

Development of an Educational Game Exploring Indonesian Traditional Houses Based on Leap Motion for Elementary School Students

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Abstract

Indonesia is facing a cultural literacy crisis among younger generations, with traditional cultural knowledge, including architecture, increasingly disconnected from elementary students. Conventional learning media such as textbooks are limited in engaging students and fostering cultural understanding. Technological advancements, especially motion-based learning media, offer opportunities to deliver interactive cultural education. This study aims to develop an interactive educational game titled ArchiLeap: Leap Motion Educational Game Exploring the Traditional Houses of the Archipelago to introduce Indonesian traditional houses to elementary school students. The research focuses on the design and development stages, exploring how Leap Motion technology can enhance cultural learning and student motivation. The research employed a Research and Development (R&D) approach using the ADDIE model (Analyze, Design, Development, Implementation, Evaluation). The study emphasized the design and development phases, including needs analysis, storyboard creation, 3D modeling of traditional houses, and integration of Leap Motion for gesture-based interaction. Expert validation was conducted for media, language, and content feasibility. The developed ArchiLeap game includes interactive 3D simulations, audiovisual learning materials, quizzes, and technical documentation. Feasibility testing showed excellent ratings across media (86.9%), language (83.1%), and content (82.3%) aspects. Expert feedback led to refinements in interface interactivity, cultural contextualization, and instructional language. ArchiLeap is a valid and feasible culturally based interactive learning medium that leverages Leap Motion technology to enhance elementary students' engagement and understanding of Indonesian traditional houses. The integration of gesture-based interaction and culturally rich content supports embodied learning and cultural preservation. Further research is recommended to assess its impact on motivation and learning outcomes in broader implementation contexts.

Keywords: Educational Game, Elementary School Learning Media, Leap Motion, Traditional Indonesian Houses

Abstrak

Indonesia sedang menghadapi krisis literasi budaya di kalangan generasi muda, di mana pengetahuan budaya tradisional, termasuk arsitektur, semakin terputus dari siswa sekolah dasar. Media pembelajaran konvensional seperti buku teks memiliki keterbatasan dalam melibatkan siswa dan menumbuhkan pemahaman budaya. Kemajuan teknologi, terutama media pembelajaran berbasis gerakan, menawarkan peluang untuk menyajikan pendidikan budaya secara interaktif. Penelitian ini bertujuan untuk mengembangkan permainan edukatif interaktif berjudul ArchiLeap: Gim Edukasi Leap Motion Jelajah Rumah Adat Nusantara guna memperkenalkan rumah tradisional Indonesia kepada siswa sekolah dasar. Penelitian ini berfokus pada tahap desain dan pengembangan, dengan mengeksplorasi bagaimana teknologi Leap Motion dapat meningkatkan pembelajaran budaya dan motivasi siswa. Penelitian ini menggunakan pendekatan Penelitian dan Pengembangan (R&D) dengan menerapkan model ADDIE (Analisis, Desain, Pengembangan, Implementasi, Evaluasi). Studi ini menekankan pada fase desain dan pengembangan, termasuk analisis kebutuhan, pembuatan storyboard, pemodelan 3D rumah tradisional, serta integrasi Leap Motion untuk interaksi berbasis gerakan. Validasi oleh para ahli dilakukan untuk menilai kelayakan media, bahasa, dan konten. Permainan ArchiLeap yang dikembangkan mencakup simulasi 3D interaktif, materi pembelajaran audiovisual, kuis, dan dokumentasi teknis. Pengujian kelayakan menunjukkan peringkat yang sangat baik pada aspek media (86,9%), bahasa (83,1%), dan konten (82,3%). Masukan dari para ahli menghasilkan penyempurnaan pada interaktivitas antarmuka, kontekstualisasi budaya, dan bahasa instruksional. ArchiLeap merupakan media pembelajaran interaktif berbasis budaya yang valid dan layak, yang memanfaatkan teknologi Leap Motion untuk meningkatkan keterlibatan dan pemahaman siswa sekolah dasar terhadap rumah tradisional Indonesia. Integrasi interaksi berbasis gerakan dan konten yang kaya akan unsur budaya mendukung pembelajaran yang terintegrasi dengan pengalaman fisik serta pelestarian budaya. Disarankan untuk melakukan penelitian lebih lanjut guna mengevaluasi dampaknya terhadap motivasi dan hasil belajar dalam konteks implementasi yang lebih luas.

Kata Kunci: Permainan Edukasi, Media Pembelajaran Sekolah Dasar, Leap Motion, Rumah Tradisional Indonesia

Introduction

There are multidimensional issues currently affecting Indonesia, one of which is the fragility of national character, namely a cultural crisis related to moral values among the younger generation (Feroni et al., 2024). Our assumptions about local culture often conflict with the realities faced by today's youth (Suryatniani, 2019). Local culture is increasingly being eroded by the influence of foreign cultures, which are often not deeply understood and therefore pose a threat to the preservation of national identity. Traditional knowledge, or culture, is viewed as a valuable resource that can complement research and scientific understanding. A society's cultural wisdom is a collection of information and ways of thinking gathered through experience and education over generations, which they consider valid and use as a framework for daily life (Noor, 2020; Rahmat, 2018; Setiadi, 2019). However, today's younger generation is beginning to lose connection with these values, potentially leading to a long-term crisis of cultural identity.

To address this issue, strategic steps must be taken, particularly at the elementary education level. Knowledge of civic values and culture must be instilled in students from an early age. Children lay the foundation for their knowledge and worldview during the early years of formal schooling. This is why elementary school plays a critical role in embedding political and cultural literacy in students from a young age. A culturally literate individual has a deep understanding of how various human communities pass down their languages,

beliefs, practices, culinary traditions, artistic expressions, and daily routines from generation to generation (Putri & Nurhasanah, 2023). People with this understanding are better equipped to recognize and appreciate the cultural diversity in their surroundings. The aim of teaching children about other cultures and encouraging them to become active citizens is to help them adapt to an increasingly diverse and globalized world. A previous study by Julianto dalam Lestari & Ramadan (2023) showed that a digital society characterized by tolerance, patience, and a habit of sharing can be formed by instilling the principles of unity in diversity.

In developing cultural literacy, technology can be utilized to educate and raise awareness about traditional houses in Indonesia. By leveraging modern technology, it becomes a promising idea to create educational resources that introduce students to the richness of Indonesian culture from various perspectives (Sulistyaningrum & Kastuhandani, 2024). The use of lengthy and expository classroom teaching needs to be reconsidered. Teachers who simply deliver information rarely inspire students to take an active role in their own learning. The issue lies not in teaching style or lack of student engagement, but in the variation of what children are exposed to in their learning. When students encounter diverse content, they tend to become more actively involved in their education (RimahDani et al., 2023). Currently, cultural learning systems still rely heavily on conventional media such as textbooks. These traditional media can only present information in a descriptive and two-dimensional format, making them less interactive and engaging for students. This limitation results in low student interest and understanding regarding Indonesia's cultural diversity. In fact, understanding local culture, such as traditional houses, is not only vital for preserving cultural heritage but also for building national identity and fostering appreciation for diversity.

On the other hand, technological advancements have opened up new opportunities to introduce culture in more engaging and interactive ways. To address the previously mentioned issues, educators and instructors need to think outside the box and find innovative ways to engage students through learning materials that are both appealing and entertaining (Fitria et al., 2023). As we live in a digital world, it is essential to introduce digital media, such as educational games, to children.

One innovative learning medium that captures students' interest is the use of educational games. Children enjoy playing games (Schlichting, 2019), and studies have shown that gaming can enhance cognitive development and motor skills in children (Kashi et al., 2019; Page et al., 2017; Tomporowski et al., 2015). Game-based learning approaches help students immerse themselves in interactive, movement-based learning environments and boost their learning motivation (Yan et al., 2023).

The movement-based learning approach integrates physical movement with instructional content to help students improve their academic performance and motor skills within a student-centered context (Ge & Fan, 2017). Motion-based devices such as Leap Motion can be used to create interactive virtual learning environments, allowing users to control and interact with computers through body movements (Hsiao & Chen, 2016). Shakroum et al. (2016) found that gesture-based learning systems positively influence students' intrinsic motivation, which in turn leads to improved learning outcomes and motor skills. This more natural form of motion-based interaction offers greater enjoyment and usability for children (Lee-Cultura et al., 2022). The use of motion-based media combined with instructional materials can enrich learners' knowledge representations, help them grasp abstract concepts, and enhance both learning performance and motor skills

(Faella et al., 2025; Hsiao & Chen, 2016).

Solfiah et al. (2021) demonstrated that educational games developed for Android could improve number recognition skills in early childhood learners. Validation findings highlighted the uniqueness of the educational game, and the significant improvement in number recognition skills was supported by the study's results. A development study conducted in Fitri & Rakhmawati (2022) showed that a culturally based educational game called *Sumbang Duo Baleh* achieved a very high practicality score (84.4%). The use of this culturally rooted game proved to be highly effective. These findings indicate that *Sumbang Duo Baleh*, an educational game grounded in local culture, can enhance emotional intelligence (EQ), making it a credible, practical, and beneficial tool for developing interpersonal skills.

The development of a Leap Motion-based educational game for elementary school students represents an innovative approach to supporting the learning of Indonesian culture, particularly in relation to traditional houses. Previous research has shown that augmented reality (AR) technology is effective in introducing cultural content. For instance, a study on a markerless AR application for educating users about Indonesian traditional houses demonstrated high compatibility with modern devices and received positive user feedback (Boediono et al., 2023). Similarly, an AR-based application for introducing traditional Indonesian clothing provided an interactive experience, although it was still limited by the use of markers (Indra et al., 2020). Other studies have developed AR applications for Balinese traditional architecture and the Tongkonan houses of the Toraja, both of which successfully enhanced user experience and cultural knowledge (Nadita et al., 2023; Setiawan et al., 2024). However, these studies tended to focus on static visualization or limited interaction.

This research focuses on the integration of Leap Motion technology into an educational game, allowing students to interact directly with traditional house content through body movements. This approach offers a more immersive and enjoyable learning experience compared to static AR-based applications. The novelty of this study lies in the combination of Leap Motion technology with a culturally themed educational game—a topic that has been scarcely explored in previous research. Literature reviews indicate a lack of exploration into interactive technologies aimed at increasing student engagement in cultural learning through innovative methods, particularly involving Leap Motion.

The research problem addressed in this study is how to design an effective Leap Motion-based educational game to introduce Indonesian traditional houses to elementary students. Additionally, the study aims to investigate how this technology can enhance students' motivation and understanding of Indonesian culture. The ultimate goal is to evaluate the effectiveness of Leap Motion technology in providing a more engaging learning experience compared to conventional methods. Through the development of this educational game, it is expected that students will be more actively involved in cultural learning, thereby increasing their interest and understanding of Indonesia's cultural diversity. This research also contributes to cultural preservation using technology that is relevant and accessible for elementary school learners.

Research Method

The method used in this study is Research and Development (R&D). This research focuses on the development of an innovation in the form of an educational game titled *Exploring Indonesian Traditional Houses*, based on Leap Motion technology, designed for

elementary school students. The educational game introduces several traditional houses from different regions of Indonesia. The development of this media is based on the instructional design model by Robert Maribe Branch, as cited in [Sugiyono \(2017\)](#), commonly known as the ADDIE model (Analyze, Design, Development, Implementation, Evaluation). The ADDIE model provides a structured approach to instructional design, enabling the development of learning materials that are both engaging and theoretically grounded.

In this project, the ADDIE model, recognized as one of the most systematic instructional design frameworks, has been adopted as the development model. According to Romiszowski (as cited in [Ma'ruf, 2021](#)), the ADDIE model has proven effective in designing and developing learning materials, including texts, audiovisual content, and computer-based programs, due to its systematic approach and strong foundation in instructional design theory.

The ADDIE model comprises five phases: Analysis, Design, Development, Implementation, and Evaluation. However, the present study focused exclusively on the Design and Development phases, drawing on the findings of the Analysis phase conducted in a previous study, which examined elementary school students' needs, characteristics, and cultural literacy within the learning context. The Design phase involved designing learning materials and planning Leap Motion-based educational media to introduce traditional houses to elementary school students. The Development phase involved creating the educational game based on the design and conducting expert validation covering media, language, and content aspects. Implementation with students and teachers and evaluation of the product's effectiveness have not yet been conducted. These phases are planned for subsequent research and fall outside the scope of this paper. Accordingly, the findings reported here are limited to product development and expert-assessed feasibility.

In this study, the design and development processes are the focus in creating an educational game themed *Exploring Traditional Houses* for elementary school students. This focus is based on the results of a prior needs analysis, allowing the design and development of the media to be tailored to the identified learning requirements. The design phase is a follow-up to the needs analysis, considering both technical and pedagogical aspects in developing the educational game. This phase includes the selection of appropriate software, interface design, and the integration of multimedia elements such as images and educational videos to support the learning process about traditional houses in Indonesia. The purpose of this design is to produce a learning medium that is not only visually appealing but also effective in enhancing students' understanding of the material presented. Once the design phase is complete, the study proceeds to the development stage, where the product is realized and prepared for testing. During this stage, the developed educational game is also subjected to validity testing by experts, including media experts, language experts, and subject matter experts, to ensure that the media meets quality and feasibility standards before being implemented in a broader learning context.

Results

The product developed in this study is an educational game for elementary school students based on Leap Motion technology, titled *ArchiLeap: Leap Motion Educational Game Exploring the Traditional Houses of the Archipelago*. This game utilizes the Leap Motion motion sensor, allowing students to rotate, zoom in, and explore 3D models of traditional houses using hand gestures. The content of *ArchiLeap* includes interactive 3D simulations,

audiovisual learning materials in the form of videos and PowerPoint presentations, interactive quizzes, and an "About" section containing information about the development of *ArchiLeap*. All of these components are integrated into a single educational application designed with a child-friendly interface that is easy to use in a learning environment. These components were developed based on a needs analysis involving elementary school students, teachers, and experts from previous studies.

The development of *ArchiLeap* was guided by the ADDIE model, which comprises five phases: Analysis, Design, Development, Implementation, and Evaluation. Consistent with the methods section, this study was limited to the Design and Development phases, drawing on the needs analysis conducted in a previous study. The Design phase focused on planning the learning materials and educational games, while the Development phase involved producing the prototype and conducting expert validation of its media, language, and content aspects. This validation formed part of the Development phase and did not constitute implementation or evaluation with actual users. The Implementation and Evaluation phases involving students and teachers have not yet been conducted and are planned for subsequent research outside the scope of this paper.

The development process consists of two main stages: (1) the initial product design phase, which includes creating a storyboard and instructional materials, and (2) the development of the initial product and validation testing by experts who assess the feasibility of the content, media, and language to determine the suitability of the developed media. Following this, the initial product is refined before moving on to the implementation and evaluation stages. During the development phase, 3D graphic assets of traditional houses were designed using Blender software, audiovisual materials were produced using Adobe Premiere Pro, and interactive scripting based on Leap Motion technology was carried out through the Unity platform. Once the initial version of the game was developed, it underwent validation by media, content, and language experts to ensure content accuracy and presentation quality. Feedback from these experts was used to refine the product before its implementation. The refinement stage included incorporating expert suggestions to improve the game and learning materials for introducing traditional houses. Upon completion of the Leap Motion media development, the expected outcome is that the media will be declared valid and appropriate for educational purposes. The following section provides a more detailed explanation of each phase that has been carried out.

Initial Product Design

In the first stage, the research focused on the initial product design of the *ArchiLeap* educational game. The design process began with the development of a narrative storyboard that mapped the students' exploration journey, from the historical introduction, exploration of building structures, to the reflection on the philosophical values of each traditional house. This was intended to ensure instructional continuity and content cohesion. Subsequently, audio-visual learning materials were developed in the form of micro-format videos (3–5 minutes) and interactive PowerPoint presentations. This approach is supported by [Hanipah's \(2023\)](#) findings, which emphasized that instructional materials within the *Kurikulum Merdeka* should be designed innovatively to effectively support learning processes and benefit students.

The design process continued with the creation of 3D graphic assets of traditional houses using Blender, ensuring that every carved ornament and spatial proportion reflected authentic ethnographic data. The asset creation was aligned with the technical capabilities

of the research team. These assets were then imported into Unity and enhanced with Leap Motion scripting, allowing hand gestures, such as swiping, pinching, and finger bending, to rotate the buildings 360° and explore the traditional houses interactively. This aligns with the findings of [De Paolis & De Luca \(2022\)](#), which highlight the enhanced sense of presence achieved through gesture-based interactions.

In parallel, the editorial team integrated 3D renders, voice narration, traditional music, and explanatory text to produce clips that complement the interactive exploration sessions. To ensure instructional quality, interactive quizzes were embedded after each exploration session. The quiz items were tailored to the cognitive level of elementary school students. The initial prototype was then validated by media, language, and content experts to assess the accuracy, text readability, and gesture responsiveness. Feedback from the experts was incorporated before the game entered the classroom implementation stage, ensuring that the final product meets the criteria of validity, practicality, and effectiveness as recommended by the ADDIE model ([Branch, 2009](#)).

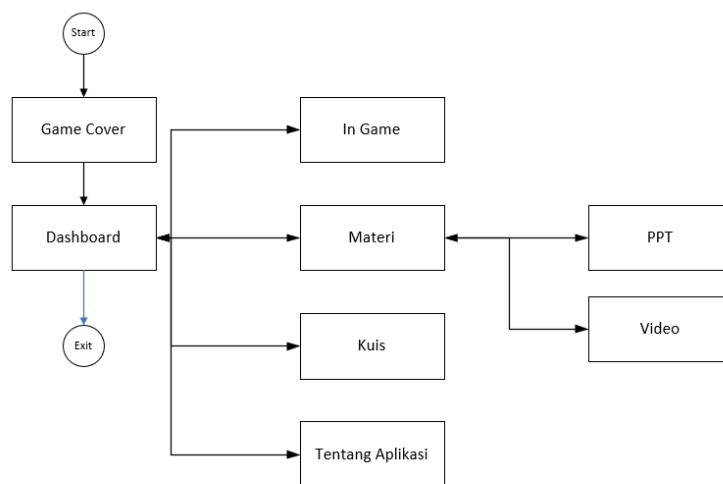


Figure 1 Archileap Flowchart

ArchiLeap comprises four submenus: 3D Leap Motion Simulation, Learning, Quiz, and About. These provide access to interactive simulations, learning resources in PowerPoint (PPT) and video formats, formative assessments, and technical information about the application.

The 3D Leap Motion Simulation submenu is accessible through the *Start* button on the dashboard, which directs users to a map of the Indonesian archipelago. Students explore the map through hand gestures, waving left or right to navigate, pinching to adjust the zoom, and using a palm-click gesture to select a province. When a traditional house is selected, it appears in full-screen mode alongside icons illustrating the finger poses required to return to the map or activate descriptive audio narration.

The Learning submenu offers resources in PPT and video formats. The PPT option presents slides individually, enabling students to move between them by swiping their hands at the edge of the screen. Subtle animations and cultural map overlays support the dual coding of textual and visual information. The video option features short clips lasting 3–5 minutes, with playback controlled by hovering the palm over virtual buttons to play, pause, or stop the video. Text instructions displayed at the bottom of the screen guide these gesture-based interactions in alignment with cognitive load principles ([Syafitri, 2024](#)).

The Quiz submenu supports formative assessment by activating an adaptive question bank for each traditional house explored. The system selects 5–7 multiple-choice questions incorporating cropped images of architectural details to assess students' recognition of architectural forms, functions, and philosophical meanings. Students submit their responses by hovering their palm over an answer option for approximately two seconds, after which the system records their selection and displays immediate feedback and scores.

The About submenu provides ArchiLeap's technical specifications, including its intended desktop operating system of Windows 10 or later, the required Leap Motion Controller, and a recommended GPU of GTX 1050 or higher. It also presents information about the development team, educational objectives, and acknowledgments to supporting institutions. Links to user documentation, device calibration procedures, and help desk contacts are included to promote product transparency and accountability, as recommended by ISO/IEC 29110 standards for educational software.

With its four-submenu structure, ArchiLeap combines immersive gesture-based learning, rich multimodal content, adaptive assessments, and complete documentation, creating a cultural learning ecosystem in line with the ADDIE framework and best practices in educational serious game design (Branch, 2009; Schrader, 2023).

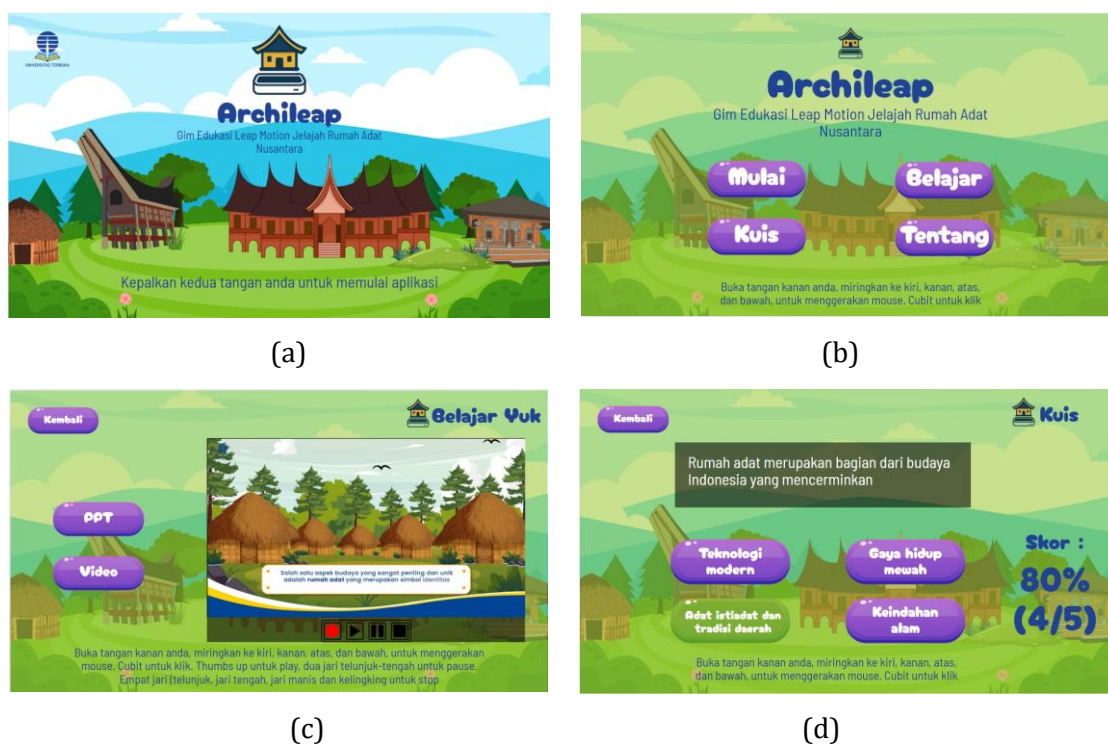


Figure 2 ArchiLeap Interface Design Layout: (a) Initial Screen; (B) Submenu Screen; (C) Learning Submenu Screen; (D) Quiz Submenu Screen

Product Development

Following the Design phase, *ArchiLeap* was developed into a Leap Motion–based educational game prototype and subjected to expert feasibility assessment within the Development phase of ADDIE (Branch, 2009). Three experts participated in the assessment, which covered media, language, and content using questionnaires containing 18, 15, and 16 items, respectively. Each item was rated on a four-point Likert scale, ranging from 1 (Very Poor) to 4 (Very Good). Open-ended questions collected qualitative feedback to guide

improvements to the 3D simulations, narration, Leap Motion interface responsiveness, and in-game assessment components.

The questionnaires were used to obtain descriptive expert judgments of prototype feasibility. Empirical instrument validity, internal consistency, and inter-rater reliability were not established in this study. Accordingly, the quantitative scores represent preliminary expert assessments and should not be interpreted as measurements derived from instruments with established psychometric properties. Instrument validation and appropriate reliability testing are recommended for subsequent research.

Feasibility percentages were calculated using $P = [\Sigma x / (4 \times n \times r)] \times 100\%$, where Σx denotes the total obtained score, n is the number of items in the assessment domain, and r is the number of experts rating that domain. The calculations reported here use $r = 3$, representing three ratings per item within each domain. Scores were classified using the following operational intervals: 25%–40% (Poor), >40%–60% (Fair), >60%–80% (Good), and >80%–100% (Very Good). The overall feasibility percentage was calculated as the arithmetic mean of the three domain percentages, giving equal weight to media, language, and content. Together with the qualitative feedback, these findings provide preliminary support for further refinement and subsequent user testing of *ArchiLeap*. Implementation with students and teachers and evaluation of learning effectiveness have not yet been conducted; these phases are planned for subsequent research outside the scope of this paper.

Media Feasibility Test Results

The media assessment covered three aspects: visual and audio presentation, Leap Motion interaction, and software engineering. It was conducted by 2 media experts with doctoral degrees in Educational Technology and Computer Science, along with over ten years of combined practical experience in educational media design, interactive virtual applications, and software development. Where an aspect was assessed by multiple experts, its percentage was calculated from the combined obtained scores divided by the combined maximum possible score. Table 1 presents the assessment results.

Table 1 Feasibility Test Results by Media Expert

No.	Aspect	Item Numbers	Feasibility Percentage (%)	Criteria
1	Visual and Audio Presentation	1—10	86.1	Very Good
2	Use of Leap Motion Media	11—15	89.4	Very Good
3	Software Engineering	16—18	85.3	Very Good
Overall Average Score			86.9	Very Good

Below is an explanation of the feasibility test results conducted by the media expert on *ArchiLeap*:

Visual and Audio Display

The visual and audio display aspects of *ArchiLeap* were measured based on six indicators: layout accuracy, design appropriateness, image clarity, text suitability, music appropriateness, and video quality. The average percentage for each indicator was 86.1%, indicating that the media feasibility aspect of *ArchiLeap* meets the "Very Good" criteria.

Use of Leap Motion Media

The utilization of Leap Motion in *ArchiLeap* was evaluated through five items using a single indicator: the Leap Motion component. The average feasibility percentage across all

items was 89.4%. This suggests that the use of Leap Motion in ArchiLeap meets the "Very Good" criteria.

Software Engineering

The software engineering aspect consists of two indicators: media quality and ease of use. The implementation and software engineering of ArchiLeap achieved an average feasibility percentage of 85.3%, which meets the "Very Good" criteria.

The aggregate average score for the ArchiLeap media evaluation was 86.9%, which is interpreted as "Excellent," calculated by combining the percentages from all three aspects. Additionally, the media expert provided input and recommendations for ArchiLeap, summarized as follows:

"Consistency in color palette and appropriate typography selection are essential. Replace the narration font and add background music to enhance the local cultural atmosphere in the simulation. Improve Leap Motion gesture recognition by increasing the confidence threshold to reduce the likelihood of false positives. Add text labels to interface icons to clarify their functions and reduce the need for repeated navigation. The application build should be compressed to under 300 MB by implementing a Level-of-Detail (LOD) system for 3D models and converting audio to OGG format to ensure memory efficiency without compromising visual and audio quality."

Based on the recommendations and feedback from the media expert, ArchiLeap was refined to enhance its quality. The researcher revised the components highlighted in the feedback according to the expert's suggestions.

Results of Language Feasibility Test

The language assessment covered sentence effectiveness, communicativeness, and text comprehensibility. It was conducted by 2 language experts with master's degrees in Indonesian Applied Linguistics and specialized expertise in elementary-level language assessment and instructional material development. Table 2 presents the results.

Table 2 Results of Feasibility Test by Language Expert

No.	Aspect	Item Numbers	Feasibility Percentage (%)	Criteria
1	Sentence Effectiveness	1—5	82,5	Very Good
2	Communicativeness	6—10	85,1	Very Good
3	Text Comprehensibility	11—15	81,6	Very Good
Overall Average Score			83,1	Very Good

The following is a description of the language aspect assessment results for ArchiLeap conducted by the language expert:

Sentence Effectiveness

The average feasibility percentage for each indicator is 82.5%, which indicates that this aspect meets the "Very Good" criterion.

Communicativeness of Media Texts

The average feasibility percentage for each indicator is 85.1%, which also meets the "Very Good" criterion.

Text Comprehensibility

The average feasibility percentage for each indicator is 81.6%, which falls under the

"Very Good" category.

Overall, the language feasibility of this virtual reality media was rated as "Very Good" with an aggregate average of 83.1%, based on the combined percentages from the three aspects. The language expert also provided the following suggestions and comments as additional input to the evaluation:

"The use of engaging language that sparks curiosity can make user interaction more interesting. It is also important to avoid overloading the media with excessive text, which may cause users to become fatigued or bored. Compound sentences should be simplified into single sentences to enhance clarity for elementary school students. Static text on the screen should be limited to a maximum of 40 words per panel to reduce users' cognitive load and maintain engagement during simulation exploration."

Based on the expert's remarks and recommendations, *ArchiLeap* was refined to enhance its quality. The researcher made improvements to the components that received comments, in accordance with the feedback from the language expert.

Material Feasibility Test Results

The content assessment covered content feasibility, presentation feasibility, and cultural context relevance. It was conducted by 2 content experts with doctoral degrees in Elementary Education and Cultural Anthropology, specializing in primary curriculum design and Indonesian cultural heritage preservation. Table 3 presents the results.

Table 3 Feasibility Test Results by Content Expert

No.	Aspect	Item Numbers	Feasibility Percentage (%)	Criteria
1	Content Feasibility	1—10	84,2	Very Good
2	Presentation Feasibility	11—13	82,1	Very Good
3	Cultural Context Relevance	14—16	80,6	Very Good
Overall Average Score			82,3	Very Good

Below is a description of the material feasibility evaluation of *ArchiLeap* conducted by the content expert:

Content Feasibility

Two indicators serve as the basis for assessing the content feasibility of the *ArchiLeap* media: content accuracy and the alignment of the material with core competencies. The average feasibility percentage across all indicators was 84.2%, indicating that the content in *ArchiLeap* meets the "Very Good" feasibility criteria.

Presentation Feasibility

Two indicators used to assess the presentation feasibility of *ArchiLeap* media are the material presentation technique and the presentation support. The average feasibility percentage across all indicators was 82.1%, showing that the presentation of the leap motion media meets the "Very Good" criteria.

Relevance of Cultural Context

The relevance of the cultural context within the material is represented by one indicator and three questions in *ArchiLeap*. Based on the average feasibility percentage, the indicator scored 80.6%. Thus, the integration of cultural content is rated "Very Good" and meets the required criteria.

The average result of the material feasibility assessment for the *ArchiLeap* media is

82.3%, with an interpretation of "Very Good," based on the percentages from the three aspects. Additional suggestions and comments from the content expert include:

"The developed media is sufficient and feasible for use. You may consider adding functional space examples (e.g., the 'amben' in Joglo houses used as a family discussion space) to help students better understand the connection between form and function in traditional houses. Also, integrating cultural philosophical values, such as the principle of gotong royong in the Minangkabau traditional house, into the narrative scenarios and reflective quizzes would enhance the learning's meaningfulness."

Based on the suggestions and comments provided by the content experts, the *Leap Motion* application was refined for improved effectiveness. The researcher made enhancements to the components highlighted in the feedback, following the experts' recommendations and inputs. Taken together, the assessments support further prototype refinement and subsequent user testing. They do not establish learning effectiveness or cultural-literacy outcomes, as implementation and evaluation with students and teachers have not yet been conducted.

Product Refinement

The refinement of the *ArchiLeap* prototype is a further stage aimed at ensuring that this Leap Motion-based educational game meets both technical and pedagogical specifications while aligning with the learning patterns of elementary school students. Based on expert validation findings, several strategic components were identified and revised. First, in terms of interactivity, experts demanded a more intuitive interface. Therefore, the Leap Motion detection threshold was increased, and the gesture recognition algorithm recalibrated to allow smoother and more natural rotation, zooming, and navigation of traditional houses. This improvement is expected to enhance the sense of presence while increasing cognitive engagement. Second, the visual aspect was strengthened through the implementation of high-resolution PBR (Physically Based Rendering) textures and dynamic lighting settings, so that the details of carvings and the material nuances of traditional houses appear more realistic. More authentic visualization enriches aesthetics and supports the development of cultural schemata through dual image-text processing. Third, in accordance with language expert recommendations, narration and instructions were simplified into conversational single sentences, complemented by interactive definitions for architectural terms, for example, a pop-up definition of "*amben*" when students point to the central room of a *Joglo* house. All instructions were integrated into a gesture-sensitive heads-up display, reducing working memory load and facilitating movement orientation. Through this iterative process, *ArchiLeap* is expected to become more responsive, immersive, and accessible, while also proving more effective in helping learners explore the concept of cultural diversity in the Indonesian archipelago. These results highlight the vital role of cyclic design-evaluation in the development of technology-based learning media, where continuous input-improvement cycles are key to achieving instructional quality and optimal learning experiences ([Raybourn, 2003](#)).

Discussion

The expert assessments provide preliminary support for the feasibility of *ArchiLeap*, with media, language, and content ratings of 86.9%, 83.1%, and 82.3%, respectively. These findings indicate favorable expert judgments of the prototype's technical presentation, instructional language, and learning content. However, they do not demonstrate

improvements in student engagement, cultural literacy, or learning outcomes, as the study was limited to the Design and Development phases.

Compared with the studies introduced earlier, *ArchiLeap* shares the objective of using digital representations to introduce Indonesian cultural heritage. [Boediono et al. \(2023\)](#) developed a markerless AR application for traditional-house education, whereas [Indra et al. \(2020\)](#) developed an Android-based AR application introducing traditional clothing. Both provide relevant precedents for presenting cultural objects through digital media. *ArchiLeap* extends this line of development through a different interaction approach: hand gestures captured by Leap Motion enable users to rotate, enlarge, and explore traditional-house models within an educational game integrating audiovisual explanations and quizzes. Its contribution therefore concerns the integration of gesture-based exploration with instructional activities rather than the use of 3D cultural representations alone.

A more specific comparison can be made with [Nadita et al. \(2023\)](#), who developed AR media introducing Tongkonan Toraja houses, and [Setiawan et al. \(2024\)](#), who applied Android-based AR to traditional Sikut Satak architecture in Balinese houses. These studies address architectural traditions, while *ArchiLeap* brings models of houses from different Indonesian regions into a shared learning environment intended for elementary school students. Its proposed contribution lies in combining this cross-regional content with Leap Motion interaction, narration, and quizzes. Nevertheless, differences in interaction technology and content scope do not establish educational superiority. Without direct comparative testing, the present findings cannot demonstrate that *ArchiLeap* is more engaging, usable, or effective than these AR applications.

The integration of hand movements and spatial exploration also provides a rationale for considering embodied learning. Rotating or enlarging a house model could help learners examine architectural features while connecting physical actions with visual information. However, this remains a proposed learning mechanism rather than an observed outcome. [Colombini et al. \(2021\)](#) reviewed the potential of Leap Motion applications in neurodevelopmental and neurocognitive contexts while emphasizing limitations in the available evidence. Their review supports further investigation of gesture-based interaction but cannot establish its effectiveness for cultural learning among elementary school students.

Expert feedback further indicates that interaction technology requires appropriate instructional and cultural support. Recommendations concerning gesture recognition, interface labels, typography, and concise instructions identified priorities for making the prototype easier to navigate and interpret. Content recommendations concerning spatial functions and cultural meanings also suggest that traditional houses should be presented as expressions of social practices and cultural values, alongside their architectural forms. Whether these refinements improve children's understanding requires direct assessment.

The contribution of this study is therefore an expert-assessed prototype combining gesture-based interaction and culturally contextualized learning activities. Its practical application remains dependent on access to a Leap Motion controller and compatible computing equipment. Further research should examine usability, gesture recognition during actual use, cultural understanding, and learning outcomes with students and teachers. Comparative testing against an AR application or conventional instructional media would help determine the educational value of the proposed interaction approach.

Conclusion

This study designed and developed *ArchiLeap: A Leap Motion Educational Game for Exploring Traditional Indonesian House* to elementary school students. The research followed the Design and Development phases of ADDIE, drawing on a needs analysis conducted in a previous study. The prototype integrates gesture-controlled 3D house models, audiovisual materials, and quizzes. Expert assessments yielded feasibility ratings of 86.9% for media, 83.1% for language, and 82.3% for content, all classified as Very Good. Expert feedback guided refinements to gesture interaction, visual and typographic consistency, instructional language, and cultural contextualization. These findings provide preliminary evidence of expert-assessed prototype feasibility and support further development and user testing.

This study has several limitations. It did not include the Implementation and Evaluation phases with students and teachers; therefore, usability, classroom practicality, engagement, motivation, and learning outcomes have not been established through actual use. Furthermore, the feasibility scores represent descriptive expert judgments, as instrument validity and reliability were not established. Access to a Leap Motion controller and compatible computing equipment also remains a practical consideration for classroom deployment. Subsequent research should validate assessment instruments, conduct user trials, and evaluate learning outcomes using an appropriate research design. Accordingly, the present contribution is limited to prototype development and preliminary expert-assessed feasibility.

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The authors declare that ChatGPT was used during the preparation of this manuscript to assist with language editing, sentence restructuring, improving coherence between sections, and aligning the manuscript with academic writing conventions. AI was not used to design the research, collect data, replace data analysis, determine research findings, or formulate substantive conclusions without author verification. Following the use of this tool, the authors thoroughly reviewed, verified, and edited all content as necessary and accepted full responsibility for the accuracy, integrity, and substantive content of this publication.

Participant Consent

The authors declare that informed consent was not required because this research did not involve human participants.

Conflict of Interest

The authors declare that this research was conducted without any financial, institutional, or personal conflicts of interest that could have influenced the conduct of the research, data analysis and interpretation, manuscript preparation, or publication process.

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Author Contributions

C.C.D.A. contributed to the conceptualization, research design, development of the educational game, and preparation of the manuscript (20%). G.W. contributed to the research methodology, instructional design, and critical revision of the manuscript (15%). M.A.P. contributed to the research methodology, analysis and interpretation of the findings, and critical revision of the manuscript (20%). K.A. contributed to the development of the educational media, validation process, and review of the manuscript (15%). A.S.A.P. contributed to the technical development of the ArchiLeap prototype, integration of Leap Motion technology, and review of the manuscript (15%). Y.B. contributed to the conceptualization, instructional content development, interpretation of the findings, and critical revision of the manuscript (15%). All authors confirm that they have read and approved the final version of this manuscript. The percentage contributions are as follows: C.C.D.A.: 20%, G.W.: 15%, M.A.P.: 20%, K.A.: 15%, A.S.A.P.: 15%, and Y.B.: 15%, totaling 100%.

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