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Cultural heritage preservation through second life platform in the ecomuseum approach

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Abstract

This study explores integrating immersive virtual technologies into the ecomuseum concept as an innovative strategy for preserving cultural heritage. The research centers on developing and evaluating a virtual ecomuseum that represents the cultural legacy of the Batak Toba community in North Sumatra, Indonesia. The project uses the Second Life platform to construct an interactive, three-dimensional environment that digitally reconstructs tangible and intangible cultural elements. The methodological approach incorporates participatory design principles, involving cultural experts and local community members in the collaborative identification, curation, and validation of cultural representations to ensure authenticity and contextual relevance. Data were collected using the Virtual Data Collection Interface (VDCI), which enabled monitoring user interactions and administering online surveys. A total of 900 respondents participated in the evaluation process. Findings indicate that interactive features significantly enhance user satisfaction and engagement. The thematic analysis highlights interactivity, visual richness, cultural fidelity, and navigational accessibility as key determinants of the visitor experience. Furthermore, statistical analysis demonstrates that users exposed to interactive elements reported significantly higher satisfaction levels. The study concludes that virtual ecomuseums constitute a promising platform for inclusive, participatory, and sustainable cultural heritage preservation in the digital age. Strategic recommendations are presented to improve platform usability, strengthen community involvement, and bridge virtual engagement with real-world cultural action.

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Introduction

Cultural heritage is an important asset that reflects the identity, history, and values of a society. As part of the invaluable heritage, cultural heritage includes tangible elements such as archaeological sites, monuments, and artifacts and intangible elements such as traditions, languages, and performing arts. However, the existence of this cultural heritage faces various major challenges, including the threat of environmental degradation, uncontrolled urbanization, and low public awareness of the importance of cultural preservation (Bosher et al., 2019). If not addressed immediately, this can lead to the loss of a community's cultural identity that should be passed on to future generations (Bosher et al., 2019; Hutson, 2024).

In the rapidly developing digital era, technology offers new opportunities that can help overcome challenges in preserving cultural heritage. One potential solution is to integrate virtual technology with museums' function as cultural preservation institutions (Palumbo et al., 2022). Museums have long been known as institutions that document, preserve, and exhibit cultural heritage. Now, this role is expanded by utilizing digital technology to reach a wider audience and provide a more in-depth interactive experience.

One of the innovative approaches that has emerged is the concept of ecomuseums. An ecomuseum is a community-based museum that focuses on holistic cultural preservation involving the physical environment, local communities, and the cultural values contained therein (Gollo et al., 2025). Unlike traditional museums that often focus on collections of certain objects, ecomuseums prioritize the collective narrative of the community and the active involvement of the community in managing and promoting their cultural heritage (Li & Selim, 2024).

With the advancement of immersive technologies, applying ecomuseum principles in virtual environments has become increasingly relevant. Second Life, one of the most established and flexible virtual worlds, offers a dynamic platform for creating immersive cultural ecosystems (Allam et al., 2022; Hutson & Hutson, 2024; McMahan, 2024). Through this environment, cultural sites, artifact collections, and traditional practices can be digitally reconstructed, allowing global audiences to experience and engage with cultural heritage beyond the constraints of geography and physical access (Li & Selim, 2024; Xinda et al., 2025).

In addition to its representational capacity, Second Life facilitates collaboration among diverse stakeholders including government institutions, local communities, educators, and technology developers in co-creating educational and entertaining cultural experiences (Allam et al., 2022). This collaborative potential aligns closely with the core values of the ecomuseum movement, which emphasize community participation, self-representation, and local empowerment.

Second Life has several advantages in supporting the preservation of cultural heritage (Gao, 2024; Huang & Han, 2014; Loaiza Carvajal et al., 2020). This platform allows users to virtually explore real-world and imaginary destinations, such as replicas of Paris, London, and fictional places created by the user community (Huang et al., 2013; Oladokun et al., 2024). The access provided by Second Life is global and inclusive, beneficial for individuals with limited mobility or hindered by social norms, such as women in countries with travel restrictions. The experiences offered are immersive and interactive, including visits to virtual concerts, art galleries, language classes, and cultural performances that allow users to experience the atmosphere of a place without having to be physically present (Tavakoli & Mura, 2015).

In addition, Second Life platform provides the freedom to express identity through avatar personalization, a form of self-representation in virtual space. This creates a deep, reflective, and creative space, especially in social and cultural contexts (Urban, 2007). Regarding sustainability, Second Life supports environmentally friendly tourism because it does not cause physical impacts on cultural sites, making it very relevant in efforts to preserve cultural heritage (Huang et al., 2013; Messinger et al., 2009). In education, this platform is an innovative learning tool, allowing the younger generation to understand history and culture interestingly and contextually (As et al., 2023; Messinger et al., 2009). Equally important, Second Life also opens up creative economic opportunities, where users can create, manage, and monetize virtual cultural content they build. These advantages make Second Life one of the potential tools for preserving cultural heritage in the digital era.

Moreover, in virtual ecomuseum development, Second Life has several advantages over virtual reality (VR)-based platforms, especially regarding accessibility, community participation, and development flexibility. Second Life can be accessed via a regular computer without additional devices, thus reaching more users from various social and economic backgrounds (Ma et al., 2023; Xinda et al., 2025). In addition, Second Life allows active community participation through avatars, self-content creation, and collaborative spaces, in line with the principles of ecomuseums based on participation and local representation (As et al., 2023). While VR platforms offer a more immersive visual experience, their access is limited because they require special hardware and high technical expertise (Milenović, 2025). Second Life has also proven to be stable and sustainable as a long-term platform, compared to VR

projects which tend to be temporary (Gao, 2024; Huang & Han, 2014; Tavakoli & Mura, 2015). Therefore, Second Life is considered more suitable for developing an inclusive, participatory, and sustainable virtual ecomuseum in the context of preserving digital culture.

In conclusion, Second Life demonstrates strong potential as a platform for developing virtual ecomuseums that address contemporary challenges in cultural heritage preservation. Blending immersive technologies with participatory methodologies offers innovative pathways for making heritage more accessible, inclusive, and engaging in the digital age.

Based on this background, this study focuses on the integrative exploration of the concept of ecomuseum and the virtual world of Second Life to preserve cultural heritage in a participatory and sustainable manner. This study aims to identify how cultural representations can be presented authentically in digital space and to design a conceptual model of a virtual ecomuseum that can strengthen community involvement in maintaining and promoting its cultural identity. With this approach, this study offers an innovative contribution to the field of digital cultural preservation through the use of collaborative and contextual immersive technology.

Literature Review

The ecomuseum concept, introduced by Georges Henri Rivière in the 1970s, represents a paradigm shift in museology. Unlike conventional museums, which focus on centralized collections of physical artifacts, ecomuseums are community-oriented institutions emphasizing self-representation, participatory governance, and preserving both cultural and natural heritage within their original context (Li & Selim, 2024; Montanari, 2015). These institutions promote sustainable development by integrating social, environmental, and economic dimensions, while also functioning as educational and cultural tourism hubs (Allam et al., 2022; Chang et al., 2015).

With the advancement of digital technologies, the ecomuseum model has evolved into virtual ecomuseums, digitally mediated spaces that enable broader access, collaborative curation, and intergenerational transmission of heritage. These platforms employ 3D visualization, augmented reality, and digital storytelling tools to enhance cognitive and emotional engagement with cultural narratives (Ajani et al., 2024; Milenović, 2025; Oladokun et al., 2024). Virtual ecomuseums maintain the core principles of participation and local empowerment while extending their reach to global audiences.

Among available platforms, Second Life offers a particularly conducive environment for developing virtual ecomuseums. As a persistent, user-driven virtual world, it facilitates interactive cultural experiences, supports avatar-based social engagement, and enables users to co-create personalized virtual heritage spaces (Caffrey, 2024; McMahan, 2024). Prior studies have demonstrated its effectiveness in digitally reconstructing endangered cultural sites, supporting both cultural preservation and education through immersive participation (Penfold, 2009; Rodriguez-Garcia et al., 2024; Vrettakis et al., 2023).

The platform also reinforces constructivist learning by enabling experiential engagement with cultural content and fostering hybrid identities through digital interaction (Hutson & Hutson, 2024; Sookhanaphibarn & Thawonmas, 2009). Furthermore, it aligns with postmodern theories of authenticity and representation, wherein meaning and experience rather than material originality constitute cultural legitimacy in digital contexts (Pavlis, 2024; Urban, 2007).

Nevertheless, virtual ecomuseums face notable challenges, including disparities in digital access, limited digital literacy among marginalized communities, and the complexity of authentically representing intangible cultural expressions (Siliutina et al., 2024). Addressing these issues requires context-sensitive approaches that uphold cultural integrity while leveraging the affordances of digital media.

In summary, virtual ecomuseums constitute a transformative approach within contemporary museology, offering participatory, accessible, and sustainable avenues for cultural heritage preservation in the digital era.

Method

This study employed a qualitative approach, complemented by descriptive and quantitative methods, to explore the potential and challenges of integrating virtual technology into the ecomuseum concept. The qualitative approach examined conceptual frameworks and user experiences in adopting a virtual ecomuseums. In contrast, the descriptive method systematically documented the features, advantages, and limitations of the virtual ecomuseums prototype (Mandić & McCool, 2023). Research data were collected through literature review, in-depth interviews, and participant/visitor observations.

In developing the virtual ecomuseums, the Second Life platform adopted a digital ethnographic approach. This platform enables the creation of immersive and interactive cultural spaces. The development process began with constructing a 3D

model of a Batak Toba cultural site, based on historical documentation, direct field observations, and expert consultations. The Batak Toba, an indigenous ethnic group from North Sumatra, Indonesia, possesses a rich cultural heritage in the Lake Toba region, including traditional architecture (rumah Bolon), ancestral rituals, and customary law (adat), which collectively form the core of their sociocultural identity (Sibarani et al., 2025). These cultural elements were digitally reconstructed and embedded within the virtual environment to ensure cultural accuracy and experiential authenticity.

The methodology also incorporated participatory design principles, allowing local stakeholders and cultural experts to be directly involved in the development process. The community played an active role in identifying which cultural elements to represent and participated in validating and evaluating the virtual representations. Their involvement included participatory discussions, co-design workshops, and usability trials of the virtual ecomuseum. These activities provided valuable feedback on authenticity, ease of navigation, and the representation of cultural values. As a result, the final product reflects the perspectives and cultural aspirations of the Batak Toba community.

The virtual ecomuseum features various interactive components, including digital artifact exhibitions, simulated traditional practices, and communal discussion areas. Narrative elements were integrated to enrich user engagement and provide deeper contextual understanding. Additionally, interactive scripts were developed to allow users to interact directly with cultural objects and rituals.

Next, the Virtual Data Collection Interface (VDCI) was utilized. VDCI facilitated monitoring of user activity, such as interaction patterns, time spent, and frequency of feature use, while also enabling qualitative data collection through in-platform text-based interviews and surveys (Bell et al., 2009). Quantitative data, including visitor numbers and usage statistics, were also processed through this interface. The survey instrument was designed to capture users' perceptions regarding their experience, satisfaction levels, the appeal of interactive features, and the perceived authenticity of the cultural content presented.

Finally, the collected data were analyzed using a mixed-methods approach. Qualitative data were examined thematically to identify key patterns and emerging themes, while quantitative data were analyzed using descriptive statistical techniques, including means, frequencies, and distributions. This integrative methodological framework comprehensively understood the effectiveness, opportunities, and challenges in creating interactive and inclusive virtual technology-based ecomuseums (Li & Selim, 2024). The overall process of data collection and analysis employed in this study is illustrated in Figure 1.

Here, the data obtained through the VDCI and survey were analyzed using the following approaches:

1. Descriptive Statistical Analysis: Quantitative data were analyzed to generate descriptive statistics, such as the average visit duration, the number of interactions with cultural elements, and the demographic distribution of visitors.

2. Inferential Statistical Analysis: A *t*-test was used to test the relationship between certain variables, such as the influence of interactive elements on visitor satisfaction levels. This analysis aims to provide insight into the factors that contribute most to the virtual ecomuseum's effectiveness.

3. Thematic Analysis: Qualitative data from the survey and interviews were analyzed to identify key themes related to visitor experience, cultural relevance, and the ecomuseum's impact on cultural preservation awareness. This analysis was conducted using a coding method to group responses based on certain patterns.

This methodology is designed to provide comprehensive insights into how virtual ecomuseums can effectively preserve and promote cultural heritage in the digital era.

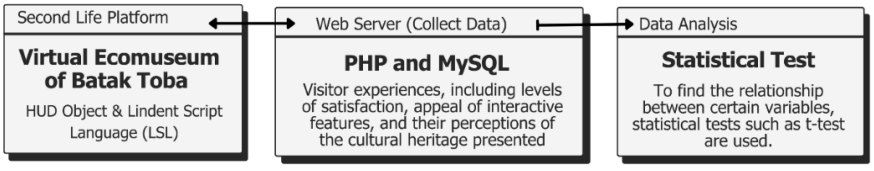


Figure 1 Data collection and analysis diagram

Results

This research resulted in a virtual ecomuseum successfully designed and implemented on the Second Life platform. This project created digital replicas of various cultural elements, including important sites such as traditional houses, places of worship, and natural landscapes with historical value, as shown in Figure 2. In addition, a collection of virtual artifacts such as traditional equipment, traditional costumes, and local fine arts are also included to provide a rich visual experience to visitors. The design of the ecomuseum is not only to represent cultural elements visually but also to convey historical narratives and symbolic meanings through interactive information that visitors can access.

One of the outstanding features of this ecomuseum is the interactive elements that allow visitors to understand cultural values better through virtual simulations. For example, visitors can "touch" a digital artifact to access a story about its origins or follow a virtual tutorial on how to make traditional crafts. In this space, intangible elements of tradition, such as folklore and performing arts, are reproduced in an audio-visual form that can be accessed directly. This makes the ecomuseum a visual exploration space and an effective educational medium. Furthermore, visitor activity data collected through the Virtual Data Collection Interface (VDCI) shows that this virtual ecomuseum has received a very positive response. During the first 6 months, a total of 1,500 visitors accessed the ecomuseum, and around 60 percent or 900 visitors filled out the survey, with the average duration of the visit varying widely, as in Figure 3.

Figure 3 shows the statistical data of the ecomuseum, which consists of various categories of visitors with diverse distributions. Visitors from the Student category dominate, covering 40 percent of total visitors, indicating great interest from young people in educational experiences and cultural exploration in virtual formats. The Historian category follows with a percentage of 30 percent, reflecting the relevance of the ecomuseum in providing informative and in-depth content that is interesting for professionals in the field of history. Meanwhile, the Teacher and Lecturer category only covers 10 percent of visitors. However, the average visit duration is fairly high, 17 min, indicating their involvement in exploring content that supports their professional needs. The Cultural Community category, which only covers 15 percent of visitors, has the shortest average visit duration, which is 15 min, which may reflect their preference for more specific or practical experiences. Finally, the others category covers 5 percent of total visitors, with an average visit duration of 17 min, indicating their interest in certain features of the ecomuseum. Overall, the highest average visit length was recorded for Historians, at 18 min, confirming that this group tends to engage longer in exploring cultural content.



(a) (b)

Figure 2 Virtual ecomuseum: (a) Visitor survey data collected through the Virtual Data Collection Interface (VDCI). (b) Digital replicas of various cultural elements, including important sites such as traditional houses, places of worship, and natural landscapes

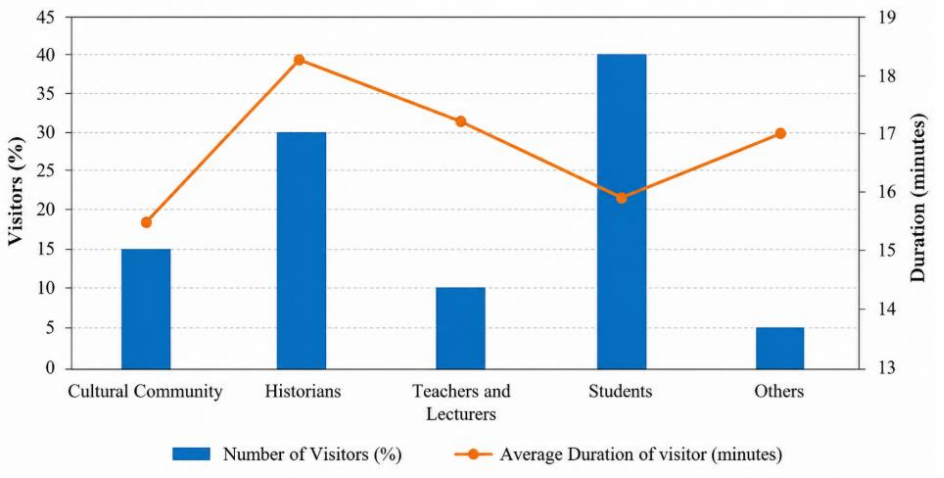


Figure 3 Statistical data of the visitors

In contrast, although College and University Students had the most significant number of visitors, their average visit length was shorter, at 16 min, which may indicate a preference for a quick yet informative experience. To enhance attractiveness, the ecomuseum could consider more relevant interactive programs for each visitor category, such as virtual cultural workshops for Teachers and Lecturers and more in-depth historical narratives for Historians. Additionally, collaboration with cultural communities could help extend the length of visits while increasing engagement for this group.

Next, the results of an Inferential Statistical Analysis to test the relationship between the influence of interactive elements and the level of visitor satisfaction. This analysis aims to provide insight into the factors that contribute most to the ecomuseum's effectiveness of the 1,500 visitors to the ecomuseum, around 60 percent or 900 visitors filled out the survey. The Descriptive statistical results of the satisfaction based on interactive elements are shown in Table 1 below.

Based on the *t*-test results in Table 1, obtained *t*-value = 8.12 with a *p*-value = .000 ($p < .05$), indicating that there is a significant difference in the average level of satisfaction between the two groups. Thus, the null hypothesis (H_0) is rejected, and it can be concluded that interactive elements significantly influence the level of visitor satisfaction. Thus, the results of the t-test show that interactive elements in the virtual ecomuseum significantly influence visitor satisfaction. Visitors exposed to interactive elements tend to be more satisfied than visitors not exposed to interactive elements. Next, the results of the identification of the main themes of 900 visitors who filled out the survey aimed to identify the main themes related to the visitor experience, cultural relevance, and the ecomuseum's impact on cultural preservation awareness. Based on the coding method, several important themes provided insight into the elements contributing to the ecomuseum's success.

The main themes of visitor experience identified from the survey responses are presented in Table 2, providing a comprehensive overview of how users perceive the effectiveness of interactive features, ease of navigation, visual presentation, and overall usability of the virtual ecomuseum.

As shown in Table 2, interactive elements and technology are the most appreciated features in the visitor experience, with 40 percent of respondents stating that these features improve their experience. However, 30 percent of respondents felt that the accessibility of the content needed to be improved, especially for more complex sections. Interesting visualizations helped 20 percent of respondents understand history, but 10 percent complained about the lack of clear guidance.

The main themes related to cultural relevance, which emerged from the qualitative analysis of respondents' feedback, are presented in Table 3, providing an overview of how effectively the virtual ecomuseum conveys cultural authenticity, historical context, and relevance to different user groups.

Table 1 Results of the satisfaction based on interactive elements

Group	Avg. Satisfaction Level	*SD*	Number of Respondents
With interactive elements	4.3	.8	500
Without interactive elements	3.6	.9	400

Table 2 Main themes of visitor experience

Themes	Responses Frequency (%)	Sample Responses
Interactivity and technology	40	"Interactive features such as cultural simulations were interesting."
Content accessibility	30	"Easy to navigate, but some information was difficult to access."
Visual satisfaction	20	"The visual design helped me understand history better."
Lack of clear guidance	10	"Some sections were difficult to understand without additional explanation."

Table 3 Main themes of cultural relevance

Themes	Responses Frequency (%)	Sample Responses
Strong cultural representation	50	"This ecomuseum really reflects our local traditions."
Lack of historical context	25	"Some cultural stories are not accompanied by their history."
Relevance to younger generations	15	"Helps younger generations understand the importance of traditions."
Overfocus on modern aspects	10	"Too many modern features, not enough focus on traditions."

Table 4 Main themes of cultural preservation awareness

Themes	Responses Frequency (%)	Sample Responses
Raising awareness	60	"I have come to appreciate the importance of preserving culture more."
Inspiring real action	20	"After the visit, I started participating in cultural activities."
No immediate impact	10	"I do not feel much has changed after the visit."
Lack of practical information	10	"There is no guidance on how I can participate in preserving."

As shown in Table 3, 50 percent of respondents perceived strong cultural representation, indicating that the virtual ecomuseum effectively reflects local traditions. However, 25 percent suggested the need for additional historical context to enrich cultural narratives. Furthermore, 15 percent emphasized its relevance for younger generations, while 10 percent indicated an overemphasis on modern aspects compared to traditional elements.

The themes related to cultural preservation awareness are summarized in Table 4, providing an overview of respondents' perceptions regarding the impact of the virtual ecomuseum on their awareness and engagement in cultural preservation efforts.

As shown in Table 4, the majority (60 percent) felt that visiting the ecomuseum increased their awareness of the importance of cultural preservation. As many as 20 percent were inspired to take real action, such as participating in cultural activities. However, 10 percent of respondents did not feel a significant impact, and another 10% wanted more practical information on how to contribute to preservation.

Conclusion and Discussion

This study underscores the significant potential of virtual ecomuseums especially those built on platforms like Second Life in enhancing cultural engagement, representational authenticity, and preservation awareness. Survey data from 900 participants highlight the importance of interactive elements such as immersive 3D spaces and cultural simulations in elevating user satisfaction, affirming the role of interactivity in digital heritage experiences (Vrettakis et al., 2023). Although most users found the virtual ecomuseum culturally authentic, several limitations were noted, including limited historical depth, usability challenges, and the need for more precise navigation. Suggestions included gamified content and youth-oriented narratives to improve accessibility and intergenerational appeal. Some users also noted a disproportionate emphasis on modern features, suggesting a better balance with traditional cultural elements.

Regarding impact, 60 percent of users reported increased cultural awareness, and 20 percent were inspired to engage in real-world preservation efforts. However, the lack of clear follow-up actions limits long-term engagement. To address this, the platform should offer features such as digital volunteering, community storytelling portals, and educational partnerships to facilitate real-world impact (Gao, 2024; Siliutina et al., 2024). To ensure sustainability, three recommendations are proposed: (1) regular content and system updates, (2) deeper community participation through co-creation and localized storytelling, and (3) actionable pathways for users to contribute beyond the virtual environment.

This study is limited by its reliance on self-reported data and a localized context. Future research should explore diverse case studies and employ longitudinal approaches to assess broader societal impacts.

In conclusion, virtual ecomuseums represent a promising model for inclusive and participatory cultural heritage preservation. Their success depends on thoughtful design, cultural authenticity, and strong community integration.

Conflict of Interest

The authors declare that there is no conflict of interest.

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