aufi et al., 2024).

Malaysia, recognized as a global leader in the halal industry, offers a strong foundation for the development and implementation of the Malaysian Halal Standard (JAKIM, 2009), which is regulated by the Department of Islamic Development Malaysia (JAKIM). It has established one of the world's most comprehensive halal frameworks to ensure that food and meat production adhere to both ethical and religious requirements (Ahmed, 2019). Despite significant progress in the halal industry, several pressing challenges remain unresolved, particularly in halal slaughter training. Variations in halal standards across regions create inconsistencies in practice and undermine efforts toward global harmonization (Akbar et al., 2023; Abdallah et al., 2021). More critically, training is still heavily dependent on live demonstrations, a method that is prone to human error, lacks scalability, and raises ethical concerns, including stress, moral distress, and repeated use of live animals (Kumari & Sahoo, 2022). This approach not only imposes substantial financial and operational burdens, requiring continuous access to live animals, specialized facilities, and qualified trainers, but also limits accessibility and sustainability, especially for organizations in resource-constrained environments or regions with limited expertise. Consequently, the absence of cost-effective, standardized, and ethically responsible training tools hampers broader dissemination of halal knowledge and the assurance of compliance with both religious and regulatory frameworks.

In this context, the adoption of modern technologies presents a viable solution to enhance halal food production, expand accessibility, and promote global standardization. While cultural and technological advancements have progressed significantly since the time of the Prophet Muhammad (peace be upon him), the Qur'an and his teachings remain timeless and adaptable. They provide guidance for integrating contemporary tools that improve halal practices while remaining consistent with Islamic principles (Alias et al., 2024). Consequently, the Muslim ummah should embrace such innovations to address contemporary challenges while safeguarding religious authenticity (Syukri & Rosyad, 2025).

Aims and Objectives

This study aims to develop a 3D interactive application specifically for the halal slaughtering industry. The objectives are as follows:

1. To design an interactive multimedia application that simulates the halal slaughtering process.
2. To develop a VR-based halal slaughtering application that complies with halal principles and guidelines.

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3. To evaluate the effectiveness and clarity of the multimedia content in conveying halal slaughtering practices and information.

The scope of this study is limited to the development of a 3D interactive application that simulates halal slaughtering procedures in accordance with syariah guidelines. The system is designed primarily for training purposes, targeting individuals and institutions such as halal certification bodies, butchers, and trainees. The focus is on simulating core aspects of halal slaughtering practices, including compliance with ethical and religious requirements, while excluding the broader supply chain and certification processes.

Literature Review

Halal, an Arabic term meaning "permissible" or "lawful" under Islamic law, extends beyond dietary practices to encompass various aspects of daily life. Within the context of food, halal certification requires that meat originates from lawful sources and is prepared according to prescribed slaughtering methods, known as dhabiha. These methods emphasize animal welfare, hygiene, and compliance with syariah principles. Key requirements include that the animal must be healthy at the time of slaughter, the slaughterer must be a Muslim, and the act must be performed using a sharp knife to swiftly sever the carotid artery, jugular veins, and windpipe in a single motion, ensuring the blood is fully drained(S. A. Rahman, 2017; Saddiqa, 2024).

While rooted in religious obligations derived from the Qur'an and Hadith, halal slaughtering also promotes broader values of food safety (Fajri & Sihombing, 2025), cleanliness (Al-Nuaimi et al., 2024), and ethical treatment of animals (M. M. Rahman et al., 2024), reflecting its significance within both Islamic tradition and modern food industry practices. However, debates continue among Islamic scholars regarding the permissibility of pre-slaughter stunning, a method commonly applied in conventional slaughtering, with concerns raised about both its compliance with syariah principles and its implications for animal welfare (Alam et al., 2024; Fuseini, Knowles, Hadley, et al., 2016).

Traditionally, halal slaughtering follows prescribed procedures in accordance with Islamic teachings to ensure that meat is permissible, safe for consumption, and ethically prepared. The Malaysian Standard MS 1500:2009, issued by JAKIM emphasizes humane treatment of animals, cleanliness, and strict adherence to religious requirements (JAKIM, 2009). While these practices remain central to halal training, they rely heavily on live demonstrations and physical resources, which create challenges in terms of cost, accessibility, and ethical considerations related to animal welfare.

To overcome these limitations, virtual reality (VR) technology offers a promising alternative by providing realistic, safe, and controlled training environments that replicate halal slaughtering procedures without the need for live animals. VR has been widely recognized as a powerful educational tool across various disciplines, including military training, medical education, and scientific research, due to its ability to deliver immersive and interactive experiences (Radianti et al., 2020). Such affordances are strongly aligned with Kolb's Experiential Learning Theory (1984), which posits that effective learning occurs through concrete experience, reflective observation, abstract conceptualization, and active experimentation. VR-based training supports these stages by allowing learners to experience slaughtering procedures in a realistic simulation, reflect on their performance, receive structured feedback, and re-practice until mastery is achieved.

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Applying VR technology to halal slaughtering training offers distinct advantages in addressing long-standing challenges faced by the industry. Conventional training often relies on live demonstrations with animals, which not only incurs high costs and logistical demands but also raises ethical concerns regarding animal welfare (Fuseini et al., 2022; Fuseini, Knowles, Lines, et al., 2016). By contrast, VR provides a safe, controlled, and repeatable environment where trainees can practice the procedures of slaughtering without the need for physical resources. This approach reduces dependence on live animals, minimizes training errors, and allows institutions to deliver standardized content aligned with halal certification requirements across diverse regions, including non-Muslim-majority countries where access to expert trainers and facilities may be limited. Furthermore, VR-based simulations can integrate religious guidelines, step-by-step instructions, and real-time feedback, thereby enhancing both the clarity and effectiveness of training. Such applications not only improve accessibility and cost efficiency but also align with Islamic principles by offering an ethical and innovative solution to modern halal training needs.

Methodology

The methodological approach for this research is structured around a systematic Waterfall Model (Ali & Yahaya, 2023) tailored for the development and evaluation of a VR application. This framework ensures a rigorous process from initial concept to final validation, aligning with established principles of software engineering and user-centered design. The process is delineated into four consecutive phases as depicted in Figure 1: Identification, System Design, Development, and Testing.

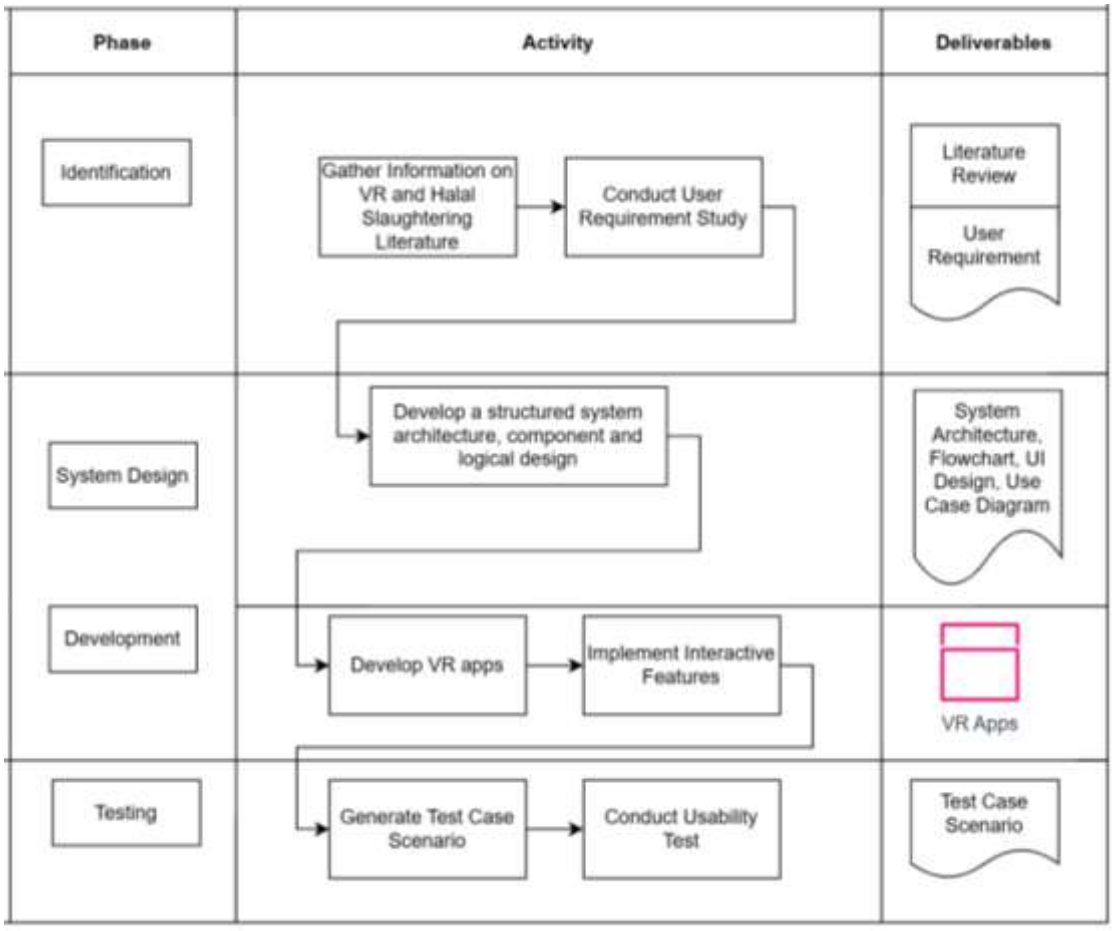

Figure 1: Waterfall Model Framework for VR Halal Application

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The initial phase is focusing on the identification of information related with two central themes of the study; VR development and Halal Slaughtering. The objective is to establish a clear and detailed set of requirements that will guide the entire project. The deliverables of this phase are literature review and formalized User Requirement, which serves as the definitive benchmark for all subsequent design and development decisions.

Next, System Design phase translates the identified needs into a robust and well-structured architectural blueprint. Activities involve designing the system's high-level architecture and defining data flow. Detailed design of user interaction paradigms, 3D environments, and interface elements is also conducted here. The culmination of this phase is a comprehensive System Design Document which includes System Architecture, Flowchart, UI Design, Use Case Diagram.

The third phase is Development which entails the practical implementation of the designed system architecture. Activities are centered on agile programming and iterative building, using game engines, Unity and supported by Graphics API DirectX12. Key tasks include 3D asset integration, scripting interactive behaviors, implementing user interface components, and ensuring real-time performance optimization. This phase produces a functional VR Application Prototype ready for rigorous evaluation.

The final phase is Testing to verify both its functional integrity and its usability from an end-user perspective. Functional testing involves systematic checks to ensure all features operate as intended and are free from critical bugs. Usability testing involves recruiting participants from the target user group to perform predefined tasks within the VR environment. The findings from this phase are analyzed to identify bugs, usability issues, and areas for improvement, feeding back into an iterative refinement cycle until the application meets the established requirements.

Implementation

The system design was implemented within the Unity engine with the C# language as its main scripting language. The scripts will dictate the function needed for the application such as the knife function, the animal status, the blood drain percentages and others. These features provided by the Unity's scripting function allows modularity to easily manage and modified.
To guide the implementation process, a use case diagram (shown in Figure 2) was developed to represent the interactions between the user and the main system functionalities. This diagram helps translate user requirements into concrete system features, ensuring that the application design aligns with the halal slaughtering training objectives.

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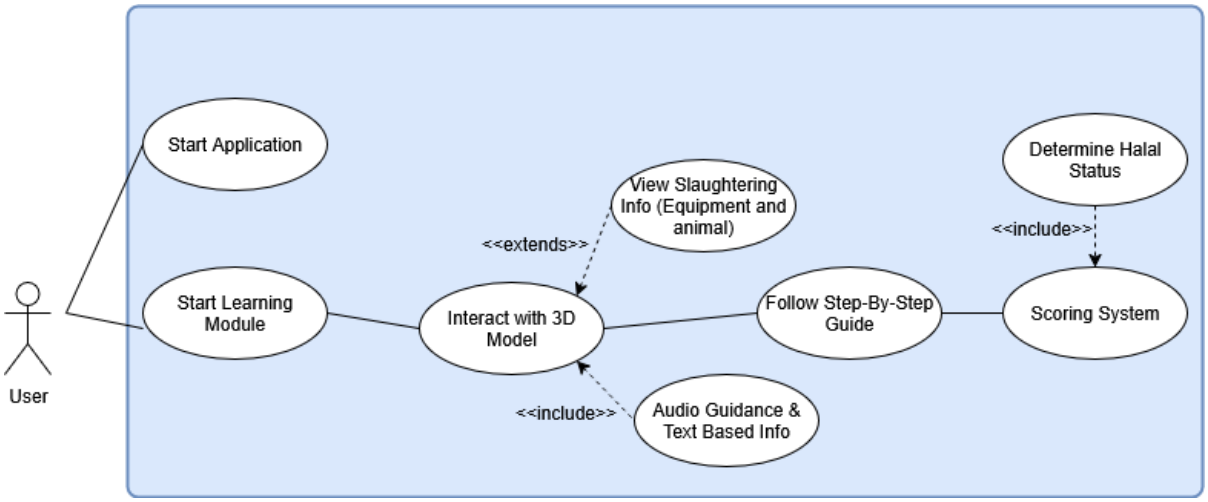

Figure 2: Use Case Diagram for VR Halal Application

As depicted in Figure 2, the main actor is the User, who initiates the system through the Start Application function. From this point, the user can proceed to the Learning Module, which provides structured guidance on the halal slaughtering process. Within the module, the user can interact with a 3D model, enabling immersive exploration of the slaughtering procedure. This interaction is extended by the option to view slaughtering information, including details about equipment and animals. Additionally, the 3D interaction includes audio guidance and text-based information to enhance user understanding.

The system further supports a step-by-step guide, which ensures users follow the halal slaughtering sequence correctly. Integrated within this guide is a scoring system, designed to evaluate user performance and knowledge. The scoring function also includes the capability to determine halal status, reinforcing the application's educational and evaluative purpose. In this study, Halal Status is determined by three parameters following the JAKIM Halal Standard MS 1500-2009 (JAKIM, 2009) shown in Table 1. By aligning the system's evaluation mechanism with these standards, the application can assess whether each step in the slaughtering procedure adheres to halal requirements.

Table 1: Parameters for Evaluating Halal Status based on JAKIM MS 1500-2009

Parameters	MS 1500:2009
Time taken for the slaughter of the animals	The bleeding shall be spontaneous and complete
Blood percentage to be drained from the animal	The slaughter act shall sever the trachea (halqum), oesophagus (mari') and both the carotid arteries and the jugular veins (wadajain) to hasten the bleeding and death of the animal.
The status of the animal (Alive or Deceased)	

Source: Malaysian Standard Halal Food-Production, Preparation, Handling and Storage-General Guidelines (Second Revision)

The halal status evaluation integrates a rule-based scoring mechanism with a time-based constraint to ensure compliance with JAKIM MS 1500:2009. Mathematical representation for Halal Evaluation is described in (1).
The scoring process begins with an initial score, S_0, which is reduced by penalty values P_i for each non-compliance, such as failure to recite *Bismillah* or using a blunt knife. In addition to

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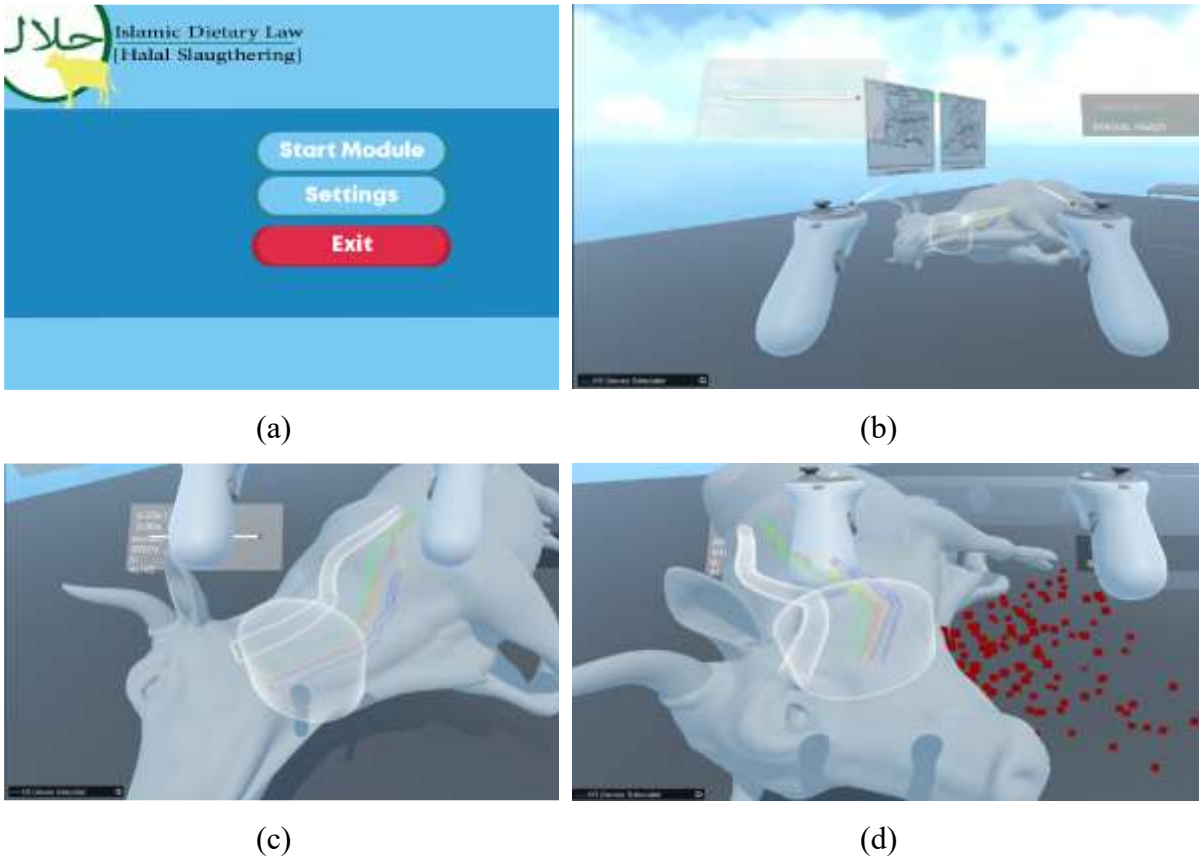
procedural checks, the evaluation incorporates a temporal requirement where the actual slaughtering time, T, must not exceed the maximum defined threshold, T_{max}. The system determines halal status, H, as true only if all procedural conditions are satisfied and the slaughtering process is completed within the defined time limit. Otherwise, the status is returned as false, thereby ensuring that both ritual correctness and efficiency are considered in the implementation. The evaluation rules are defined as S, total score.

$$S = S_0 - \sum_{i=1}^{n} P_i \tag{1}$$

Halal Status is determined as:

$$H = \begin{cases} True, & if\ all\ conditions\ satisfied\ and\ T \leq T_{max} \\ False, & Otherwise \end{cases}$$

The User Interface (UI) was designed to serve as the primary interaction point between the user and the halal slaughtering multimedia application. As shown in Figure 3, the interface provides a simple and intuitive navigation menu, enabling users to access the apps interactively.



(a) (b)

(c) (d)

Figure 3: Interface Design of VR Halal Application a) Main Page b) Guide Page c) X-Ray View of the Anatomy and d) Blood Drainage Effect

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Results and Discussion

The functionality of the halal slaughtering multimedia application was evaluated through functionality testing to ensure that each implemented module performed as intended. The test cases were derived from the system requirements identified during the design phase and covered core functionalities such as the user interface, learning module, 3D simulation, scoring mechanism, and halal compliance evaluation. Each test was executed under controlled conditions, and the outcomes were recorded to verify whether the expected results matched the actual system behavior.

Table 2 presents the functionality testing results. All modules achieved the expected outcomes, confirming that the implementation aligns with the design specifications.

Table 2: Functionality Testing Results for VR Halal Application

Feature	Test Description	Expected Results	Status
Knife Collision	Detects the knife to hit certain area for the process to begin	Knife simulation is accurately detecting the object	Passed
Blood drain percentage	Blood drainage is consistent event with the display	Blood drainage shows accurate percentage over time	Passed
Timing Rule	Rule Set with timing Condition	Timing is accurately taken during the slaughtering process	Passed
X-Ray function	Display the X-ray of trachea (halqum), oesophagus (mari') and both the carotid arteries and the jugular veins (wadajain)	Accurately display the trachea, oesophagus and both carotid arteries and jugular veins	Passed
Halal Evaluation Status	Evaluate the Halal Status according to rule-based defined	Display the Halal Status accurately	Passed

The results show that all modules function as intended. The interface supports seamless navigation, while the learning module effectively integrates text and audio guidance. The simulation provides realistic feedback with interactive 3D models, including blood spilling effects. Importantly, the step-by-step enforcement prevents users from bypassing critical halal slaughtering requirements. The scoring system and compliance engine further validate user actions against JAKIM MS 1500:2009, confirming that the application delivers technically reliable results.

To complement functionality testing, usability analysis was conducted to evaluate user experience in terms of ease of use, content clarity, and engagement. A group of respondents was invited to use the application and provide feedback through a structured questionnaire based on usability factors such as VR navigation, engaging experience and accuracy, and the results as presented in Table 3.

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Table 3: Usability Testing Results for VR Halal Application

Usability Analysis	User Feedback	Interpretation
Immersive VR Controls	High Immersion During the Simulation	Very Good
Engaging Experience	Realistic Blood Effect	Excellent
Accuracy	Halal Status accurately evaluated based on JAKIM Standards	Very Good
Overall Satisfaction	Users described the app as educational and immersive	Excellent

The usability results indicate that the application is user-friendly and engaging. Respondents found the 3D simulation was rated highly for its immersive and realistic representation of the slaughtering process. The step-by-step guide and scoring system enhanced learning effectiveness by reinforcing procedural correctness with the halal status is accurately evaluated. Overall, participants expressed high satisfaction with the system, suggesting its potential as an effective educational tool for halal slaughtering practices.

Conclusions

This project successfully developed a 3D interactive, VR-compatible halal slaughtering training application that addresses the limitations of traditional live demonstration methods. By integrating realistic 3D livestock models, anatomical animations, and instructional content grounded in Qur'anic and Hadith principles, the system provides a structured, ethical, and accessible training solution. Functionality and usability testing confirmed its effectiveness in improving user comprehension, engagement, and confidence, while alignment with Malaysia's MS1500:2009 standards ensures compliance with recognized halal requirements. Overall, the application demonstrates the potential of immersive technologies to modernize religious education, reduce reliance on live animals, and promote standardized halal practices globally.

To further enhance this project, several improvements are recommended. First, incorporating additional animal models such as goats, sheep, and poultry would allow the application to reflect a broader range of halal slaughtering scenarios. Second, the integration of AI-based animal reactions could simulate stress, compliance, and behavior prior to slaughter, thereby increasing realism and educational value. Finally, expanding language support would make the application more accessible to global audiences, ensuring that the system can be effectively utilized in diverse cultural and linguistic contexts.

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