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A Comprehensive Study of Virtual Reality Applications in Religious Ritual Simulation and Cultural Education

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Abstract

Virtual Reality (VR), on the other hand, has shown promise in terms of the potential improvements that it can make in the field of religious education. Current practices in the training of pilgrims for the rituals associated with the annual pilgrimage of Hajj and the minor pilgrimage of ʿUmrah depend on the description and demonstration of the rituals. However, these practices are limited in their ability to ensure that the trainees are adequately trained in the precise manner in which the rituals are to be carried out. In the current study, a VR-based simulation of the ritual of Saʾi—the devotional walk between the two hills of Al-Safa and Al-Marwa in the Grand Mosque—is presented as a case study in the application of technology in the instruction of religious rituals. The system is based on the three-dimensional modeling of the Masʿa in a highly accurate manner and is implemented in two different forms: a fully immersive version that is based on standalone head-mounted displays and a PC/web-based version that is aimed at enhancing the accessibility of the system. The performance of the system is discussed in terms of various design-oriented parameters such as usability, accessibility, completeness, and inclusiveness. One of the limitations that are associated with the current study is the lack of empirical data on the learning that is associated with the proposed framework.

Keywords: Virtual Reality; VR simulation; Sa'i; Hajj; ʿUmrah; religious education; immersive learning; multilingual training.

1 | Introduction

The rapid development of digital technologies has led to the transformation of various aspects of education, including the development of new forms of interactive and experiential learning [1–4]. Among the digital technologies developed for this purpose, Virtual Reality (VR) has been identified as an effective tool for the simulation of real environments and the provision of immersive learning experiences that are not easily possible with traditional forms of instruction[5–10]. Unlike traditional forms of instruction, VR allows the user to have an interactive experience with three-dimensional environments and space, which are not easily possible with two-dimensional forms of instruction[11–15]. Such characteristics of VR have made it an effective tool for the instruction of domains in which learning outcomes are highly dependent on spatial and procedural aspects[16–18].

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VR has been extensively used in the training of professionals and students in various domains, including medicine, aviation, and emergency response[19–21]. Studies conducted in these domains have shown the effectiveness of VR in the instruction of learners and the reduction of anxiety levels during real-life situations. Such benefits of VR have made it an attractive platform for the instruction of various domains, including cultural and religious education [9, 16].

Apart from technical education, the role of VR is growing in the maintenance and transfer of cultural and religious knowledge. Virtual reality helps learners experience cultural heritage in an immersive and captivating way[22–25]. In the Islamic educational domain, the education of individuals for the rituals of Hajj and ʿUmrah poses an important challenge. It not only demands religious understanding but also needs understanding of the sequence of actions and the spatial layout of the sacred sites[24, 26]. New pilgrims often face problems due to their state of anxiety, unfamiliarity with the environment, or confusion about the sequence of actions. Traditional educational resources, like books or videos, can provide useful information but cannot help the learner experience the rituals or the spatial layout of the environment[27, 28].

Among the various rituals of pilgrimage, the ritual of Sa'i, or the act of moving seven times between the hills of Al-Safa and Al-Marwa, stands out as particularly conducive to the application of the simulation approach to learning. The ritual is a structured process, requires spatial cognition, and is rich in symbolism that is closely associated with the historical account of Hagar's search for water[18, 27, 28]. As the ritual combines physical and spiritual elements, it requires the learner to understand the process and the context. Virtual reality technology provides the potential to enable this process of understanding the procedure and the context of the ritual[18, 29]. Learners can be presented with the opportunity to move in a virtual environment that simulates the Masʿaa, be led through the process, and be exposed to contextual information that links the procedure with the historical and spiritual context [30].

Despite the potential of the technology to provide the required functionality, there are certain challenges that need to be addressed to facilitate the application of the technology in the educational domain. The main challenges are the high cost of the equipment and the need to create applications that provide better guidance and context. This is especially important for widespread use and acceptance in education[31, 32]. There is also the issue of the limited number of studies conducted on the application of technology and the need to develop applications that are accessible to users who may not be proficient in the dominant language of the application[33]. This study is presented under the form of a system design and conceptual case study that focuses on the development of a VR-based simulation of the Sa'i ritual. The study focuses on design principles and strategies for accessibility and education rather than the evaluation of learning outcomes. The study is underpinned by the following research questions, How does the VR-based simulation accurately represent the spatial, procedural, and symbolic aspects of the Sa'i ritual?, How does the dual-platform deployment strategy improve accessibility and inclusiveness in ritual education?, What are the design principles that improve learners' preparedness and procedural knowledge in the virtual environment? The research questions inform the design and development decisions that are discussed in this study and form the basis for future research that could inform the evaluation of various outcomes.

1.1 | Technical Implementation Details

The development of the Sa'i simulation required the integration of advanced design tools and interactive platforms to ensure both visual fidelity and pedagogical effectiveness. The following list describes the major components of the implementation pipeline including development and environment construction tools.

1. **Three-Dimensional Modeling with Autodesk 3ds Max**

   The initial stage of the project involved creating accurate 3D models of the Masʿaa—the corridor connecting Al-Safa and Al-Marwa within the Grand Mosque. Using Autodesk 3ds Max, developers designed detailed models that reproduced the stone textures of the hills, the marble flooring, and architectural elements such as arches and pillars [28]. Emphasis was placed on texture mapping, lighting effects, and architectural realism, ensuring that the digital representation captured the

ambience of the sacred site. The professional modeling workflow provided a strong foundation for authentic user experience.

2. **Interactive Development with Unreal Engine**

The 3D assets were subsequently integrated into a virtual environment using Unreal Engine, which served as the primary development framework. Unreal Engine's advanced rendering capabilities allowed for smooth visualization of large-scale environments while maintaining acceptable performance on VR headsets [31]. Its visual scripting system (Blueprints) was used to implement lap tracking, ritual guidance prompts, and context-sensitive feedback. For instance, when a user completed a circuit of Sa'i, the system automatically updated the lap count and triggered instructional messages at the appropriate points [27, 32]. This integration ensured both graphical realism and interactive depth.

3. **Immersive VR Mode (Oculus Quest)**

To maximize realism, the first deployment targeted the Oculus Quest, a standalone VR headset offering wireless operation and high user adoption. The Quest platform enabled full immersion, allowing learners to look around freely, move naturally, and navigate using handheld controllers [18]. Its wireless setup also supported scalability in training centers and individual households, thereby widening the scope of access to the simulation. Compared to PC-tethered VR, Oculus Quest provided an optimal balance between immersion, affordability, and portability [24, 33].

4. **PC and Web-Based Modes**

Acknowledging the digital divide, a parallel PC/web-based version was developed. This version ran on standard browsers and offered a first-person walkthrough of Sa'i with keyboard, mouse, or touchscreen controls [32]. While less immersive than HMD-based VR, this mode preserved essential educational features such as lap tracking, historical explanations, and structured guidance. It further allowed schools, mosques, and community organizations to implement the simulation without requiring costly VR hardware, thereby ensuring inclusivity [33].

5. **Multilingual and Inclusive Design**

Because the Hajj and 'Umrah rituals attract Muslims from across the world, the application was developed to support multiple languages. Upon launching, users could select their preferred language, after which textual and audio instructions were delivered in Arabic, English, and other global languages [33, 34]. This multilingual design not only expanded accessibility but also aligned with the universal and inclusive ethos of the pilgrimage [35].

6. **Platform Diversity and Accessibility Strategy**

Finally, a dual-platform strategy was pursued to balance immersion with accessibility. The Oculus Quest implementation prioritized realism and presence, whereas the PC/web-based mode focused on scalability and inclusivity. Together, these complementary platforms allowed the project to accommodate a wide spectrum of users—ranging from individuals with high-end VR equipment to those with only basic computing devices [36, 37]. This strategic dual deployment reinforced the project's overarching goal of democratizing access to ritual learning through technology.

Focusing on platform diversity to allow accessibility and inclusion, the practical differences between the two deployment strategies are summarized in Table 1. It provides the comparative features of the Oculus Quest–based VR implementation and the PC/web-based version.

Table 1. Comparison of Oculus Quest VR Mode PC/Web-Based Mode.

Feature	Oculus Quest (VR Mode)	PC/Web-Based Mode
Immersion Level	High – full VR immersion with head tracking and 3D audio	Moderate – first-person walkthrough, limited realism
Hardware Requirement	Dedicated VR headset (Oculus Quest)	Standard PC, laptop, or smartphone browser
Accessibility	Restricted to users with VR equipment	Broad – accessible to anyone with internet-enabled devices
Interactivity	Natural movement, controller-based navigation, lap tracking	Keyboard/mouse or touchscreen navigation, lap tracking
Cost	Higher (requires purchase of VR headset)	Lower (no special hardware required)
Target Users	Training centers, VR-equipped institutions, individuals seeking high realism	Schools, mosques, community organizations, general learners
Scalability	Moderate (limited by hardware availability)	High (internet-based distribution)

This comparison reinforces the importance of adopting a dual-platform strategy, ensuring that the simulation serves both technology-rich environments and resource-constrained communities like [38].

2 | Methodology

This is a concept-driven, system design grounded case study that attempts to follow the formation of a Virtual Reality simulation of the Sa'i ritual. The objective is not to follow any learning outcomes through experimentation, but to identify the different aspects of the design, development, and accessibility factors that make up an educational Virtual Reality environment.

The development of the Virtual Reality simulation of the Sa'i ritual has followed a very specific and well-defined four-stage design process. The first is the requirements analysis, where the Sa'i ritual is analyzed through reliable sources to determine the accuracy of the steps and layout. This also helps identify the needs of the user, such as providing adequate guidance and making it accessible to those who are new to the environment.

The environment design phase has seen the conceptualization of the Mas'aa area, which has been designed to resemble the actual environment and has included some of the important features of the ritual. The emphasis has been on providing adequate guidance to the user, including directions, instructions, and context, to help understand the procedure.

In the implementation phase, the main concern was to integrate the interactive elements that would allow the users to move around the space and perform the ritual steps in an ordered fashion. An alternative platform was also considered for the deployment of the simulation to enhance the accessibility of the simulation. It was decided to deploy simulation on both VR headsets and regular desktop platforms.

2.1 | Simulating the Sa'i Ritual in Virtual Reality

Virtual Reality (VR) has demonstrated vast potential in transforming educational experiences across disciplines ranging from medicine to engineering and cultural studies [1, 3, 30, 39]. In the context of Islamic rituals, VR provides an unprecedented opportunity to combine procedural training with spiritual reflection, offering pilgrims and learners a safe, immersive, and repeatable way to engage with acts of worship even before reaching the holy sites. Among the central rituals of pilgrimage, Sa'i—the symbolic journey between Safa and Marwa—holds particular importance for its spiritual meaning and structured sequence.

This section presents how the Sa'i ritual was digitally reconstructed using VR, focusing on the educational value of platform inclusivity, the authenticity of environmental replication, and the integration of spiritual context. It also explores multilingual, step-by-step, and interactive elements

that make simulation a powerful tool for both training and religious enrichment. Figure 1 illustrates the flowchart for the Sa'i VR simulation process.

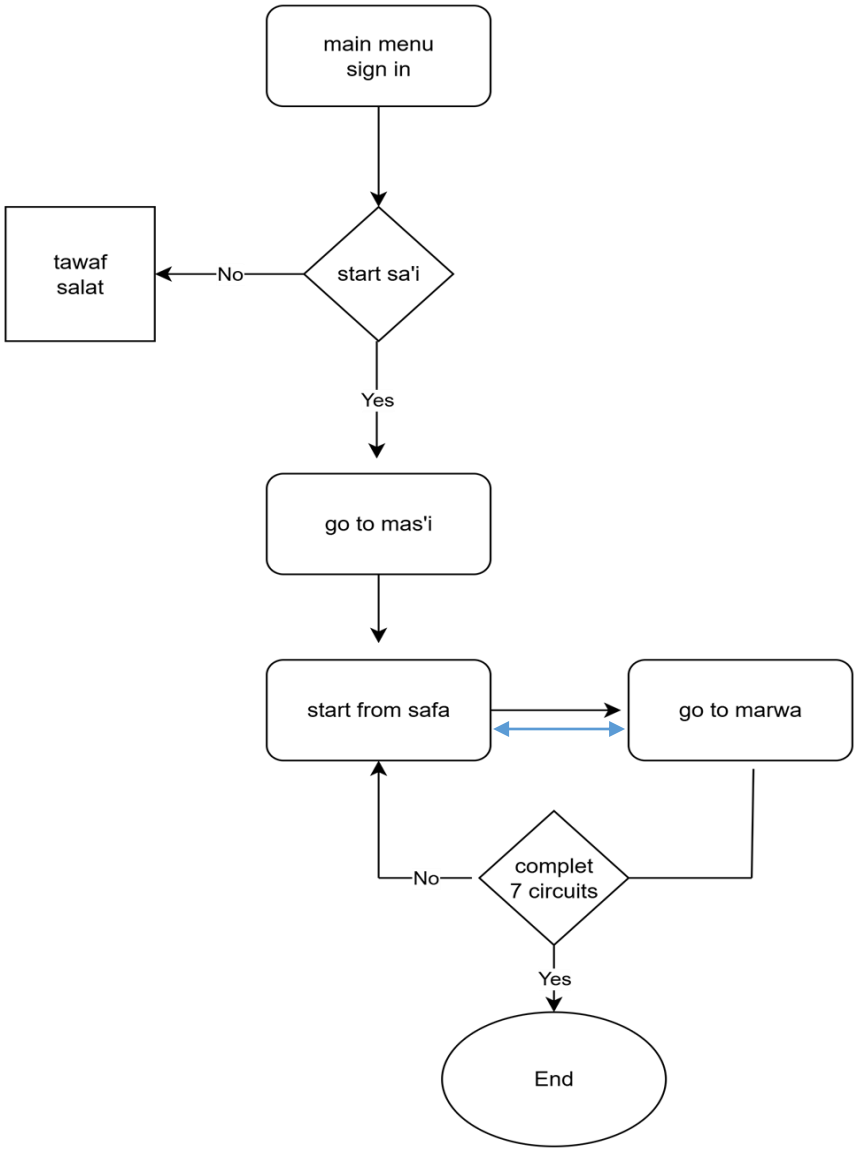

Figure 1. Flowchart for the Sa'i VR simulation process.

2.2| Introduction to VR Applications in Sa'i Education

Virtual Reality (VR) has emerged as a powerful tool in education due to its capacity to replicate real-world environments while providing immersive, repeatable, and risk-free learning opportunities [1, 3, 30, 39]. In the context of religious education, VR holds promise because it allows learners to experience sacred rituals in a lifelike environment even before traveling to the holy sites [31, 33]. This section explores how the Sa'i ritual—the walk between Safa and Marwa during Hajj and 'Umrah—was digitally reconstructed within the VR environment, highlighting its educational, spiritual, and technological significance.

The dual-platform strategy ensures that both high-tech and resource-constrained users benefit from the VR Sa'i simulation. Users with Oculus Quest or equivalent headsets enjoy a fully immersive 3D experience, while the PC/web version provides accessible alternatives for those without specialized equipment [32, 38]. This inclusivity maximizes reach across diverse demographics, from young students learning in classrooms to elderly pilgrims preparing for their first journey [25, 27].

By offering multiple access points, the project reinforces the principle that religious education should be universally accessible, regardless of technological or financial limitations.

2.3| Environment Replication and Ritual Context

The Sa'i ritual was carefully modeled to capture both its physical layout and spiritual context. The virtual environment reconstructs the Mas'aa—the corridor between Safa and Marwa (see Figure 2 and Figure 3)—ensuring that the user experiences the seven required circuits in their correct sequence [7, 8].

- Architectural details such as the stone outcrops of Safa and Marwa, the green-lit jogging section, and guiding signs were faithfully reproduced to reflect the real-world environment [31].
- Contextual explanations provide real-time narration, linking each physical step to its associated spiritual meaning [16, 40].

This blend of realism and narration transforms the VR experience into more than a walkthrough—it becomes an interactive educational journey.

Figure 2. Virtual reconstruction of Safa Hill within the Sa'i simulation.

Figure 3. Virtual reconstruction of Marwa Hill within the Sa'i simulation.

2.4| Step-by-Step User Interaction

The simulation is designed as if the learner is accompanied by a digital instructor, ensuring both procedural accuracy and confidence-building practice [4, 17].

1. Initiation at Safa – Users begin at Safa, introduced through audiovisual prompts explaining the ritual's origin and recommended prayers [11, 12].
2. Circuit Tracking – Each lap is tracked and displayed with a lap counter to ensure the required seven circuits are completed [5, 6].
3. Guided Prompts – Context-sensitive instructions appear, such as reminders to jog between the green markers or face the Ka'bah when reaching Safa or Marwa [18, 19].
4. Completion at Marwa – At the seventh lap, learners receive a summary of the ritual's symbolic lessons, reinforcing both form and meaning [41–43].

This structured interactivity reflects broader findings in VR pedagogy: repetition, feedback, and sensory immersion significantly improve knowledge retention [1, 3, 16].

2.5| Multilingual Educational Support

Given the international diversity of pilgrims, the simulation incorporates multilingual support. Voice and text prompts are localized to major languages, ensuring learners not only understand the sequence but also grasp the spiritual meaning in their own language [25, 40]. This feature enhances inclusivity, particularly for non-Arabic speakers and first-time pilgrims, aligning with research emphasizing accessibility as a cornerstone of effective virtual education [24, 26].

Beyond procedural practice, the VR environment integrates historical and spiritual overlays to deepen reflection:

- At Safa, overlays narrate Hagar's perseverance and the divine emergence of Zamzam [31, 33].
- At Marwa, learners encounter contextual lessons on faith and reliance on God [34].

These overlays elevate the simulation from a technical training exercise to a holistic spiritual rehearsal, uniting ritual practice with religious meaning [16, 30].

2.6| Integration with Broader Religious Education

The VR Sa'i module exemplifies how immersive technologies can enhance both ritual competency and spiritual growth, confirming earlier findings in VR applications for cultural, historical, and medical education [3, 5, 10, 30, 44–47]. By combining authenticity, accessibility, and inclusivity, the simulation demonstrates VR's transformative role in religious pedagogy and contributes to the preservation and dissemination of Islamic rituals in the digital age.

As a matter of fact, throughout the entire design process, usability and accessibility have been at the forefront of our minds. We have strived to ensure that the system has a simple interface, as well as clear visual cues and multilingual instructions. While this study does not include a formal experimental evaluation, the design decisions described in this paper provide a foundation upon which future studies could be conducted.

3| Evaluation Framework

Although the study is focused on system design and architectural implementation, an important part is defining an evaluation framework that can be used to empirically test the system in the future. In the following paragraphs, I propose an evaluation framework that is multi-dimensional in nature and can be used to assess the impact of the proposed VR-based simulation of the Islamic practice of Sa'i.

3.1| Evaluation Framework

The proposed evaluation framework is multi-dimensional in nature and can be used to assess the impact of the proposed VR-based simulation of the Islamic practice of Sa'i. There are four aspects that are considered important in the proposed framework:

- Procedural Accuracy
  This involves how well the user can complete the seven circuits in the correct order and follow the guidelines provided in the Islamic practice of Sa'i.
- Learner Confidence and Preparedness
  This involves how confident the learners are before and after using the proposed system.
- Usability and User Experience
  This involves how well the learners can understand and comfortably interact with the proposed system.
- Accessibility and Inclusivity
  This involves how well the proposed system can be accessed by learners with different linguistic capabilities.

All the above aspects are important and are related to the research questions proposed in the Introduction chapter.

3.2| Evaluation Methods

Future research could also incorporate numbers with stories by employing a variety of quantitatively and qualitatively defined measures like:

- Task completion rates: the rates at which users complete seven correct circuits
- Error rates: e.g., missing a lap or going the wrong way
- Time to completion metrics
- Confidence surveys pre- and post-simulation
- Various usability studies, including the System Usability Scale (SUS)
- Qualitative findings from structured interview techniques

This allows for a comprehensive assessment of not only how users learn the procedures but also how they feel about the system.

3.3| Experimental Design

A possible design for a future study to validate the effectiveness of the proposed intervention could take the following form:

- Control Group: Traditional materials for the process of Sa'i, such as a manual or instructional video
- Experimental Group: A simulation of the process of Sa'i in a virtual reality environment

We could compare the effectiveness of the intervention in the following ways: the number of errors made in the process, the level of confidence of the participants in the process, and the retention of the knowledge gained. The study could be made more robust in terms of internal validity using random assignment of participants to the groups. A long-term study could provide useful insights into the retention of knowledge gained from the intervention and the effectiveness of the skills gained in the actual pilgrimage.

3.4| Limitations and Ethical Considerations

However, in the larger validation of the intervention, the potential dangers of the long-term use of virtual reality in the simulation of the process of Sa'i could provide useful insights. These dangers include the occurrence of cyber sickness in the users of technology. Ethical considerations need to be considered in the study, particularly in the use of the intervention among older adults or those with health conditions. Consideration would need to be given to the accessibility of the intervention to cater to different levels of technology available to different socio-economic groups.

4| Discussion

The aim of this current study is to explore the potential of designing a Virtual Reality-based simulation to facilitate ritual education with the use of the ritual of Sa'i as a model. Instead of focusing on empirical measurements of learning outcomes, the current study attempts to formulate and document a framework that can integrate spatial realism, procedural guidance, accessibility, and contextual information within a unified architecture.

In terms of pedagogical potential, the simulation has been designed to demonstrate the potential of Virtual Reality to facilitate procedural learning within contexts that require spatial and embodied practice to be effective. By including lap tracking and contextual information, the simulation has been able to cover both

the mechanical and contextual requirements of the ritual. This approach to designing the simulation is based on experiential learning theories that emphasize participation and repetition as essential components of learning. Although the current study has not attempted to measure the learning outcomes of the ritual of Sa'i, the structured interaction model provides a potential framework to measure the accuracy of procedural learning in the future.

Access and inclusion became the key design drivers. Dual-platform deployment helps to overcome the well-known difficulties with VR adoption: cost and hardware availability, as the same instructional logic can work on both platforms and keep realism and scalability aligned. This addresses Research Question 2: platform variety increases access without compromising instructional consistency. Support for multiple languages and simplified interface elements are additional factors to increase the potential audience. Language diversity is a key factor for global pilgrimage preparations. With the inclusion of localization within the design, the simulation moves from simple visualization to inclusion and education.

While there are a few caveats to be noted, the work certainly moves the discourse forward. Firstly, there is no empirical testing with users to date, so we cannot assert any level of learning outcomes with reduced error rates, retention levels, or increases in self-confidence. Secondly, architecture is scalable from a technical perspective, but effectiveness will be contingent upon how comfortable users are with technology or whether they possess the requisite hardware. Thirdly, the spiritual effects of immersive ritual rehearsal are a multifaceted topic that requires exploration beyond the scope of a technical system evaluation.

Despite the limitations noted above, the research contributes to the emerging discourse on immersive technologies for religious or cultural education. How? By offering a structured design model for the creation of an immersive system that balances architecture, accessibility considerations, and instructional design. By outlining the system components and offering a future research agenda for validation, the research offers a potential pathway for the application of the model to other pilgrimage rituals or ritualistic education more broadly.

4.1| Feedback and Educational Impact and Learner Preparedness

The effectiveness of any educational simulation depends not only on the accuracy of content but also on the feedback mechanisms and the educational outcomes it produces. The Sa'i VR simulation was designed to operate as a virtual tutor, offering learners both corrective guidance and opportunities for reflection.

4.2| Real-Time Feedback as a Learning Tool

One of the strongest features of VR is its ability to provide immediate feedback during the learning process. When a user makes an error—such as skipping a lap, moving in the wrong direction, or failing to follow the recommended sequence—the system delivers gentle prompts. These notifications do not merely correct mistakes; they also reinforce the learner's awareness of proper ritual procedures [1, 3, 48]. This dynamic interaction mirrors real-world supervision by a teacher or mentor but occurs in a risk-free environment, where mistakes can be repeated and corrected until mastery is achieved.

4.3| Bridging the Gap between Theory and Practice

Traditional teaching approaches—such as lectures, printed manuals, or videos—often result in a cognitive gap between knowledge acquisition and real-life performance. By immersing learners in a faithful reconstruction of the Mas'aa, VR enables them to practice rituals as if they were physically present, thereby strengthening procedural memory [5, 16, 27]. Unlike passive methods, this immersive setting allows learners to integrate both the mechanical actions and the accompanying intentions or prayers, ensuring that ritual learning encompasses both the external form and the spiritual meaning [30, 49].

4.4| Enhancing Learner Preparedness and Confidence

Early exposure to Sa'i through VR prepares pilgrims for the stressful and crowded environment of Mecca. Learners arrive with prior practice, having already internalized the steps in a calm, guided context. As a result, they are less likely to feel overwhelmed by the physical demands or distracted by uncertainty [4, 25]. This preparation has two direct benefits:

- Improved Accuracy – reducing procedural mistakes such as skipping circuits or reversing direction.
- Heightened Spiritual Focus – allowing pilgrims to concentrate on the spiritual essence of Sa'i rather than worrying about mechanical details.

Reports from similar VR-based training programs in fields such as medicine, aviation, and emergency response confirm that simulation-based practice reduces anxiety, increases confidence, and improves performance outcomes [3, 9, 21]. Applying the same principle to religious rituals ensures that learner's approach Sa'i with a balance of technical competence and spiritual readiness.

4.5| Broader Educational Impact

The Sa'i VR system also contributes to inclusive education. Elderly or physically challenged individuals, as well as those unable to travel, can still engage with the ritual in a meaningful way [12, 23, 40]. In this sense, the system extends beyond training to serve as a cultural and spiritual preservation tool, ensuring that ritual knowledge is transmitted accurately to future generations [11, 15, 39].

5| Expanded Analysis

The findings presented in the previous section highlight the educational value and learner preparedness achieved through VR-based simulations of Sa'i. However, to fully understand the scope of this work, it is necessary to move beyond immediate training outcomes and explore the broader implications. Expanded analysis allows us to examine the system's performance from multiple perspectives, including pedagogical depth, cultural significance, and technical feasibility. This not only clarifies the strengths and limitations of the proposed VR approach but also establishes a foundation for its potential integration into wider educational frameworks.

5.1| Accessibility and Inclusivity

A pronounced strength of the Sa'i VR simulation lies in its commitment to technological inclusivity. By offering both a high-fidelity VR headset experience and a web-based PC alternative, the project ensures that users across varying socio-economic backgrounds can engage meaningfully. Research in inclusive VR learning underscores the importance of designing systems that accommodate diverse user needs—leveraging frameworks like Universal Design for Learning (UDL) to make experiences accessible to a heterogeneous audience [48].

Moreover, recent work emphasizes how integrating AI and VR technologies can enhance personalization for learners with disabilities, though literature also stresses challenges such as cost and technical readiness [50]. The Sa'i simulation mitigates these concerns through its dual-platform strategy, while also incorporating multilingual support, vital for addressing the linguistic diversity of the global Muslim community. This inclusive design philosophy democratizes access to pilgrimage education, ensuring that quality preparation is not restricted by age, region, or income level.

5.2| Realism and Spiritual Engagement

The immersive nature of VR creates a compelling sense of presence, an effect difficult to replicate with traditional media [51]. Users often report profound emotional and spiritual engagement—a feeling of "being

there." In the context of religious rituals, this translates into deeper spiritual reflection as users practice within environments that visually and aurally mirror the Grand Mosque.

Educational overlays enrich this immersion by adding symbolic and historical depth. For instance, reminders of Hagar's perseverance during the act of walking between Safa and Marwa elevate the simulation from physical exercise to a spiritually resonant experience. This aligns with findings in VR pilgrimage tools, which note that immersive recreation of sacred spaces helps users focus more intently on metaphysical dimensions rather than logistical anxieties [39, 50].

5.3| Broader Implications for Cultural Education

Beyond immediate ritual training, the Sa'i VR simulation models are a powerful tool for cultural preservation and interfaith education. Digitizing sacred rituals ensures that future generations can experience and appreciate them—even if geographical, financial, or physical barriers arise. VR environments can be adopted not only by pilgrims but also by educational institutions, museums, and interfaith programs to foster cross-cultural understanding.

Immersive technologies allow learners worldwide to explore sacred spaces like the area between Safa and Marwa, experiencing both the historical and spiritual significance of these rituals in a way that traditional media cannot capture. This demonstrates VR's capacity to bridge cultural gaps, expand accessibility, and preserve heritage for diverse audiences [39, 50].

6|Future Outlook

The trajectory of Virtual Reality (VR) development indicates that immersive simulations will play an increasingly central role in education, training, and cultural preservation over the next decade. As VR hardware becomes lighter, more affordable, and user-friendly, barriers to adoption will continue to diminish. Standalone headsets are already evolving to feature higher-resolution displays, improved motion tracking, and natural hand or eye-based interaction, which will make experiences like the Sa'i simulation more realistic, intuitive, and widely accessible [48, 51].

From an educational perspective, VR is moving towards becoming a standard tool for experiential learning. Institutions in fields such as healthcare, aviation, and engineering already employ immersive simulations for professional training, with measurable improvements in performance and safety. Religious education is expected to follow a similar trajectory. The success of the Sa'i simulation demonstrates the feasibility of applying VR to sacred practices, and similar models can be extended to other Hajj and 'Umrah rites such as Tawaf and Jamarat, forming a comprehensive digital curriculum for global pilgrimage preparation [39, 50].

A promising frontier lies in the integration of artificial intelligence (AI) with VR. Intelligent virtual guides could adapt instructions based on user performance, deliver personalized feedback, and evaluate readiness for the actual pilgrimage. Recent work in inclusive VR education confirms that AI-enhanced VR environments increase pedagogical value by tailoring the learning experience to individual learners, especially those with diverse backgrounds and abilities [48, 49, 52].

Culturally, VR provides a transformative medium for heritage preservation and interfaith dialogue. By digitizing rituals, landmarks, and historical practices, VR ensures continuity for future generations while also offering respectful access to global audiences. For example, immersive recreations of the Sacred Mosque and the Sa'i pathway allow Muslims and non-Muslims alike to explore their religious and cultural significance, thereby promoting cross-cultural understanding [39, 50, 53, 54].

Economically, the global VR market is projected to surpass 100 billion USD in value within the next decade, with education emerging as one of its fastest-growing applications [51, 55–58]. Religious and cultural education represent a small but meaningful niche within this expansion. Initiatives like the Sa'i simulation show that sacred applications can coexist alongside entertainment, industrial training, and healthcare, while maintaining authenticity and reverence.

In summary, the future of VR in simulation development is bright and expansive. The Sa'i case study illustrates immediate benefits for ritual training while also pointing to a broader horizon where immersive technologies support faith, culture, and global understanding. The ongoing evolution of VR hardware, software, and AI integration will strengthen its role as a transformative medium in religious education [50, 51].

7 | Conclusion

Virtual Reality (VR) has emerged as a transformative medium that extends far beyond entertainment, offering powerful applications in education, cultural heritage, and spiritual practice. When designed with sensitivity and pedagogical precision, VR can bridge the gap between ritual knowledge and experiential learning, allowing users not only to understand but also to internalize and engage with sacred practices.

The Sa'i simulation, as a case study, illustrates how immersive environments can empower learners, reduce anxiety, and improve preparedness for religious rituals by linking physical actions with their historical, spiritual, and symbolic dimensions. This highlights the unique value of VR in ensuring that tradition is preserved while remaining accessible to new generations through innovative technologies.

Furthermore, the findings demonstrate that VR-based ritual simulations contribute significantly to learner readiness, inclusivity, and global cultural preservation. By offering multilingual support and adaptable platforms—ranging from high-end headsets to web-based modules—these technologies democratize access and strengthen collective identity within diverse Muslim communities worldwide.

Looking ahead, the integration of VR with artificial intelligence, adaptive feedback systems, and mobile or augmented reality platforms promises to expand its reach even further. Such developments could transform VR into a mainstream educational tool that not only supports religious preparation but also enhances cross-cultural understanding, interfaith dialogue, and heritage safeguarding.

In conclusion, Virtual Reality should no longer be viewed merely as an emerging trend but as a strategic, pedagogically valuable, and spiritually enriching medium. By embracing its potential, educators, religious institutions, and cultural organizations can ensure that rituals, traditions, and identities are both preserved and revitalized for future generations.

Author Contributions

All authors contributed equally to this work.

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Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data, but are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest in this research.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

References

[1] Tudor A-D, Minocha S, Collins M, Tilling S (2018) Mobile virtual reality for environmental education

[2] Bagher MM, Sajjadi P, Carr J, et al (2020) Fostering Penetrative Thinking in Geosciences through Immersive Experiences: A Case Study in Visualizing Earthquake Locations in 3D. Proceedings of 6th International Conference of the Immersive Learning Research Network, iLRN 2020 132–139. https://doi.org/10.23919/iLRN47897.2020.9155123

[3] Bhagavathula R, Williams B, Owens J, Gibbons R (2018) The reality of virtual reality: A comparison of pedestrian behavior in real and virtual environments. Proceedings of the Human Factors and Ergonomics Society 3:2056–2060. https://doi.org/10.1177/1541931218621464

[4] Schwebel DC, Combs T, Rodriguez D, et al (2016) Community-based pedestrian safety training in virtual reality: A pragmatic trial. Accid Anal Prev 86:9–15. https://doi.org/10.1016/j.aap.2015.10.002

[5] Grabowski A, Jankowski J (2015) Virtual Reality-based pilot training for underground coal miners. Saf Sci 72:310–314. https://doi.org/10.1016/j.ssci.2014.09.017

[6] Argota Sánchez-Vaquerizo J, Hausladen CI, Mahajan S, et al (2024) A virtual reality experiment to study pedestrian perception of future street scenarios. Scientific Reports 2024 14:1 14:4571-. https://doi.org/10.1038/s41598-024-55073-x

[7] Caporusso N, Biasi L, Cinquepalmi G, Bevilacqua V (2019) An immersive environment for experiential training and remote control in hazardous industrial tasks. Advances in Intelligent Systems and Computing 795:88–97. https://doi.org/10.1007/978-3-319-94619-1_9

[8] Zhang M, Zhang M, Zhang Z, et al (2018) Recent Developments in Game-Based Virtual Reality Educational Laboratories... International Journal of Emerging Technologies in Learning (iJET) 13:138–159. https://doi.org/10.3991/ijet.v13i01.7773

[9] Radianti J, Majchrzak TA, Fromm J, Wohlgenannt I (2020) A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Comput Educ 147:103778. https://doi.org/10.1016/j.compedu.2019.103778

[10] Ip HHS, Wong SWL, Chan DFY, et al (2024) Enhance affective expression and social reciprocity for children with autism spectrum disorder: using virtual reality headsets at schools. Interactive Learning Environments 32:1012–1035. https://doi.org/10.1080/10494820.2022.2107681

[11] Blazauskas T, Maskeliunas R, Bartkute R, et al (2017) Virtual reality in education: New ways to learn. Communications in Computer and Information Science 756:457–465. https://doi.org/10.1007/978-3-319-67642-5_38

[12] Coburn JQ, Freeman I, Salmon JL (2017) A Review of the Capabilities of Current Low-Cost Virtual Reality Technology and Its Potential to Enhance the Design Process. J Comput Inf Sci Eng 17:. https://doi.org/10.1115/1.4036921

[13] Saredakis D, Szpak A, Birckhead B, et al (2020) Factors associated with virtual reality sickness in head-mounted displays: A systematic review and meta-analysis. Front Hum Neurosci 14:512264. https://doi.org/10.3389/fnhum.2020.00096

[14] Caserman P, Garcia-Agundez A, Gámez Zerban A, Göbel S (2021) Cybersickness in current-generation virtual reality head-mounted displays: systematic review and outlook. Virtual Reality 2021 25:4 25:1153–1170. https://doi.org/10.1007/s10055-021-00513-6

[15] Abbas JR, O'Connor A, Ganapathy E, et al (2023) What is Virtual Reality? A healthcare-focused systematic review of definitions. Health Policy Technol 12:100741. https://doi.org/10.1016/j.hlpt.2023.100741

[16] Sherman WR, Craig AB (2018) Understanding Virtual Reality: Interface, Application, and Design, Second Edition. Understanding Virtual Reality: Interface, Application, and Design, Second Edition 1–908. https://doi.org/10.1016/C2013-0-18583-2

[17] Asril Z, Syafril S, Raden Intan Lampung Jl Letnan Kolonel Jl Endro Suratmin Sukarame Bandar Lampung NH, et al (2023) Advancing Educational Practices: Implementation and Impact of Virtual Reality in Islamic Religious Education. Jurnal Pendidikan Islam 9:199–210. https://doi.org/10.15575/jpi.v9i2.20567

[18] Fikria A, Rafsanjanie FH (2025) Exploring Virtual Reality in Pre-Hajj Training to Deepen Pilgrims' Sense of Spiritual Understanding. Munazzama: Journal of Islamic Management and Pilgrimage 5:21–37. https://doi.org/10.21580/mz.v5i1.25150

[19] Bizami NA, Tasir Z, Kew SN (2022) Innovative pedagogical principles and technological tools capabilities for immersive blended learning: a systematic literature review. Education and Information Technologies 2022 28:2 28:1373–1425. https://doi.org/10.1007/s10639-022-11243-w

[20] Zhao Y, Li Y, Dai T, et al (2025) Virtual reality in heritage education for enhanced learning experience: a mini-review and design considerations. Front Virtual Real 6:1560594. https://doi.org/10.3389/frvir.2025.1560594

[21] Kaswan KS, Dhatterwal JS, Ojha RP (2024) AI in personalized learning. Advances in Technological Innovations in Higher Education: Theory and Practices 103–117. https://doi.org/10.1201/9781003376699-9

[22] Liu R, Wang L, Koszalka TA, Wan K (2022) Effects of immersive virtual reality classrooms on students' academic achievement, motivation and cognitive load in science lessons. J Comput Assist Learn 38:1422–1433. https://doi.org/10.1111/jcal.12688

[23] Hwang K, tom Dieck MC, Jung T, Kwon O (2024) The influence of virtual reality on the experience of religious cultural heritage content. Internet Research 34:1198–1218. https://doi.org/10.1108/INTR-08-2022-0669

[24] Rizal M, 1* R, Hasanah SM, et al (2025) Building Virtual Reality Hajj Journey Learning Media as a Simulation Tool for Teaching Hajj and Umrah Topics. Nadwa: Jurnal Pendidikan Islam 19:39–64. https://doi.org/10.21580/nw.2025.19.1.26704

[25] Selmanović E, Rizvic S, Harvey C, et al (2020) Improving Accessibility to Intangible Cultural Heritage Preservation Using Virtual Reality. Journal on Computing and Cultural Heritage 13:13. https://doi.org/10.1145/3377143

[26] Papakostas C (2025) Artificial Intelligence in Religious Education: Ethical, Pedagogical, and Theological Perspectives. Religions 2025, Vol 16, 16:. https://doi.org/10.3390/rel16050563

[27] Suh A, Prophet J (2018) The state of immersive technology research: A literature analysis. Comput Human Behav 86:77–90. https://doi.org/10.1016/j.chb.2018.04.019

[28] Wolf S, Nord I, Hurtienne J (2024) Exploring Virtual Reality for Religious Education in Real-World Settings. Proceedings - 2024 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops, VRW 2024 953–954. https://doi.org/10.1109/VRW62533.2024.00273

[29] Rambaree K, Nässén N, Holmberg J, Fransson G (2023) Enhancing Cultural Empathy in International Social Work Education through Virtual Reality. Education Sciences 2023, Vol 13, 13:. https://doi.org/10.3390/educsci13050507

[30] Mohamed KS (2023) Deep Learning for Spatial Computing: Augmented Reality and Metaverse "the Digital Universe." 131–150. https://doi.org/10.1007/978-3-031-35737-4_4

[31] Makransky G, Petersen GB (2021) The Cognitive Affective Model of Immersive Learning (CAMIL): a Theoretical Research-Based Model of Learning in Immersive Virtual Reality. Educational Psychology Review 2021 33:3 33:937–958. https://doi.org/10.1007/s10648-020-09586-2

[32] Ch'Ng E, Li Y, Cai S, Leow FT (2020) The effects of VR environments on the acceptance, experience, and expectations of cultural heritage learning. Journal on Computing and Cultural Heritage 13:. https://doi.org/10.1145/3352933

[33] Baker J, Nam K, Dutt CS (2023) A user experience perspective on heritage tourism in the metaverse: Empirical evidence and design dilemmas for VR. Information Technology & Tourism 2023 25:3 25:265–306. https://doi.org/10.1007/s40558-023-00256-x

[34] Guttentag DA (2010) Virtual reality: Applications and implications for tourism. Tour Manag 31:637–651. https://doi.org/10.1016/j.tourman.2009.07.003

[35] Fenu C, Pittarello F (2018) Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum. Int J Hum Comput Stud 114:20–35. https://doi.org/10.1016/j.ijhcs.2018.01.009

[36] Selmanovic E, Rizvic S, Harvey C, et al (2018) VR Video storytelling for intangible cultural heritage preservation. GCH 2018 - Eurographics Workshop on Graphics and Cultural Heritage 57–66. https://doi.org/10.2312/gch.20181341

[37] Cantoni V, Dondi P, Lombardi L, et al (2018) A Multi-Sensory Approach to Cultural Heritage: The Battle of Pavia Exhibition. IOP Conf Ser Mater Sci Eng 364:012039. https://doi.org/10.1088/1757-899X/364/1/012039

[38] Slater M (2018) Immersion and the illusion of presence in virtual reality. British Journal of Psychology 109:431–433. https://doi.org/10.1111/bjop.12305

[39] Hussein ZA, Al Ali SSM (2025) Augmented reality as a tool for improving perception of authenticity of the built heritage site. Journal of Cultural Heritage Management and Sustainable Development. https://doi.org/10.1108/JCHMSD-01-2024-0016

[40] Roman N (2024) THE ROLE OF DIGITAL TECHNOLOGIES IN PRESERVING CULTURAL HERITAGE. Cold Science

[41] Slater M, Sanchez-Vives M V. (2016) Enhancing our lives with immersive virtual reality. Frontiers Robotics AI 3:. https://doi.org/10.3389/frobt.2016.00074

[42] Bekele MK, Pierdicca R, Frontoni E, et al (2018) A survey of augmented, virtual, and mixed reality for cultural heritage. Journal on Computing and Cultural Heritage 11:. https://doi.org/10.1145/3145534

[43] Kiourt C, Koutsoudis A, Pavlidis G (2016) DynaMus: A fully dynamic 3D virtual museum framework. J Cult Herit 22:984–991. https://doi.org/10.1016/j.culher.2016.06.007

[44] Buhalis D, Leung D, Lin M (2023) Metaverse as a disruptive technology revolutionising tourism management and marketing. Tour Manag 97:. https://doi.org/10.1016/j.tourman.2023.104724

[45] Caneparo L (2001) Shared virtual reality for design and management: The Porta Susa project. Autom Constr 10:217–228. https://doi.org/10.1016/S0926-5805(99)00032-1

[46] Kang H (2020) Impact of VR on impulsive desire for a destination. Journal of Hospitality and Tourism Management 42:244–255. https://doi.org/10.1016/j.jhtm.2020.02.003

[47] Tussyadiah IP, Wang D, Jung TH, tom Dieck MC (2018) Virtual reality, presence, and attitude change: Empirical evidence from tourism. Tour Manag 66:140–154. https://doi.org/10.1016/j.tourman.2017.12.003

[48] Li Q, Liu Q, Jiang M, Wang R (2024) Virtual reality as a bridge: enhancing intercultural learning and communication skills among international students. International Communication of Chinese Culture 2024 11:3 11:385–411. https://doi.org/10.1007/s40636-024-00297-9

[49] Madani A, Watanabe Y, Vassiliou MC, et al (2015) Long-term knowledge retention following simulation-based training for electrosurgical safety: 1-year follow-up of a randomized controlled trial. Surgical Endoscopy 2015 30:3 30:1156–1163. https://doi.org/10.1007/s00464-015-4320-9

[50] De Ascaniis S, Adukaite A, Cantoni L, et al (2018) Pilgrims in the Digital Age: a research manifesto. INTERNATIONAL JOURNAL OF RELIGIOUS TOURISM AND PILGRIMAGE 4:1–5. https://doi.org/10.21427/D7Z120

[51] Mugo AM, Nyaga MN, Ndwiga ZN, Atitwa EB (2024) Evaluating learning outcomes of Christian religious education learners: A comparison of constructive simulation and conventional method. Heliyon 10:e32632. https://doi.org/10.1016/j.heliyon.2024.e32632

[52] Leal Filho W, Raath S, Lazzarini B, et al (2018) The role of transformation in learning and education for sustainability. J Clean Prod 199:286–295. https://doi.org/10.1016/j.jclepro.2018.07.017

[53] Cheong R (1995) The virtual threat to travel and tourism. Tour Manag 16:417–422. https://doi.org/10.1016/0261-5177(95)00049-T

[54] Kim MJ, Lee CK, Jung T (2020) Exploring Consumer Behavior in Virtual Reality Tourism Using an Extended Stimulus-Organism-Response Model. J Travel Res 59:69–89. https://doi.org/10.1177/0047287518818915

[55] Cranmer EE, tom Dieck MC, Fountoulaki P (2020) Exploring the value of augmented reality for tourism. Tour Manag Perspect 35:. https://doi.org/10.1016/j.tmp.2020.100672

[56] Shen S, Xu K, Sotiriadis M, Wang Y (2022) Exploring the factors influencing the adoption and usage of Augmented Reality and Virtual Reality applications in tourism education within the context of COVID-19 pandemic. J Hosp Leis Sport Tour Educ 30:. https://doi.org/10.1016/j.jhlste.2022.100373

[57] tom Dieck MC, Jung TH (2017) Value of augmented reality at cultural heritage sites: A stakeholder approach. Journal of Destination Marketing and Management 6:110–117. https://doi.org/10.1016/j.jdmm.2017.03.002

[58] Flavián C, Ibáñez-Sánchez S, Orús C (2019) The impact of virtual, augmented and mixed reality technologies on the customer experience. J Bus Res 100:547–560. https://doi.org/10.1016/j.jbusres.2018.10.050