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Systematic Review of Augmented Reality Applications in Wayang Heritage Preservation

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Abstract

This study presents a systematic literature review on Augmented Reality (AR) in Wayang from 2020 to 2025. AR has become an innovative solution that combines education and entertainment to increase the engagement of the younger generation and expand access to traditional Wayang art. This study examines the trend of AR in Wayang, including design approaches and user interaction strategies, as well as the benefits and challenges of implementing this technology. It also identifies research gaps and future development directions. This review discusses explicitly the application of AR to various forms of Wayang, including Wayang Kulit, Wayang Golek, and other traditional variants, while excluding Virtual Reality (VR) and other digital art forms. The results indicate that AR applications based on mobile platforms with gesture interaction and gamification effectively enrich the user experience in digital Wayang performances. However, significant challenges related to technological limitations, cultural sensitivity, and involvement of indigenous communities still need to be overcome. This study recommends a multidisciplinary and collaborative approach to developing AR Wayang, enabling authentic and sustainable cultural preservation. These findings are expected to serve as the basis for inclusive digital cultural innovation, which will have a positive impact on preserving Wayang's cultural heritage.

Keywords: Augmented Reality; Digital Wayang; Interactive Cultural Heritage; Cultural Preservation; Systematic Literature Review

1. INTRODUCTION

Wayang is one form of Indonesia's intangible cultural heritage with high historical, philosophical, and aesthetic value. As a traditional performance medium, Wayang functions as entertainment and a means of moral education and conveying local wisdom values [1]. In some areas, Wayang has developed with characteristics that distinguish it from other Wayang traditions, such as Wayang Kulit [2], Wayang Golek [3], Wayang Suket [4] and several different types. However, in recent decades, the interest of the community, especially the younger generation, in

wayang performances has declined along with the dominance of digital entertainment media and changes in cultural consumption patterns.

This condition creates an urgency to revitalize Wayang performances so that they remain relevant and can be enjoyed by modern society. One approach that is being widely used is the digital transformation of cultural heritage, especially through Augmented Reality (AR) technology. This technology allows visual elements of wayang performances, such as characters, background stories, and character movements, to be presented digitally and interactively on user devices [5], creating a new cultural experience without losing their traditional meaning [6]. AR offers great potential in reviving Wayang as a medium that can be enjoyed passively and interactively. Users can observe wayang characters from various angles, interact with the storyline, and obtain narrative and philosophical information from the characters that appear. Through AR, it is possible to increase understanding of educational contexts [7], and culture [8], extend the duration of user engagement [9], and strengthen interest in traditional values [10]. Several initial applications have been carried out, for example, in the context of museums or educational applications, where wayang characters are brought to life digitally through mobile devices or AR glasses [11], [12]. AR in introducing wayang kulit to elementary school students in Central Java can increase their interest in learning and understanding local history and culture [13]. However, this implementation is often still partial. It has not been built on a conceptual framework considering the complexity of cultural values, visualization ethics, and participatory approaches from local cultural actors [14].

Several challenges must be overcome, including the limited digital documentation of Wayang, the minimal involvement of puppeteers or artists in the digital design process, and the lack of interoperability standards in cultural AR platforms [15]. In addition, the participation of cultural communities in the design of preservation technology is also important, so that the results are not merely "digital representations", but truly become an extension of living cultural practices [16]. A systematic literature review (SLR) is needed to examine AR implementation's trends, design approaches, and impacts in preserving Wayang as a digital cultural heritage.

This study identifies various studies conducted from 2020 to 2025 and evaluates the extent to which this technology can bridge traditional values with the needs of the digital era's interactivity. This article aims to provide conceptual and practical guidance for cultural technology developers, academics, and traditional arts practitioners through SLR. The results of this study are expected to formulate a new direction for the development of AR applications for Wayang that are visually attractive, maintain cultural authenticity, strengthen value transfer, and make ancestral heritage part of the nation's future digital narrative.

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Although various studies have developed AR applications for cultural preservation, such as the introduction of Wayang in museums, the development of AR-based learning in Wayang in schools, and the development of AR-based educational gamification, most of these studies still focus on the early prototype stage and have not explored much about the long-term impact on participatory cultural preservation. The minimal involvement of artistic communities, such as "Dalang" and local artists, in the AR content development process is a significant gap that has not been widely addressed. The emphasis on integrating authentic cultural collaboration is the primary novel contribution of this systematic review.

2. METHODS

This study uses a SLR approach to identify, evaluate, and synthesize previous studies that discuss the application of AR technology in preserving cultural heritage, especially in the context of interactive digital Wayang. The SLR method was chosen because it can present a comprehensive and objective picture of the existing literature and assist in identifying research gaps and potential future development directions [17], [18].

2.1. Research Questions

Research questions (RQ) are the study's main foundation, which systematically directs the process of searching, selecting, and analyzing literature. By establishing clear and specific RQs, this study aims to obtain a comprehensive picture of AR technology's application in preserving interactive digital cultural heritage, especially in wayang performances. Each question is designed to explore key aspects that include technology development trends, design and interaction approaches, and the benefits and challenges faced in implementing this technology. The RQ also helps identify research gaps and future development opportunities that can be used as references for researchers, developers, and cultural actors. The RQs that form the basis of this study are formulated as follows:

1) RQ1: What are the trends in AR implementation in the context of interactive digital cultural heritage, especially Wayang, from 2020–2025?
2) RQ2: What are the design approaches, platforms, and user interaction strategies used in developing AR for digital Wayang?
3) RQ3: What benefits and challenges are reported in applying AR technology to preserve local cultural values?
4) RQ4: What research gaps have not been widely studied and potential directions for further research in this area?

2.2. Inclusion and Exclusion Criteria

Strict inclusion and exclusion criteria are applied to ensure that the studies analyzed in this review are relevant to the research focus and have adequate academic

quality. Inclusion criteria are used to filter articles that meet certain requirements so that they can make a meaningful contribution to the understanding of AR implementation in preserving cultural heritage, especially digital Wayang.

1) Inclusion Criteria:
    a. Scientific articles published in the period 2020–2025.
    b. Studies that discuss the application of AR in a cultural context (especially Wayang performances or traditional arts).
    c. Articles published in indexed journals or proceedings (Scopus, IEEE, Sinta 1–3).
    d. Studies that have full access to the full text.
2) Exclusion Criteria:
    a. Articles that only discuss Virtual Reality (VR) or other technologies that do not involve AR.
    b. Studies that do not focus on the cultural context, or only discuss technical aspects without relevance to cultural heritage.
    c. Articles in languages other than English or Indonesian.

2.3. Data Sources and Search Strategy

In this study, literature was collected through a systematic search of various leading academic databases to ensure a broad and representative coverage of sources. The selection of diverse data sources aims to capture multiple perspectives and research results related to implementing AR technology in the context of interactive digital cultural heritage, especially in Wayang. The databases used include international platforms such as Scopus, IEEE Xplore, and ACM Digital Library, as well as national sources such as Portal Garuda and SINTA, to accommodate literature from various levels and languages.

The search strategy uses a combination of keywords relevant to the research topic, applying Boolean techniques to narrow or expand the search results. This approach allows the identification of articles that explicitly discuss AR, cultural preservation, education, and interactive aspects of cultural heritage. All search results are recorded and managed systematically to support the literature review's subsequent selection and analysis stages. All search results are stored, selected, and evaluated based on the content's title, abstract, and suitability to the research focus. The search strategy uses a combination of keywords presented in Figure 1.

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"Augmented Reality" AND "cultural heritage" AND "wayang"
"Augmented Reality" AND "interactive heritage"
"Augmented Reality" AND "traditional performance" AND "Indonesia"
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Figure 1. Search strategy using a combination of keywords

2.4. Study Selection Procedure

In the SLR process, the study selection procedure is an important stage that ensures that only relevant and quality articles are analyzed further. This procedure is carried out in phases, starting from the initial collection of articles (identification), screening based on title and abstract (screening), assessment of eligibility by reading the full text (eligibility), to determining the final articles included in the analysis (inclusion). This method aims to minimize bias and increase the validity of the literature review results. The results of the study selection procedure, presenting the stages, the results of the number of articles and their descriptions, are shown in Table 1 and Figure 2.

Table 1. Study Selection Procedure Table

Stage	Description	Number of Articles	Additional Information
Identification	Collection of articles from databases (Scopus, IEEE Xplore, ACM Digital Library, Portal Garuda, and SINTA)	145	All articles found
Screening	Selection based on title and abstract	95	Removing duplicates and irrelevant articles
Eligibility	Full text evaluation according to inclusion and exclusion criteria	43	Reading full text and assessing suitability
Inclusion	Articles selected for synthesis and analysis	32	Final articles analyzed

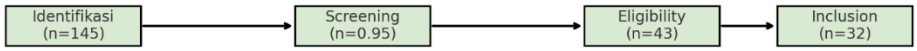

Figure 2. Results of the number of selected articles

To ensure the academic quality assessment of articles included in the analysis, a systematic quality assessment process was carried out at the eligibility stage. The criteria used included:

1) Clarity of research objectives;
2) Appropriateness of the methods used (e.g. experiments, case studies, prototype development);
3) The existence of empirical data or implementation results;
4) Direct relevance to AR-based cultural preservation in the context of Wayang;
5) Theoretical or practical contributions produced. Articles that did not meet at least three of the five criteria were eliminated from the final analysis.

This process was carried out by consensus by two researchers to minimize subjective bias.

2.5. Data Extraction and Analysis Techniques

After the selection stage, articles that meet the criteria will undergo a systematic data extraction process. This process aims to extract important information relevant to the research focus on the application of AR in the context of interactive digital cultural heritage, especially Wayang. The extracted data includes several main elements, as presented in Table 2.

Table 2. Systematic data extraction process

Data Element	Description
Year and Author's Name	Information on the year of publication and the main author of the article
AR Application Domain	AR usage area (museum, performance, education)
Objectives and Methodology	Research focus and methods (qualitative, quantitative, case studies, experiments)
Platform and Interaction	Technology used, and the type of user interaction
Results and Contributions	Reported achievements and benefits
Challenges and Limitations	Barriers and problems faced, both technical and cultural

2.6. Limitations

The SLR process, while comprehensive, has several limitations that should be considered when interpreting the findings:

1) Language Barrier: Only articles in English and Indonesian were included, which may have resulted in the exclusion of relevant studies published in other languages.
2) Publication Bias: The use of formal databases, such as Scopus, IEEE, ACM, and SINTA, limits coverage to peer-reviewed literature indexed in these platforms, potentially excluding relevant studies published outside these channels. This can lead to a publication bias, where studies published in less-represented journals or gray literature are overlooked.
3) Prototype Focus: The majority of studies included in this review concentrate on initial prototype development and early evaluations. This limits the ability to generalize findings to large-scale implementations or long-term effects.
4) Cultural Representation: There is limited involvement of indigenous cultural actors, such as puppeteers and traditional artists, in the design of AR applications. This may impact the authenticity and cultural sensitivity of digital representations of Wayang.
5) Technological Limitations: The accessibility and affordability of AR devices continue to be significant barriers to widespread adoption. Many regions

with limited technological infrastructure may not benefit from AR-based cultural preservation initiatives.

These limitations highlight areas for future research, particularly in improving collaboration with local cultural communities, conducting longitudinal studies, and expanding the accessibility of AR technologies.

3. RESULTS AND DISCUSSION

This chapter presents the results of the SLR analysis related to the implementation of AR technology in the context of interactive digital cultural heritage, especially in Wayang. Based on 32 articles selected and analyzed, this chapter discusses trends in technology development, design approaches, user interactions, benefits, and implementation challenges. It identifies research gaps that can be opportunities for future growth. The discussion is carried out thematically by formulating the research questions that have been formulated, thus providing a comprehensive picture of the current conditions and prospects for the development of AR technology for the digital preservation of traditional culture.

3.1. Trends in the Implementation of Augmented Reality in Interactive Digital Cultural Heritage (RQ1)

Based on the results of the selection and analysis of 32 articles that meet the criteria, there is a significant increase in the use of AR technology in interactive digital cultural heritage from 2020 to 2025. This development shows that AR is increasingly considered an innovative solution to overcome the challenges of preserving traditional culture in the digital era, especially to attract the interest of the younger generation who are more familiar with technology. Most studies focus on developing AR applications that combine educational and entertainment elements to introduce cultural heritage, especially in traditional art performances such as Wayang, dance, and historical artifacts in museums. Integrating interactive narratives and three-dimensional visualizations in AR can create a more interesting and easily understood learning experience for various groups [19], [20].

As many as 40% of the articles analyzed focused on AR applications in museums and art galleries. In this context, AR provides additional information that cannot be conveyed optimally through physical exhibitions alone, for example, by displaying digital reconstructions of artifacts, audio-visual historical stories, and direct interaction with collections via mobile devices [21], [22]. This approach has succeeded in increasing visitor engagement and expanding digital cultural access. Meanwhile, around 35% of studies highlighted the implementation of AR in the context of digital traditional performances, especially Wayang Kulit. This technology presents Wayang figures virtually and allows user interaction with the

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story and character movements, thus providing a more immersive performance sensation [23], [24]. This model effectively maintains and introduces Wayang art to the digital generation without relying on physical performances. In addition, another 25% of articles raised the use of AR in cultural education in schools and local communities. AR is integrated into the curriculum as an innovative learning medium [25], so that it can instill an understanding of local cultural values practically and enjoyably [26], [27]. This method has been proven to increase learning motivation and help strengthen cultural identity among students.

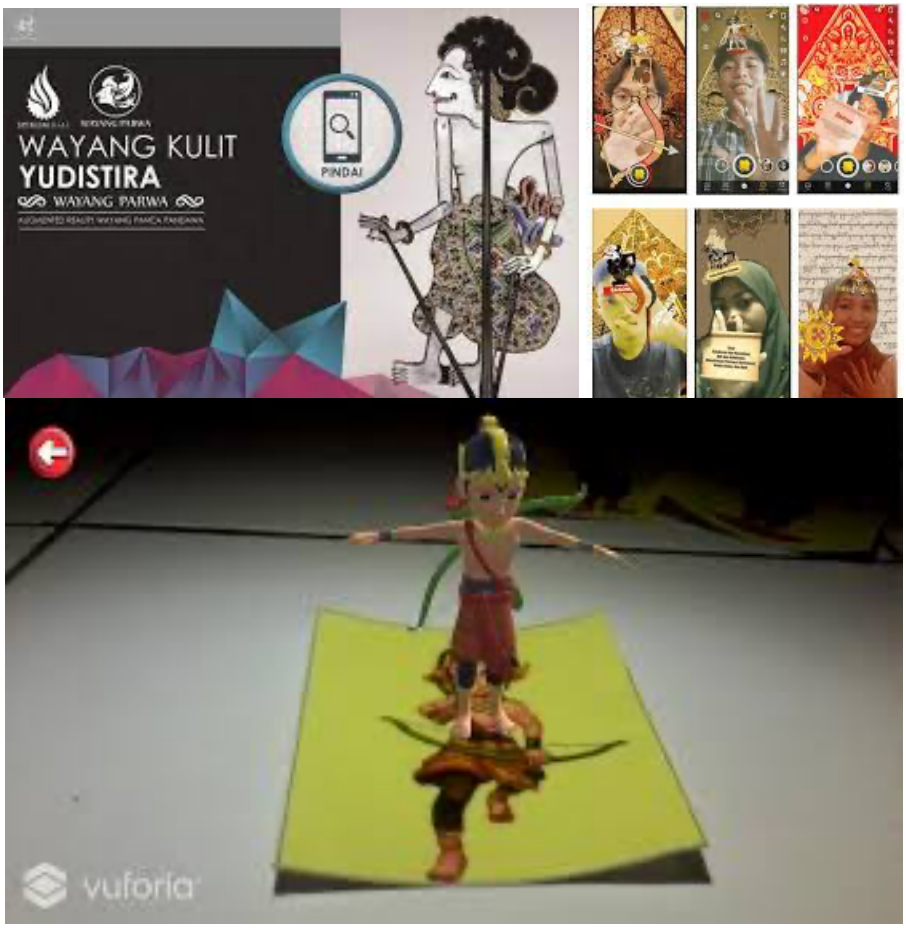

Figure 3. Several Examples of AR Wayang Applications [28], [29]

Figure 3 shows several examples of AR-based wayang implementations that researchers have widely developed. AR technology allows wayang characters that previously only existed in physical form to be presented digitally in a virtual space that users can see and interact with. Various studies have utilized AR to enhance

the Wayang performance experience by adding interactive elements such as user-controlled character movements, dynamic visual narratives, and educational elements that enrich the audience's understanding of the story and philosophy in Wayang. This innovation opens up great opportunities to preserve Wayang culture, allowing for more engaging performances that can be accessed by a wider audience, especially the younger generation, which is more familiar with digital technology. Thus, AR not only introduces a new way to enjoy Wayang, but also plays an important role in introducing and preserving traditional cultural heritage.

This trend indicates that AR effectively connects traditional cultural values with modern communication needs emphasizing interactivity and user experience [30], [31]. Thus, AR technology is a visualization tool and a medium for learning and preserving culture that is more inclusive and adaptive to changing times. However, most studies still focus on prototype development and initial evaluation, while large-scale implementation and sustainability of AR applications in the cultural sector are still challenges. This opens up opportunities for further research and development to improve the effectiveness and adoption of AR technology in preserving cultural heritage in the future.

3.2. Design Approaches and User Interaction Strategies in AR Applications (RQ2)

Analysis of design approaches and user interaction strategies in AR applications shows that most developers choose mobile device platforms such as smartphones and tablets. The most commonly applied interaction models are gesture and touch-based, considering the ease of access and the general public's familiarity with these devices [32], [33]. This approach allows users to interact directly with digital cultural elements intuitively, thus facilitating the adoption of AR technology in traditional cultural contexts.

In addition to mobile platforms, several studies have also begun to explore the use of smart glasses devices (Figure 4) that offer a hands-free and more immersive experience [34], [35]. However, the adoption of smart glasses is still limited by price constraints, device availability, and technical challenges such as battery limitations and user comfort [36]. Nevertheless, the potential of this technology is considered very large, especially for cultural applications that require freedom of movement and natural interaction.

In content design, many AR applications integrate cultural narratives in multimedia, such as audio, video, and 3D animation, combined with interactive storytelling [38], [39]. This strategy presents information visually and provides a deep story context so that users can holistically understand the meaning of culture. Gamification or game elements also increase user engagement and motivation in

exploring cultural content [40]. One popular innovation in cultural AR applications is using digital avatars, especially in the context of digital puppetry. Users can control these avatars by choosing characters and directing movements, thus creating a more personal and interactive experience [41], [42]. Real-time character movement animation also adds visual appeal. It gives the impression of a lively performance, which has been proven to attract the attention of children and adolescents, groups that have been difficult to reach by conventional traditional cultural media [43], [44]. Figure 5 shows an example of a 3D puppet object in AR [45], [46], which researchers have widely developed in recent years. In this implementation, traditional Wayang characters are brought to life in three-dimensional and two-dimensional forms that can interact with the surrounding environment in real-time via digital devices.

Figure 4. Example of the Application of AR smart glasses devices [37]

Figure 5. Examples of Wayang Objects presented in 3D and 2D

However, several studies have noted a lack of participation of indigenous cultural actors, such as puppeteers and traditional artists, in the application design process [47]. This causes some content to be less sensitive and less representative of actual cultural values, potentially leading to misinterpretation or loss of important meanings [48]. Therefore, closer collaboration between technology developers and artistic communities is needed so that AR applications can reflect cultural authenticity while meeting the needs of modern users. In conclusion, design and interaction strategies in AR applications for cultural preservation continue to develop and innovate. The use of mobile devices remains dominant, but new technologies such as smart glasses are starting to receive attention. Multimedia and gamification approaches have proven effective in increasing engagement, while collaboration with cultural actors is key to creating authentic and culturally meaningful applications.

3.3. Benefits and Challenges of AR Implementation for Local Cultural Preservation (RQ3)

The application of AR technology in preserving digital cultural heritage has brought various significant benefits. One of the main benefits is increasing audience engagement and participation through interactive and engaging learning experiences [49], [50]. By using AR, audiences, especially the younger generation, can interact directly with cultural content, making transferring cultural values and meanings more effective and enjoyable.

In addition, AR provides wider accessibility in various aspects of learning [51], including cultural heritage. People from different regions, including physically inaccessible areas, can access and learn about local culture through AR applications. This opens up opportunities for spreading and preserving more even and inclusive culture without geographical limitations. However, the implementation of AR is not without challenges. One of the main obstacles is the limited device technology, especially for segments of society who do not yet have access to or the ability to use the latest devices [52]. This is an obstacle in achieving the target of wide reach and equal distribution of the benefits of AR technology in cultural preservation.

In addition to the technological aspect, cultural sensitivity is also an important concern. In some cases, digital content presented through AR is at risk of simplifying cultural values or distorting the original meaning. The lack of supervision and direct involvement from cultural actors can lead to inaccurate cultural representations and disrespect for important aspects of the tradition [53], [54]. Another obstacle is the limited resources to properly document culture digitally [55], [56]. Minimal and poorly structured documentation makes developing rich and authentic AR content difficult. This also affects the

sustainability and quality of AR applications in the long term. Therefore, close collaboration between technology developers, cultural experts, and local communities is key to the success of AR implementation. This collaboration ensures technical innovation, maintains the authenticity of cultural values, and makes a real contribution to the digital preservation of cultural heritage.

3.4. Research Gaps and Future Development Directions (RQ4)

The SLR results revealed several important gaps that need further attention in developing AR technology to preserve digital cultural heritage. One of the main gaps is the lack of studies that discuss the long-term impact of AR use on cultural preservation. Existing studies focus on prototype development and initial evaluation without examining how this technology affects cultural behavior and public awareness over a wider period [57], [58]. Furthermore, the development of participatory AR applications involving indigenous cultural communities is still very limited. Many applications are developed without directly involving cultural actors in the design and development process [59], [60]. These risks reducing the authenticity and cultural sensitivity of digital content, so a more inclusive approach is needed so that AR technology can reflect cultural values accurately and meaningfully for local communities.

On the other hand, testing the effectiveness of AR applications in cultural education also still needs to be strengthened. So far, the evaluation methods have been mostly qualitative and limited in sample coverage [61], [62]. More comprehensive quantitative evaluations and longitudinal studies are needed to ensure that AR applications can significantly improve cultural understanding and appreciation, especially among the younger generation. In addition, the challenges of accessibility and affordability of AR devices are real obstacles to the widespread application of this technology [63], [64]. The development of a simpler, more affordable, and more accessible AR platform for the wider community is urgently needed to ensure the equal distribution of the benefits of preserving digital culture. This is important so that technology is not only enjoyed by a limited group of people with financial and technical capabilities. To address these gaps, the direction of future development is suggested to adopt a multidisciplinary approach involving cultural experts, educators, technologists, and local communities from the early stages of designing AR applications. This collaboration is expected to produce technically innovative and authentic technological solutions that respect traditional cultural values. Thus, future research and development of Augmented Reality technology for cultural preservation must strengthen cross-disciplinary collaboration, improve evaluation quality, and equalize access to technology so that its benefits can be felt widely and sustainably.

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Overall, the results of this systematic literature review reveal a clear trend in the use of AR technology for interactive digital cultural heritage preservation, particularly in Wayang performances and other traditional arts. The diverse design approaches and user interaction strategies demonstrate significant progress in developing engaging and educational applications. The benefits of implementing this technology are diverse, ranging from increased audience engagement to expanded cultural access, although they are not without complex technical and artistic challenges. The identified research gaps provide opportunities for further in-depth and collaborative studies, particularly regarding long-term impact, community participation, and technology accessibility. These findings provide an important foundation for developing more effective and sustainable cultural technology innovations in the future.

3.4. Discussion

The results from this systematic literature review (SLR) illuminate the increasing integration of Augmented Reality (AR) in preserving and promoting interactive digital cultural heritage, especially in the realm of traditional Wayang art. This discussion delves into the key findings by aligning them with the predefined research questions (RQs), allowing for a nuanced understanding of the current developments, prevailing challenges, and potential future directions in AR cultural applications.

The upward trend in AR usage from 2020 to 2025 reflects a growing recognition of its potential in cultural preservation. This spike is not merely technological enthusiasm; it mirrors a broader societal shift towards digital engagement, particularly among younger generations. The SLR indicates that AR does more than visualize content—it redefines how users engage with it. Cultural heritage, once confined to physical spaces and limited audiences, is now becoming globally accessible and more dynamically experienced through AR platforms.

The most promising application areas include museums, traditional performances like Wayang Kulit, and educational institutions. Museums leverage AR to deepen visitor engagement by overlaying digital narratives onto static exhibits, offering immersive reconstructions of historical artifacts and performances. In the context of Wayang, AR transforms a traditionally live and physical art form into a virtual, interactive experience. This not only modernizes the medium but also extends its reach to audiences unfamiliar with or geographically distant from such cultural practices. For example, AR applications allow users to manipulate Wayang characters, follow interactive storylines, and even engage with the philosophy behind the stories—features that are particularly appealing in educational settings. However, these positive developments come with limitations. Most applications remain in prototype stages with limited longitudinal testing or real-world

deployment. While innovation thrives in controlled environments, real-world adoption and sustainability remain underexplored. This suggests a potential research trajectory focused on evaluating long-term cultural impact and user retention in AR-based cultural experiences.

The design and interaction paradigms adopted in cultural AR applications prioritize accessibility and ease of use. Mobile devices dominate the platform landscape due to their widespread availability and intuitive interfaces. Touch and gesture-based controls are not only user-friendly but also facilitate natural interaction with digital cultural elements. These interaction models democratize access, ensuring even tech-novice users can explore cultural heritage through AR without steep learning curves.

Emerging technologies like smart glasses are slowly entering the scene, promising hands-free and more immersive experiences. However, practical barriers—high costs, limited commercial availability, and hardware constraints—restrict widespread adoption. The few studies that have piloted smart glasses in cultural contexts underscore their potential but also their current impracticality for mass deployment. From a content perspective, integrating multimedia elements such as 3D animation, audio narration, and gamified storytelling has proven effective in enhancing user immersion. A standout innovation is the use of digital avatars in puppetry. These avatars, designed to mimic traditional Wayang figures, can be controlled by users in real time, allowing for personalized narrative experiences. This interactivity not only makes the content more engaging but also fosters deeper emotional and cognitive connections to cultural narratives.

Despite these advances, there is a notable shortfall in participatory design. Cultural practitioners such as dalangs (puppeteers), artisans, and historians—are rarely included in the development process. This disconnects risks diluting cultural authenticity or misrepresenting nuanced traditions. To ensure cultural sensitivity and accuracy, co-creation models that involve these stakeholders from the outset must be prioritized. Without their input, even the most technologically sophisticated AR applications may fall short of conveying true cultural essence.

AR's ability to make cultural experiences interactive and engaging is well-documented in the reviewed literature. For younger users in particular, traditional storytelling becomes more compelling when experienced through immersive technologies. AR applications stimulate curiosity, foster cultural identity, and potentially revitalize endangered art forms like Wayang. In educational settings, the integration of AR into curricula provides an enjoyable, multisensory learning medium, helping students grasp abstract cultural values in tangible ways. Equally important is AR's role in enhancing accessibility. Communities in remote or under-resourced areas can now explore cultural heritage previously restricted to urban

museums or live performances. This technological reach supports the broader agenda of democratizing culture and reducing geographic inequalities in access to heritage resources.

Yet, several challenges hinder the full realization of these benefits. First, technological access remains uneven. High-end AR applications require modern devices and robust internet connectivity—luxuries not uniformly available, especially in developing regions. Second, content accuracy and cultural sensitivity pose ethical dilemmas. Simplifying or gamifying complex traditions might inadvertently distort or trivialize sacred aspects of cultural heritage. Without oversight from cultural custodians, there is a risk of creating content that entertains but misinforms. Additionally, the lack of comprehensive digital documentation presents a critical bottleneck. AR systems rely on accurate, detailed data to function effectively. Inadequate documentation compromises content quality and limits application scalability. Addressing this requires systematic efforts to digitize cultural knowledge and artifacts, ideally with community participation to ensure cultural fidelity.

Several research gaps stand out as priorities for future exploration. Most pressing is the lack of studies examining the long-term impact of AR use in cultural settings. While short-term engagement metrics are promising, it remains unclear whether AR fosters lasting appreciation or changes in cultural behavior. Longitudinal studies tracking users over extended periods could shed light on these dynamics. Another critical gap is the low participation of local cultural communities in AR content creation. While developers and designers often spearhead technical innovation, they frequently overlook the value of community-based knowledge systems. Building AR experiences without the cultural actors whose heritage is being digitized can result in shallow or inaccurate representations. Future projects should therefore adopt participatory approaches that empower communities to become co-creators of their digital heritage.

Evaluation methods also need refinement. Current assessments are often qualitative and limited in scale. A combination of qualitative insights and quantitative metrics (e.g., learning outcomes, user retention, emotional resonance) would provide a more holistic picture of AR's effectiveness in cultural education and preservation. Lastly, technology access remains a systemic barrier. Even the best-designed AR applications are ineffective if the target audience lacks the necessary devices or digital literacy. Future innovation should focus on low-cost, lightweight AR solutions tailored for under-resourced settings. Equally important is building local capacity through digital training programs, ensuring communities are not just passive users but active contributors to their cultural futures.

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4. CONCLUSION

This study has systematically reviewed various studies on the application of AR in the preservation of interactive digital cultural heritage, particularly in relation to Wayang performances and other traditional arts, from 2020 to 2025. The results of the review indicate that AR is increasingly being widely adopted as an innovative solution that combines educational and entertainment elements to enhance the appeal of traditional culture for the younger generation, who are more familiar with digital technology. Most of the AR applications developed utilize mobile platforms with intuitive gesture and touch-based interactions, and integrate multimedia narratives and gamification to enhance user engagement. This approach has proven effective in helping users understand cultural values more deeply and enjoyably, thereby supporting cultural preservation in a more dynamic way. However, this study also found significant challenges in AR implementation, including limited access to technology in terms of hardware and user capabilities. In addition, cultural sensitivity is an important issue, where the lack of involvement of indigenous cultural communities in the design process may pose a risk of presenting less authentic content and potentially obscuring the original values of the culture.

Identified research gaps include the lack of studies examining the long-term impact of AR use on cultural preservation and the lack of participatory approaches that actively involve cultural communities in application development. Moreover, limited accessibility to technology remains a barrier to expanding the reach of AR's benefits to a wider audience, especially in areas with limited digital infrastructure. Therefore, future AR application development is recommended to adopt a multidisciplinary approach involving cultural experts, educators, technology developers, and local communities from the design phase. This inclusive approach is essential to produce products that are not only technologically innovative but also respect and authentically represent cultural values. Additionally, future research and development must focus on comprehensive evaluations that include both quantitative and qualitative aspects and assess the sustainability of using AR applications in a cultural context. This is crucial so that the technology's benefits can be felt sustainably and make a real contribution to preserving traditional culture in the digital age. Overall, Augmented Reality has great potential as an innovative and effective cultural preservation tool. The success of this technology is highly dependent on culturally sensitive design and collaborative support from all stakeholders. This research is expected to serve as a foundation and important reference for the development of sustainable digital cultural technologies and positively impact the preservation of cultural heritage both in Indonesia and globally.

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