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A CTML-Guided Virtual Reality Framework for Conceptual Learning in Islamic Civilization History

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Abstract

Developing meaningful conceptual understanding in history education requires more than immersive visualization; it demands instructional designs that effectively manage learners' cognitive processes. However, most virtual reality (VR) applications in history education emphasize sensory immersion while providing limited cognitive guidance. This study developed and validated a CTML-guided virtual reality learning framework for teaching Islamic Civilization History to junior secondary students. Using the ADDIE research and development model, the VR environment was designed by integrating five principles of the Cognitive Theory of Multimedia Learning (CTML): pre-training, segmentation, signaling, modality, and coherence. The learning environment features four interconnected historical scenes, interactive three-dimensional objects, audio narration, informative hotspots, and generative microtasks that encourage active conceptual processing. Expert evaluation confirmed the framework's high pedagogical and technical feasibility, while student trials demonstrated positive usability, engagement, and perceived learning value following iterative refinements. The findings suggest that integrating CTML principles into immersive environments can transform virtual reality from a technology-centered experience into a cognitively guided learning environment that supports conceptual understanding. This study contributes a practical instructional framework for designing theory-driven virtual reality learning environments in history and other conceptually demanding disciplines.

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INTRODUCTION

Studying the history of Islamic civilization in Islamic religious education requires conceptual understanding (Amaly et al., 2023; Amirudin et al., 2025). Conceptual understanding enables students to construct meaningful connections between the development of science, spiritual values, social structures, and the intellectual heritage of Islam within a unified framework that can be transferred to new contexts (Ahmed & Chowdhury, 2025; Baihaqi et al., 2025; Carrasco et al., 2021; Mirza, 2024). The difference between memorization and conceptual understanding is cognitive, not merely quantitative. Memorization involves retrieving information from long-term memory without establishing relationships between concepts, while conceptual understanding requires processes of elaboration, organization, and integration that produce a coherent cognitive schema that can be used flexibly in new situations (Elhilal, 2025; Liu et al., 2023; Mayer, 2024). In this framework, the history

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of Islamic civilization encompasses the ability to explain why Baghdad developed into a global intellectual center, how the Bait al-Hikmah institution facilitated the transmission of knowledge across civilizations, and the relationship between Islamic values and the scholarly tradition that flourished during the Abbasid period (Arnica et al., 2023). This ability is the core objective of Islamic religious education as outlined in the curriculum, as well as the foundation for students to internalize the legacy of Islamic civilization as part of their identity and value system (Muis, 2026).

In reality, the teaching of Islamic civilization history at the junior high school level is still far from achieving that goal. History instruction is oriented toward an expository approach, resulting in a flawed learning pattern where students merely memorize the names of figures and the sequence of events without being able to explain the underlying cause-and-effect relationships or the dynamics of the civilization (Amaly et al., 2023; Amirudin et al., 2025). This failure stems from a mismatch between the cognitive demands of the subject matter and the capacity of the available teaching materials, as conceptual understanding of the History of Islamic Civilization requires students to select relevant information from complex narratives, organize that information into a framework that illustrates causal and temporal relationships between events, and integrate that framework with their prior knowledge and values (Luft et al., 2022; Mayer, 2024; Thohir & Septiadi, 2025). The spatial context and experiences necessary for this integration are not provided by text-based media and lectures, especially when students are asked to imagine Baghdad, Bait al-Hikmah, and the network of Islamic scholars as realities that once existed, rather than mere narrative abstractions. Virtual reality possesses several architectural advantages that other media lack because it immerses students in a reconstructible historical environment, thereby providing the spatial context necessary for conceptual understanding (Bizami et al., 2023; Faqih et al., 2023; Li et al., 2025).

Virtual reality has been recognized as a technology that overcomes the limitations of traditional media in history education (Ahmad & Prasetyo, 2023; Bujang et al., 2025; Pathak et al., 2025). Virtual reality allows users to experience visiting reconstructions of historical sites, observe artifacts in their spatial context, and gain an understanding of civilizations that cannot be achieved through any two-dimensional medium (Christopoulos et al., 2024; Corrales et al., 2024; De Paolis et al., 2022; Forsyth, 2023). Various studies have found that virtual reality can enhance students' emotional engagement, sense of presence, and positive attitudes toward historical material. However, this richness of sensory experience is accompanied by significant instructional limitations, while immersive virtual reality can effectively reduce cognitive engagement despite high levels of emotional stimulation (Parong & Mayer, 2021), historical narratives in virtual reality generally lack a causal reasoning structure, so students tend to focus on visual exploration rather than learning the relationships between events (Barbara & Haahr, 2023), and virtual reality does not foster conceptual understanding without explicit instructional design, regardless of its visual quality (Li et al., 2025; Villena-Taranilla & Diago, 2025). Virtual reality, designed as a simple virtual tour, constitutes a misuse of its potential, as immersion is viewed solely from a sensory perspective rather than as a cognitively productive experience.

The Cognitive Theory of Multimedia Learning (CTML) offers a design framework that directly addresses these instructional weaknesses. CTML provides five operational principles for managing cognitive load in multimedia environments: pre-training, segmentation, signaling, modality, and coherence (Clark & Mayer, 2016). Collectively, these principles help learners manage cognitive load by activating prior knowledge, organizing information into manageable segments, directing attention to relevant elements, distributing processing across visual and auditory channels, and eliminating unnecessary information. Although each principle has been strongly validated individually (Fiorella & Mayer, 2016; Makransky & Petersen, 2021; Sweller et al., 2019). Although each CTML principle has been validated individually, existing historical virtual reality studies generally implement only one or two principles, such as visual cleansing or audio narration, without integrating pre-training, segmentation, and signaling into a complete instructional framework (Rojas, 2023; Villena-Taranilla & Diago, 2025). Consequently, virtual reality research in history continues to emphasize sensory immersion rather than cognitively guided learning, and no previous study has operationally integrated all five CTML principles into a single virtual reality design for the History of Islamic Civilization.

Several previous studies have explored the application of CTML principles in the development of VR media across various domains, such as the decomposition of organic materials (Porte et al., 2026), higher-order thinking skills in electronic circuits (Wang et al., 2026), physical education (Mokmin & Ridzuan, 2022), audiovisual media (Nirbita, 2026), 360-degree virtual reality (Bhagat et al., 2025), and virtual reality-based serious games (Rodriguez-Garcia et al., 2024). These studies demonstrate that CTML is not merely relevant to virtual reality; rather, CTML is the distinguishing factor that sets virtual reality capable of facilitating learning apart from virtual reality that merely provides an experience. However, all of these studies operate within the domains of science, technology, and physical education.

To address this gap, this study develops and validates a Virtual Reality-based learning medium grounded in the principles of the Cognitive Theory of Multimedia Learning (CTML) by simultaneously implementing all five CTML principles within a single instructional architecture for teaching the Abbasid Dynasty at the junior secondary school level. This study contributes to the literature by proposing an integrated CTML-based virtual reality design for the History of Islamic Civilization and providing a framework that can be adapted to other history and cultural learning contexts.

METHOD

This study employed a Research and Development (R&D) approach using the ADDIE framework (Analyze, Design, Develop, Implement, and Evaluate). The ADDIE model was selected because it provides a systematic and iterative framework for developing and evaluating educational products while ensuring alignment among learning objectives, instructional strategies, media features, and evaluation procedures (Rahmawati et al., 2022). During the analysis and design phases, the evaluation model proposed by Pantelidis (1997) was integrated to assess the suitability of Virtual Reality (VR) as an instructional medium based on learning objectives, realism requirements, immersion levels, and user interaction characteristics. Following the selection of VR as the primary medium, the visual and auditory elements of the virtual environment were designed in accordance with the principles of the Cognitive Theory of Multimedia Learning (Clark & Mayer, 2016). The sequence of stages and evaluative interactions that guided the development process is illustrated in Figure 1.

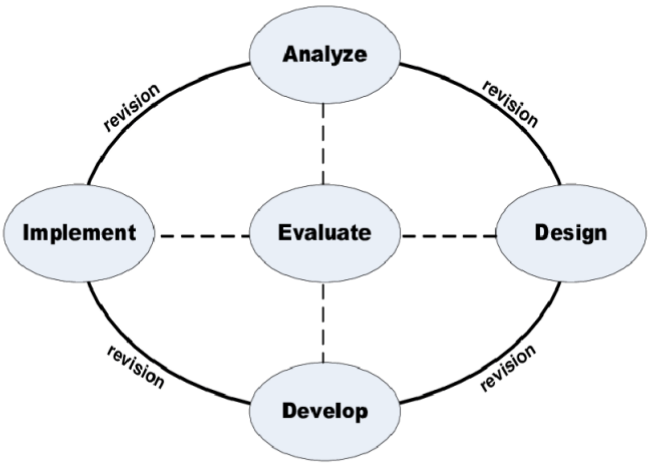

Figure 1. The ADDIE-Based Research and Development Model

Analysis

This process was carried out to determine instructional needs, learner characteristics, curricular requirements, technological readiness, and the viability of adopting VR for teaching Islamic Civilization History. The process comprised a literature review, classroom observations, semi-structured interviews with Islamic Religious Education teachers at SMPIT LHI Yogyakarta, and curriculum document analysis to determine instructional needs, learner characteristics, technological readiness, and the viability of adopting VR for teaching Islamic Civilization History.

Five aspects were analyzed: learner needs, curriculum alignment, learner characteristics, technology accessibility, and VR feasibility based on Pantelidis (1997) criteria, including realism requirements, immersion potential, spatial representation needs, and interaction characteristics. The findings informed the subsequent design phase.

Design

During the design process, the specifications established in the analysis phase were translated into an instruction blueprint and interaction architecture. The design of the VR environment concentrated on the creation of spatial storyboards and the navigation process of users based on the objectives of learning. In order to reduce any unnecessary cognitive load associated with the interaction and immersion in the virtual environment, the architecture of the visual and auditory information was meticulously designed using the principles of the Cognitive Theory of Multimedia Learning. The mapping between the CTML principles and their application in the design of the VR environment is provided in Table 1.

Table 1. Integration of CTML Principles in VR Environment Design

CTML Principle	VR Prototype Design	Description
Pre Training	Participants are provided with asynchronous pre-learning modules (PDF documents) containing basic anatomical nomenclature and characteristics prior to immersion in the VR environment.	This approach activates prior knowledge, which significantly reduces intrinsic cognitive load. As a result, when engaging with complex VR content, users can allocate their cognitive capacity to understanding spatial relationships rather than memorizing object names.
Segmenting	The simulation is divided into multiple scenes or checkpoints. Transitions between materials or scenes are controlled by user interaction (e.g., pressing "Next" or teleporting).	This enables learner-paced control, allowing users sufficient time to process one concept before moving to the next segment.
Signaling	The use of visual cues such as glowing or highlighting outlines, color changes, and directional arrows to emphasize specific objects or areas currently being explained.	This directs users' selective attention within a broad 360-degree VR environment toward essential elements that need to be processed.
Modality	Complex and lengthy conceptual explanations are delivered through audio narration, fully replacing long floating text descriptions.	This reduces cognitive overload in the visual channel, allowing users to focus on processing geometry, depth, and object movement within the 3D environment.
Coherence	Removal of irrelevant background elements, distracting background music, and unnecessary visual effects that do not contribute to instructional value.	This minimizes extraneous cognitive load by ensuring that users' attention remains focused on the core material and avoids distraction from seductive details.

Development

The development stage required the conversion of the instructional design to a viable Virtual Reality learning prototype. Informed by the results of the analysis stage, the prototype design was intended to meet the needs of students for realistic visualization of historical topics, exploratory learning, and interaction capabilities that would be easy enough for novice users to use. The Virtual Reality application was designed using Delightex (CoSpaces Edu), allowing incorporation of three-dimensional objects, interactive hotspots, audio narration, animations, and scene-based navigation.

The development stage involved four major activities. Firstly, virtual scenes illustrating various features of the Abbasid civilization were created, including historical scenes, learning environments for scholars, and learning objects consistent with the instructional goals. Secondly, audio-visual learning materials were created, including narration script, illustrative materials, informative hotspots, and generative learning tasks in accordance with the Cognitive Theory of

Multimedia Learning. Thirdly, interaction capabilities were designed using eye-gaze navigation and object selection as the minimal movement requirements for learners to interact with the virtual environment. Lastly, internal functional testing of navigation, hotspots, audio synchronization, and scene transition was done before expert validation. Following the development process, the prototype was validated by one subject matter expert and one media expert before proceeding to the implementation phase. The subject matter expert evaluated content accuracy, curriculum alignment, and content integration, whereas the media expert assessed interface design, usability, interactivity, immersion, and the implementation of Cognitive Theory of Multimedia Learning principles. Feedback obtained during the validation process was used to refine the prototype before implementation.

Implementation

Implementation was performed following the declaration by the subject matter expert and media expert regarding the viability of the Virtual Reality learning media. Testing was done in two phases to create increasingly comprehensive data before actual classroom implementation. The first phase included a small test run using six students in class VII A. This was used as the initial phase of usability testing in order to discover problems that might not have been discovered during expert validation testing. The second phase involved deploying the learning media to an entire class of 15 students in order to generate comprehensive data about student reactions and experiences. This two-phase approach follows the ADDIE method of formative evaluation, whereby evidence generated during one phase is used to improve the medium, which is then subjected to further testing at the next larger-scale phase.

Evaluation

The evaluation phase employed formative evaluation throughout the development process to ensure that the Virtual Reality learning media met both pedagogical and technical requirements (Auliya et al., 2025). Evaluation consisted of expert validation followed by limited and larger-scale student trials. Feedback obtained from experts and students was used iteratively to refine the prototype before the final implementation.

Sampel

The study involved 15 seventh-grade male students from Class VII A at SMPIT LHI Yogyakarta, selected through purposive sampling because the school offered the relevant Islamic Religious Education content and had adequate facilities for VR implementation. A limited trial involving six students was conducted before the larger-scale trial with all 15 students to refine the developed media before full implementation.

Research Instruments

This study employed non-test instruments consisting of observation sheets, interview guidelines, expert validation sheets, and student response questionnaires. The instruments were developed based on the Cognitive Theory of Multimedia Learning (Clark & Mayer, 2016). and the Pantelidis (1997) VR instructional design criteria, covering content quality, CTML implementation, interface design, usability, interactivity, immersion, and student responses. The subject matter expert validation instrument consisted of 17 items distributed across three aspects: material feasibility (7 items), alignment with Cognitive Theory of Multimedia Learning principles (6 items), and integration of learning content within the Virtual Reality environment (4 items). The media expert validation instrument also consisted of 17 items covering interface design (4 items), media usefulness (4 items), implementation of Cognitive Theory of Multimedia Learning principles (6 items), and interactivity and immersion (3 items).

Student responses were collected using a questionnaire consisting of 19 items distributed across three dimensions: usability (6 items), learning and usefulness (8 items), and emotions (5 items). Expert validation instruments employed a four-point rating scale ranging from 1 (very poor) to 4 (very good), while the student response questionnaire used a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). All instruments underwent expert content validation before data collection, and the resulting feedback was used to refine the indicators (Supurwoko et al., 2025). The reliability of the student response questionnaire was assessed using Cronbach's Alpha.

The analysis yielded a coefficient of 0.856, indicating good internal consistency and demonstrating that the instrument was sufficiently reliable for collecting students' responses toward the developed Virtual Reality learning media.

Data Collection Procedures

Data were gathered during the process of designing and implementing the Virtual Reality learning media. In the stage of analysis, the data were gathered from classroom observation, interviews, and curricular document analysis to determine the need for instruction, learner characteristics, technical readiness, and content. In the stage of development, the data were gathered through validation by experts via subject matter and media evaluation instruments. In the stage of implementation, data regarding the reaction of students to the use of the Virtual Reality learning media were gathered via questionnaires.

Data Analysis

Data analysis was conducted using both quantitative and qualitative descriptive techniques. Quantitative data were obtained from the subject matter expert validation sheets, media expert validation sheets, and student response questionnaires. These data were analyzed by calculating the percentage scores for each assessment aspect to determine the feasibility and practicality of the developed Virtual Reality learning media. Qualitative data were obtained from observations, interviews, and written comments provided by the validators during the evaluation process. These data were analyzed descriptively by identifying suggestions, criticisms, and recommendations for improvement. The findings from the qualitative analysis were used to support the interpretation of the quantitative results and to guide revisions of the developed product. The collected data were analyzed using a Likert scale. The percentage of feasibility was calculated using the following formula (Sugiyono, 2021)

$$P = \frac{\sum x}{SMI} X\ 100\%$$

Description:
P = Percentage
∑x = Total Score
SM = Maximum Score

Furthermore, the overall percentage was calculated using the following formula (Walizer & Wienir, 1987)

$$P = \frac{F}{N}$$

Description:
F = frequency
N = total respondents
P = Percentage

Subsequently, the percentage scores were categorized based on the evaluation criteria presented in Table 2 (Walizer & Wienir, 1987)

Table 2. Interpretation of Score Scale

Interval	Criteria
$0 < x \leq 20\%$	Very Inadequate
$20\% < x \leq 40\%$	Inadequate
$40\% < x \leq 60\%$	Moderately Adequate
$60\% < x \leq 80\%$	Adequate
$80\% < x \leq 100\%$	Highly Adequate

RESULTS AND DISCUSSION

In this chapter, the research findings from the entire process of Virtual Reality learning media development and evaluation will be presented. The findings are arranged in accordance with the stages of development, which include needs analysis, media development, validation by experts, and trials conducted by students. Further, the findings will be analyzed in terms of the cognitive theory of multimedia learning and research on Virtual Reality-supported learning.

Results of the Needs Analysis

Needs analysis pointed out a number of problems related to teaching the History of Islamic Civilization in SMPIT LHI Yogyakarta. Observations and interviews demonstrated that students faced problems in comprehending historical contexts while studying using only verbal instruction and reading from textbooks. Moreover, teachers claimed that the level of interest was higher in cases when students participated in exploratory and visual exercises.

Analysis of the needs also demonstrated that most students had preferences for audiovisual and interactive exercises. Moreover, students did not have much experience working with Virtual Reality technology, which implies the necessity to provide simple methods of navigation and interactions within the program. Analysis of technology accessibility showed that the school had sufficient access to the Internet and mobile devices suitable for Virtual Reality implementation.

Based on the feasibility criteria proposed by Pantelidis (1997), the topic of Abbasid civilization was considered suitable for Virtual Reality implementation because it requires spatial visualization, contextual representation of historical environments, and exploratory learning experiences. These findings informed the design decisions adopted during the development of the Virtual Reality learning media.

Development of the Virtual Reality Learning Media

On the basis of results obtained during the needs analysis, the Virtual Reality learning medium was designed and created in order to facilitate the learning process of the History of Islamic Civilization, focusing on the topic of the Abbasid Dynasty. This development followed the guidelines of the Cognitive Theory of Multimedia Learning and was carried out through the use of Delightex (CoSpaces Edu).

The final medium consists of four learning scenes that are connected. Those scenes include: Historical Portal, The Rise of Glory, The Zenith of Knowledge, and Civilizational Wisdom. They are arranged in a certain sequence in order to facilitate the exploration of historical material and the segmentation of information. The overall structure of learning in the Virtual Reality medium is depicted in Figure 2.

Figure 2. Segmentation of Virtual Reality Learning Content

Figure 2 demonstrates the division of learning content into four consecutive scenes. The above arrangement was created for gradual knowledge construction and to lessen the mental load related to handling complicated historical data in one learning session. For preparing students for entering the learning environment, a pre-training scene was created to teach navigation and interaction techniques. The implementation of the pre-training feature is presented in Figure 3.

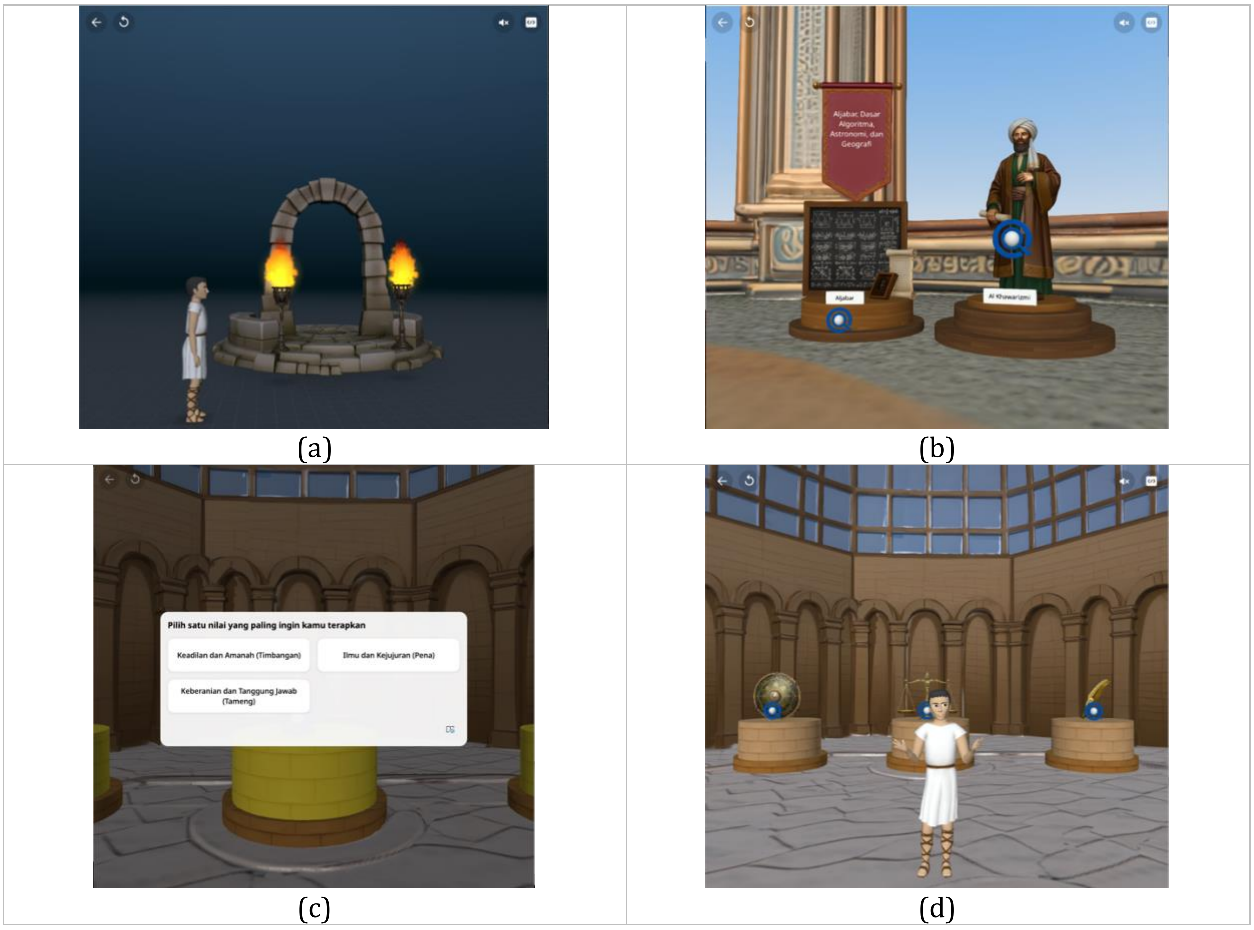

Figure 3. Key Instructional Features of the Developed Virtual Reality Learning Environment (a) Pre-Training Room (b) Signaling in the Scholars' Hall (c) Generative Micro-Task (d) Gaze-Based Selection

Figure 3 presents the implementation of the main CTML principles and interaction features in the developed Virtual Reality learning environment. Figure 3(a) illustrates the pre-training room, where students practiced basic navigation skills, including looking around, moving, teleporting, and interacting with virtual objects, before entering the learning activities. This environment was intentionally designed with minimal distractions to familiarize students with the Virtual Reality interface. Figure 3(b) shows the implementation of the signaling principle through visual cues, highlighted objects, and information hotspots that directed students' attention to key historical concepts and artifacts. Figure 3(c) presents a generative micro-task designed to encourage students to connect historical information with personal interpretation and meaning-making, thereby promoting active engagement during learning. Finally, Figure 3(d) illustrates the gaze-based selection mechanism, which enabled students to interact with virtual learning objects using eye gaze and controller confirmation, simplifying navigation and improving usability for learners with limited prior experience with Virtual Reality technology.

Feasibility of Cognitive Design–Based Virtual Reality Learning Media

The feasibility of the cognitive design-based virtual reality learning media was evaluated using expert validation conducted on both the subject matter expert and media expert. The aspect of subject matter experts included content appropriateness, content alignment with the CTML approach, and content integration, while the media expert focused on interface design, usability, interactivity, immersion, and content alignment with the CTML approach. The findings of the expert validation test are shown in Table 3 and show that the level of feasibility is highly feasible, with percentages ranging between 92% and 100%.

Table 3. Feasibility of Virtual Reality Learning Media

Validation	Aspect	Percentage	Mean	Category
Content	Content Feasibility	100%	100%	Highly Feasible
	Alignment with CTML Principle	100%		
	Content Integration	100%		
Media	Interface Design	94%	94%	Highly Feasible
	Usability	100%		
	Implementation of CTML	92%		
	Interaktivity dan Immersion	100%		

From the findings of the expert validation process, it is clear that the developed virtual reality learning media attained the highest level of feasibility in all the evaluated areas. The subject matter expert rated the virtual reality media a score of 100 percent in terms of content feasibility, consistency with the principles of Cognitive Theory of Multimedia Learning, and content integration. On its part, the media expert gave an overall score of 94 percent for feasibility, meaning that the media achieved the required standard for feasibility in terms of interface, usability, interactivity, immersion, and principles of Cognitive Theory of Multimedia Learning.

Apart from the scores given in rating the virtual reality media, some of the recommendations given by the validators included making improvements in terms of consistency in the use of visuals and content across the learning scenes. The media expert, on its part, suggested that improvements be made in the area of visibility and consistency of the signaling elements. This was done before implementing the virtual reality media. The results of both the pilot and full-scale testing are shown in Table 4.

Table 4. Results of the Small-Scale Trial

Rated Aspects	Validy Results (%)	Explanation
Ease of Use	73%	Good
Learning and Usefulness	61%	Good
Emotion	80%	Excellent
Mean	76%	Good

Most of the learners had a positive response to the VR learning media designed through the small-scale trial process. However, some of the learners faced challenges when trying to find out interactive hotspots and how the navigation works during the initial stages of use. Other learners required more assistance while moving from one learning scene to another. After collecting the results from the small-scale trial process, the following changes were made before the large-scale trial process. The changes included making the visual aids more visible, ensuring that the indicators of hotspots are consistent, and giving more navigation instructions for the VR learning media. The results of the large-scale trial process are shown in Table 5.

Table 5. Results of the Large-Scale Trial

Rated Aspects	Validity Results (%)	Expanation
Ease of Use	76%	Good
Learning and Usefulness	89%	Good
Emotion	78%	Excellent
Mean	82%	Excellent

The findings from the larger-scale trial reveal that there was an enhancement in the level of response from the students. Specifically, there was an improvement from the mean of 76% to 82%. In particular, the most significant improvement was seen in the learning and usefulness dimension, where there was an increase from 61% to 89%. This can be attributed to the changes made based on the small-scale trial, especially regarding navigation and consistent signaling. In general, the findings have revealed that the virtual reality learning media that have been developed are easy to use and have been accepted by the users. In addition, the findings reveal that the media is appropriate for use in the classroom. It is important to note that these findings do not provide any information about the level of conceptual understanding because this has not been assessed in the study.

Expert Validation Findings

As per the outcomes of the expert validation test, it can be stated that the Virtual Reality learning media created have obtained the highly feasible category in all aspects. This is because the subject matter expert gave a score of 100%, while the media expert scored it 94% in total. Thus, it can be deduced from the above results that the created media has succeeded in integrating history content with instructional objectives along with the principles of Cognitive Theory of Multimedia Learning into the VR learning context.

The design of the Virtual Reality environment was informed by the findings of the needs analysis and guided by established multimedia learning principles, including pre-training, signaling, and segmentation. These findings are consistent with previous studies reporting that Virtual Reality environments grounded in clear instructional design frameworks tend to achieve higher pedagogical quality and expert acceptance than environments emphasizing immersion alone (Christopoulos et al., 2024).

Student Trial Findings

The results of the small-scale and large-scale student trials show that the Virtual Reality Learning Media is seen as easy-to-use and interesting, as demonstrated by the rise in the response score average from 76% in the small-scale trial to 82% in the large-scale trial. The changes were particularly noticeable in the dimension of learning and usefulness, which rose from 61% to 89% after making changes in the navigation and signal.

This finding supports previous studies indicating that clear navigation structures and guided interaction mechanisms are essential for novice Virtual Reality users (Makransky & Petersen, 2021; Parong & Mayer, 2021). In the present study, the inclusion of a pre-training scene and improved signaling elements may have helped students become more familiar with the Virtual Reality environment before engaging with the learning content.

Contribution of CTML-Based Virtual Reality Design

The implementation of pre-training was found to play a crucial role in minimizing students' motoric cognitive load. During the trial, students were able to navigate the VR environment more stably after completing the orientation scene, which included practice in looking around, moving, teleporting, and using gaze-based selection.

This finding is consistent with Parong and Mayer, who found that VR users without initial orientation tend to experience extraneous cognitive load, as they expend mental effort learning how to operate the system rather than processing the learning content (Parong & Mayer, 2021). In the context of junior high school, navigation readiness plays a crucial role in determining the quality of exploration. As noted by Kobir et al. (2023), a lack of understanding of VR controls is a key factor contributing to learning failure among novice students. In this study, the pre-training scene was designed with minimal distractions, allowing students to build confidence and cognitive readiness before engaging with more information-dense historical content. This approach is also aligned with Makransky, who emphasizes the importance of an orientation phase in reducing user anxiety and enhancing engagement from the outset (Makransky & Petersen, 2021).

The segmented scene structure, consisting of the Historical Portal, The Rise of Glory, The Zenith of Knowledge, and Civilizational Wisdom, helps students process historical content gradually and systematically. Segmenting, as one of the core principles of CTML, functions to break down complex content into manageable units, which theoretically supports information processing within working memory (Clark & Mayer, 2016). The segmentation of the Abbasid chronology into four stages enables students to connect historical events progressively rather than merely memorizing facts. This finding reinforces the report by Barbara and Haahr, who criticize that many VR history applications fail to guide users' cognitive flow, resulting in learning experiences that are limited to sightseeing without meaningful conceptual construction (Barbara & Haahr, 2023). In contrast, this study shows that thematically and chronologically grouping the scenes strengthens students' mental model of the rise and decline of the Abbasid Empire. The use of segmentation also supports the processes of selecting, organizing, and integrating as described in Fiorella and Mayer's generative learning theory. When complex information is broken down into smaller and structured units, students are able to organize these elements into coherent mental representations, thereby facilitating the development of deeper conceptual understanding (Fiorella & Mayer, 2016).

The use of signaling in the form of illuminated hotspots, highlighted key objects, and textual labels plays a significant role in guiding students' attention within the 3D environment. VR environments inherently carry the risk of presenting excessive visual detail, which may distract learners and cause them to lose focus on key concepts. Makransky & Petersen (2021) emphasize that attentional cueing is essential to prevent visual overload and to ensure that learners maintain focus on relevant information In this study, visual cues enabled students to more easily identify key scholars and historical artifacts, such as Al-Khwarizmi's contributions to algebra and the scholarly symbols found in Bayt al-Hikmah. During the trial, several students reported that the hotspots helped them "know what to look at." This finding supports Sweller's theory that signaling reduces extraneous cognitive load and enhances the processing of essential information (Sweller et al., 2019).

What distinguishes this VR media from many other history-based VR applications is the inclusion of generative micro-tasks designed to stimulate conceptual elaboration. Micro-tasks such as selecting civilizational values, identifying the roles of scholars, or evaluating cause–and–effect relationships encourage students to engage in generative processing. These activities are aligned with generative learning theory (Doctorow et al., 1978) and with the findings of Fiorella and Mayer, which indicate that deep understanding is achieved when learners generate new internal representations through the processes of selecting, organizing, and integrating information (Fiorella & Mayer, 2016). Corrales' study also indicates that VR environments that incorporate reflective tasks enhance students' affective engagement and improve the quality of their interpretation of historical events (Corrales et al., 2024). The findings of this study reveal a similar phenomenon, in which students are better able to relate historical concepts to life values because they not only observe the Abbasid civilization but also actively construct meaning from it.

From an interaction perspective, the use of gaze-based selection combined with controller input has been shown to enhance comfort and accessibility for junior high school students. Gaze functions as a targeting mechanism that reduces the need for complex motor coordination, while the controller is used only for confirmation. This approach is more intuitive than fully controller-based interaction, which tends to increase motoric load for novice users (Steed et al., 2016). In this study, students only need to direct their gaze at the hotspot and press a button on the controller, allowing their attention to remain focused on the historical content. This is consistent with Makransky's view that simplified VR interaction helps ensure that cognitive capacity remains directed toward the learning material (Makransky et al., 2019). Students' responses, which rated the ease-of-use aspect in the good category, indicate that this interaction design aligns well with their characteristics and level of technological readiness.

Educational Implications

The conclusions of the current research demonstrate that the educational potential of Virtual Reality technology is not limited exclusively to its immersive capacity; the success of the application of this technology will depend on how much of the instructional design is incorporated into the learning environment itself. Positive assessments of experts and students imply that the use of the Cognitive Theory of Multimedia Learning design principles in the development of VR experiences could help create more engaging and meaningful experiences.

The difference in results achieved in small-scale and large-scale trials proves once again the crucial role of instruction in an immersive learning environment. Such elements as pre-training, signaling, and reduced complexity of interactions seem to help students adapt to the use of Virtual Reality technology, allowing them to concentrate on their tasks rather than the technology. This implies that the successful application of VR technology depends on considerations regarding the learners' characteristics and their cognitive preparedness.

In relation to the sphere beyond the scope of this particular research, the conclusions made could help develop VR experiences for learning in such fields as history or abstract knowledge. The study also demonstrates how the Cognitive Theory of Multimedia Learning can be operationalized within immersive environments, offering a design reference for educators and developers seeking to balance technological innovation with instructional effectiveness.

LIMITATIONS

Despite the generally positive outcomes of this research, some limitations should be taken into account. First of all, the research was carried out in only one institution using a rather limited sample of participants. This is why the generalization of results should be done with care. At the same time, these limitations can become a reason for future research to conduct. Future research should use a larger sample size and a broader range of disciplines in order to get a better insight into the issue under discussion.

CONCLUSION

This study successfully developed and validated a CTML-guided Virtual Reality learning medium that was found to be valid and feasible for supporting conceptual understanding in the History of Islamic Civilization. Based on the study's results, the developed Virtual Reality media has proven itself to be feasible in terms of expert evaluation and has been well-received by the students during the small-scale and large-scale assessments. It can be seen that the inclusion of the instructional components, including pre-training, segmentation, signaling, generative learning, and simplified interactions, has facilitated the usability and acceptability of the developed media among the students.

These results show that not only is it possible to design a Virtual Reality learning environment to immerse learners in learning, but it is also possible to design it in such a way as to structure learning through the use of instructional design theories. This paper offers practical advice to educators and VR developers on how to incorporate the Cognitive Theory of Multimedia Learning in designing Virtual Reality learning environments. This especially applies to subject areas that require learning of historical, abstract, and spatially complex concepts. Future research in the field needs to include wider and more varied populations and experimental designs that would enable measurement of actual learning performance.

AUTHOR CONTRIBUTIONS

DH, MVAF, MAR, and JOL conducted the study design and article development. AW developed the storyline. All researchers read and approved the final draft of the article.

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