Jurnal Publikasi Manajemen Informatika
Volume 4 Nomor 1 Tahun 2025
E-ISSN : 2808-9014; P-ISSN 2808-9359, Hal 306-326
DOI: https://doi.org/10.55606/jupumi.v4i1.3748
Available online at: https://ejurnal.stie-trianandra.ac.id/index.php/jupumi

Artificial Intelligence-Driven Digital Communication : Evaluating the Mobile-Applications and Fostering Policies for Cultural Heritage Preservation

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Abstract: *This study investigates whether AI is a possible game-changer in the communications industry for cultural manifestations digitally and, hence, an active protagonist in the moisture preservation and sustenance of Nusantara cultural heritage. By examining eight cultural applications on the Google Playstore ranging from cultural education application to local language dictionary application and so on, this research evaluate the existing mobile apps and future opportunities for integrating AI into cultural preservation endeavors. The results indicate that present applications do not employ AI but there is great potential for incorporating AI features such as adaptive learning, semantic search, and personalization of content recommendations. The study stresses having a solid digital backbone defined by an inclusive policy framework and collaborative inter-disciplines which is crucial because of challenges such as disparities in technological access, data privacy concerns, and resistance from culture. Policy recommendations ensuring the responsible use of AI are put forward in terms of ethical standards, digital literacy, and sustainable development that strive to advance Indonesia's digitalization narratives in harmony with cultural sustainability in the wake of the digital era.*

Keywords: *Artificial intelligence; digital communication; cultural heritage preservation; AI integration; digital governance*

1. INTRODUCTION

Currently artificial intelligence reshaping digital communication entirely and providing out-of-this-world possibilities for conserving and sustaining cultural heritage (Li, 2021). This amazing deluge of AI technologies, including machine learning, natural language processing, computer-vision tosses, and even various immersive tools like virtual reality (VR) and augmented reality (AR), has revolutionized the way in which cultural artifacts are documented, maintained, and spread all over the world. Symptomatic AI systems like those empowered by ChatGPT are now put to significant use in translating text across many languages in ways that effortlessly promote international cross-cultural exchange as well as give a global audience access to their heritage (Bouziane & Bouziane, 2025; Constantin & Kavoura, 2024). Just as well, AI has been used for documenting languages that are on the brink of extinction, like Bambara, with an assurance that it will be preserved to benefit generations unborn (Daou & Mohanty, 2024). In this way, the

Received: November 18, 2024; Revised: Desember 16, 2024; Accepted: Januari 27, 2025; Published: Januari 30, 2025

importance of AI unfolds in not just the preservation of culture, but also in the limitation of language barriers that have so far impaired cross-border transmission of culture.

Once considerably focused on various national public activities, there is wide belief in the integration of AI at the public sector level, with pioneering impetus by countries such as China, France, Germany, and Spain, seeking long-term approaches for incorporating AI into public infrastucturing, human resources, policies and ethics (Sandoval-Almazan et al., 2021). Not greatly ulterior to some extent these strategies are intended for a search towards service delivery that leaves bureaucracy far behind; thereby operations from the bottom, transparency, and innovation are their frontline concerns . This is something the European Union strongly supports, intending that member states should find the courage in investing in AI to bridge the digital divide within the public administration to set in place more intelligent and responsive governance systems (Androniceanu, 2023). Countless are the gains from AI interventions that have tested waters across all governmental institutions where AI applications have steered management with strengthened economic and social effectiveness, leading to more fortuitous delivery of public services. However, the rapid growth of AI also poses hurdles to governance considerations, ethical issues and the necessity for articulate laws to guide AI investment and usage (Chainoglou & Katsios, 2024).

In cultural heritage, AI has birthed 3D modeling for cultural assets in terms of high quality and offers attractive models of cultural heritage, made possible through photogrammetry and laser scanning techniques. The concept of Digital Twins is fundamental to understand AI, as these are virtual copies of physical heritage sites utilized for continuous observation, predictive maintenance, and conservation of cultural resources (Nisticò, 2024). AI also provides data analysis and restoration solutions to predict anomalies, carry out remediation for heritage assets, and monitor the health operational behavior of the structure. Moreover, AI has been employed to provide assistance in the digital restoration of severely damaged cultural artifacts stuch as murals or sculptures, helping recreate the missing or deteriorated portions with high levels of precision (Cao et al., 2019; Stanco et al., 2011). AI improvements have additionally scored marks on the accessibility to engage with cultural heritage. A number of exceptional uses, given by AI, include the possibility of developing immersive virtual experiences through VR and AR in order that one can explore and experience cultural sites in idiosyncratic ways (Jiang et al., 2024; Moral-Andrés et al., 2024). AI-transformed culture tourism has become more realistic through the provision of individualized cultural recommendations influencing

visitor experiences and education (Pavlidis, 2023). In another perspective, the AI way has been revolutionizing cultural data management by consolidating vast culture-related data, ensuring reliability of digitization, and overcoming more pertinent issues of data quality and bias (Neudecker, 2022). Preservation of intangible cultural heritage, such as traditional dance forms, has also journeyed in the blessings of AI technologies, with their application in the classification and digitizing of these cultural expressions (Reshma et al., 2023). However, AI has raised several ethical concerns regarding its use in the field of cultural heritage. Digitization, in this respect, must prioritize the integrity and authenticity of the digital artifacts, ensuring that the produced artifacts are unmistakably identified with their real counterparts, without any unintended biases or personal interference (Sangeethaa et al., 2024). Mainly, the issue of data privacy and ownership arises as crucial, given that these processes of digitization can often entail work with cultural artifacts and data that have sensitive value in protecting them against illegal access and misuse (Ailakhu, 2024; Mannheimer et al., 2024). The democratization of access to cultural heritage through AI platforms is all preached right, but then it must be balanced by cultural sensitivity and comprehensiveness to prevent marginalization and to ensure equitable representation of diverse cultural narratives (Kumar & Tiwari, 2024; Sangeethaa et al., 2024). It is imperative to lay down ethical guidelines for the uses of AI in cultural heritage addressing the concerns. These frameworks should promote transparency, sharing of responsibility, explainability, and sustainability, fostering a culture of collaboration between cultural heritage experts and technology developers (Ribeiro et al., 2024). Also, sustainability of AI-driven built-up preservation has come under scrutiny in terms of environmental considerations surrounding their ecological effectiveness, if they are adaptable, and how rapidly these innovations can be let into antiquities (Le-Nguyen, 2024).

Digitalization efforts in this context, in Indonesia have been initiated by some projects at the National Museum of Indonesia using AR and VR to bring visitors closer to cultural artifacts (Adiba et al., 2025). Mobile applications for cultural preservation-such as the applications made in this study with regard to the Dayak tribe-indicate how much AI can do in the area of cultural communication and upholding traditions (Budiman et al., 2019). In fact, one of the many shortcomings that Indonesia has in its digitization is the disparity of digital infrastructure between urban and rural areas, the gap of policy, copyright problems, and the lack of sufficient digital infrastructure (Putranto et al., 2025). Though already reported and promoted, platforms such as Batik and Wayang, as well as others, have taken great strides in the area of digital culturalization, there still exist gaps in the

study of these platforms as well as the potential of AI in cultural sustainability (Permatasari et al., 2020).

The gap this study intends to fill by investigating the role of AI in digital cultural communication; evaluating eight culture application platforms available at present; and providing policy recommendations that will facilitate cultural sustainability and further digitalization. Through research on the role of AI in digitalizing culture, this study feeds into Sustainable Development Goals/SDG 4 (Quality Education), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 11 (Sustainable Cities and Communities). AI can help culturally inclusive education be more accessible (SDG 4), build digital infrastructures for conservation of cultural heritage (SDG 9), and help ensure sustainability and accessibility of culture in this digital age (SDG 11). Offering policy recommendations, the present research identifies challenges and opportunities to further ensure sustainability and inclusiveness within the digital ecosystem for culture. This research endeavors to ensure the integrity and authenticity of cultural expressions even as AI technologies facilitate greater access to cultural heritage. While nurturing collaboration of these, and all relevant bodies, such as local communities, academicians, and policymakers, this study aspires to the development of sustainable digital heritage practices that will preserve and promote Indonesia's rich cultural identity in the digitized age.

2. METHOD

In this research work, a mixed-method approach is used that includes secondary data analysis as well as literature review to explore the roles of artificial intelligence (AI) as well as its viability for the Nusantara cultural heritage's preservation in digital cultural communication like some previous studies (Claro & Africano, 2023; Murphy et al., 2024). The exploratory-descriptive design of research was used to identify opportunities and constraints of AI integration at present and digital cultural applications. The policy recommendations are derived from a detailed review of existing literature and platform evaluation through direct analysis of selected applications. Searching and collecting data from an application involved keywords "budaya" and "Jawa," resulting in eight selected applications over Google Playstore:

Belajar Bahasa Jawa + Suara (Solite Kids); Aksara Jawa (Hirson); Menulis Aksara Jawa (Qreatif); Kamus Jawa Lengkap (Offline) (Sukron Jazuli); Belmain – Belajar Budaya Nusantara (Belmain ID); Marbel Gim Belajar Budaya (Educa Studio); Belajar Budaya Indonesia + Suara (Solite Kids); Complete Indonesian Culture (Ambo Dalle Apps)

These applications were analyzed based on all available information, including user reviews, application descriptions, features, interface design, and overall user experience. Observations were conducted directly from the Playstore pages and application interfaces, and data have been extracted into comparative analyses according to various angles, namely, AI integration, UI/UX quality, content depth, data security, and potential future uses of AI following some previous studies on the same field (Sajida et al., 2023). The analytical framework used thematic analysis to identify AI themes, cultural digitalization practices, and policy considerations. Comparative analysis evaluated the strengths and weaknesses of each application. A comprehensive literature review of AI applications in cultural heritage, digital governance, and policy frameworks was conducted simultaneously to feed into the policy recommendations. The data were coded and categorized, while the findings were triangulated using academic literature and policy documents to ensure validity. This broad-based analysis forms the basis upon which understanding current gaps, and proposing future AI-driven solutions for cultural heritage sustainability in Indonesia, are built.

3. RESULTS AND DISCUSSION

Evaluating The Existing Mobile-Applications on Cultural Preservation

An evaluation of eight Nusantara culture apps on Playstore revealed significant variation in terms of downloads, ratings, and user reviews. Aksara Jawa by Hirson is the most popular app scoring download numbers above 1 million-plus downloads, which means there is high public demand for learning Javanese script. However, there are serious technical issues accompanying this popularity. A review by a user states, "The app closes on its own every time I type 'Ngla'," indicating that even with widespread use, stability is an issue of the app. The number of downloads for this app signals that Aksara Jawa has few competitors; nevertheless, these technical issues could jeopardize any future prospects in development, particularly in implementing AI for more complex functions such as Optical Character Recognition (OCR) of Javanese script. On the other hand, Complete Indonesian Culture by Ambo Dalle App only has 5K-plus downloads but deserves a 4.5 rating (See: Table 1). Some positive reviews such as one of user said "Very good, the information is complete," reflect appreciation for apps with much cultural content, although interactivity is limited. This signifies additional users put more regard toward depth of content than solely interactive features. The applications therefore hold immense potential for AI integration, especially in managing data and providing adaptive presentations of

information based on user preferences. The Javanese Language Learning + Voice application by Solite Kids (100+ downloads, rating 4.4) and Marbel Gim Belajar Budaya by Educa Studio (100+ downloads, rating 4.5) show a growing demand for interaction-based educational applications, particularly from children and students. One of user lauded Marbel Gim: "Good, the app is also not slow, comfortable to use," highlighting the importance of a friendly user interface that is responsive. However, the app was also criticized for its limited vocabulary and lack of content updates. AI integration into such apps can garner greater user engagement through adaptive learning, where the system can evaluate the user's understanding level and, thus, adjust the learning material accordingly. In contrast, Kamus Jawa Lengkap (Offline) faces different challenges. Despite its simple features, this application has received harsh criticism such as from Savakichi (2025): "Garbage dictionary. The Javanese vocabulary entries are very few," which shows users' high expectations for data completeness. AI integration can help expand the database automatically by utilizing machine learning algorithms to update and add vocabulary periodically. The Belmain and Belajar Budaya Indonesia + Suara applications stand out for their educational content that covers various cultures of the archipelago, but are still limited in scope and interaction. For example, Wiwin Winarti (2022) praised Belajar Budaya Indonesia + Suara: "Good, I like it," but there was also criticism for its lack of content variety. AI can support the automation of content updates and provide a richer learning experience via personalization features.

Table 1. Overview of Nusantara Cultural Learning Applications on Playstore

No.	*Mobile App*	*Developer*	*Released Date*	*Download Number*	*Rating*	*Review Number*	*Size*	*Data Safety*
1	*Belajar Bahasa Jawa + Suara*	Solite Kids	Apr 15, 2024	100K+	4.4	748	35 MB	No data collected, encrypted ("No data collected" – Playstore)
2	*Aksara Jawa*	Hirson	Oct 27, 2024	1M+	4.3	7.6K	28 MB	Collects device data, unencrypted ("This app may collect device IDs" – Playstore)
3	*Menulis Aksara Jawa*	Qreatif	Jan 9, 2025	1K+	4.0	1.2K	30 MB	Collects device data ("This app may collect device IDs" – Playstore)
4	*Kamus Jawa Lengkap (Offline)*	Sukron Jazuli	Jan 20, 2025	100K+	4.1	322	20 MB	Collects data, encrypted ("No data collected" – Playstore)

5	*Belmain - Belajar Budaya Nusantara*	Belmain ID	Nov 21, 2024	1K+	4.3	11	25 MB	Collects personal data, encrypted ("This app may collect personal info" – Playstore)
6	*Marbel Gim Belajar Budaya*	Educa Studio	Jun 26, 2024	100K+	4.5	1.9K	50 MB	Collects device data ("This app may collect device IDs" – Playstore)
7	*Belajar Budaya Indonesia + Suara*	Solite Kids	Mar 5, 2024	10K+	4.3	157	30 MB	Does not collect data ("No data collected" – Playstore)
8	*Complete Indonesian Culture*	Ambo Dalle Apps	Feb 14, 2025	5K+	4.5	26	40 MB	Does not collect data ("No data collected" – Playstore)

Then, regarding to data security and privacy feature as indispensable dimensions in viewing the Nusantara cultural application usability on Playstore, especially touching on artificial intelligence policies in Indonesia as laid down by Government Regulation No. 71 of 2019 concerning the Implementation of Electronic Systems and Transactions. The analysis conducted on the eight applications under scrutiny disclosed divergent approaches to user data management and had significant consequences toward AI policy considerations and privacy safeguarding in Indonesia. Aksara Jawa by Hirson and Marbel Gim Belajar Budaya by Educa Studio are applications that collect device data like application activity, performance information, and device IDs, while granting no encryption of the data (see: Table 1). On the other hand, Complete Indonesian Culture by Ambo Dalle Apps and Belajar Bahasa Jawa + Suara by Solite Kids represent a different commercial application paradigm since they do not collect user data according to the descriptions available in Playstore. This brings extra assurance to the users, in line with the data protection policies in Indonesia, especially given increased concern regarding data tracking and exploitation of personal information. A user said, "I feel secure using this application as it does not ask for excessive access," shows appreciation from users for systems that value their privacy. But then occurs the irony; those applications that secure better privacy for the users turned out to be less interactive and dynamic. Applications that are data-oriented, conversely, exploit this information to enhance user experience by providing content and services tailored to user analysis on their behavior. This is exactly where AI finds its worth. In this respectful way, compliance to AI provides possibilities for the applications to collect and analyze data anonymously, through using encryption, thereby making personalized experiences without

compromising the individual's privacy. AI can also be used to get usage patterns to bring content suggestions without really knowing who the user is. This strategy would also be in line with Indonesia's national strategy to push artificial intelligence adoption, as stated in the National AI Strategy 2020-2045, recognizing that innovation in technology goes hand-in-hand with protection of privacy (Sajida & Pratiwi, 2025). It's a gap, hence a challenge but also an opportunity for Indonesian cultural app developers. For example, strict AI policies as enforced in developed countries may help motivate developers into adopting a higher standard of safety, meaning that apps for cultures in Nusantara would not be recreated for education but would also be examples of responsible technology application in support of digitalization by the government without making cultural digitization devices shred people's digital rights.

Next, User reviews reflect the experience, satisfaction, and challenges using an app. Eight Nusantara cultural apps on the Playstore reflect on thousands of reviews that showcase the strengths and weaknesses of each app and what users expect from cultural education apps in today's digital era. The Marbel Cultural Learning Game by Educa Studio, with 100K+ downloads and a rating of 4.5, has received constructive praise for its interactivity and usability. One of users went on to say, “Good, the app is also not slow, comfortable to use.” Such endorsements serve to highlight performance relative to speed and responsiveness where the flow path is likely to be extenuated. Interactivity remains a huge driver for app engagement, especially for children and students. Through interactive quizzes, appealing graphics, and educational audio, the entire learning experience could be enjoyable and efficient. Fun as it may be, too much negativity has emerged, such as from A Google User on 2018 also stated, “It would be better if the names of the clothes were also included,” stressing the need for more content components if the app aims to add value to real life. In contrast, Complete Indonesian Culture by Ambo Dalle Apps was praised for being rich in content by one of users saying, “Very good, complete information,” while at the same time it suffered from a lack of interactivity. In her words, “Good but too static, not interactive enough,” said a user, reiterated the challenges data-driven apps face in keeping user engagement. Even if in-depth information remains the mainstay of appeal, the app may soon come to be perceived as boring, especially for young users who are probably accustomed to apps that provide a fair share of personalization or gaming features. Other apps such as Belajar Bahasa Jawa + Suara by Solite Kids are appreciated for its basic content suitable for children, but criticism relates to limited material. One of users states, “Too basic, only a few words in Javanese,” thereby indicating that there are higher user

expectations for completeness of content. Dynamic AI can be used to update and expand content to meet those expectations, adapting to the evolving needs of users. From this review, it is obvious that user engagement is influenced greatly by content quality, technical stability, and interactivity. AI integration could propose solutions such as adaptive learning that modifies materials based on user progress, automatic detection for bugs, and real-time content updates. AI could encourage the advanced quality and engagement of the app in Nusantara cultural application to support cultural education's digitalization and protect cultural preservation in this age.

Table 2. Comparative Analysis of Data Safety, AI Integration Potential, and Policy Relevance in Cultural Learning Applications

No.	Mobile Apps	AI Indication	Mobile Apps Evaluation	Policy Relevance	Opportunities for AI Implementation
1	*Belajar Bahasa Jawa + Suara*	No indication of AI is visible.	The app uses static audio and interactive quizzes based on manual scripts, not machine learning.	Supporting local language education and technology-based cultural preservation	AI Speech Recognition to correct and assist Javanese pronunciation, or NLP-based chatbots for language learning interactions.
2	*Aksara Jawa*	Potential rule-based algorithm for transliteration	The transliteration algorithm appears static and rule-based, showing no adaptation or learning typical of AI.	Potential to support digital local language scripts in school curriculum and digital culture policies	OCR and machine learning to automatically recognize and transliterate handwritten Javanese script, adapting to the user's writing style.
3	*Menulis Aksara Jawa*	Potential simple pattern recognition.	The pattern-based proofreading is simple, showing no adaptive AI that learns from user habits.	Supporting literacy education in digital curriculum, preservation of Javanese script	AI handwriting recognition so that applications can learn and adjust script corrections based on the user's writing patterns adaptively.
4	*Kamus Jawa Lengkap (Offline)*	No indication of AI is visible, static search.	The dictionary database is static, with no features like semantic search or AI-based recommendations.	Supporting digital cultural literacy policies and AI integration in education	AI semantic search for more contextual search results, and adapt search results based on the user's search history.

5	*Belmain - Belajar Budaya Nusantara*	No indication of AI is visible.	The quizzes and educational games are manually generated, with no adaptive algorithms that adjust difficulty based on user ability.	Supporting digitalization of national cultural education, potential for interactive curriculum	AI gamification engine to automatically adjust the difficulty level of the game according to user performance, increasing engagement.
6	*Marbel Gim Belajar Budaya*	No indication of AI is visible.	The cultural content is presented statically, with no personalization or adaptation based on user interactions.	Relevant for AI integration in national cultural and education curriculum	AI-based recommendation system so that applications can recommend cultural materials according to the user's interests and learning history.
7	*Belajar Budaya Indonesia + Suara*	No indication of AI is visible.	The quizzes, puzzles, and audio content are static, with no adaptive learning algorithms or personalization.	Supporting cultural education in the digital era and AI integration in learning materials	AI visual recognition to detect cultural images from the camera and provide automatic information, enriching the cultural learning experience.
8	*Complete Indonesia n Culture*	No indication of AI is visible.	The cultural database is complete but static, with a simple search feature with no AI for autocomplete or contextual understanding.	Supporting data-based cultural preservation policies, potential for AI integration in cultural research	AI cultural archive engine to automatically update and add cultural content, according to the latest data and user preferences.

Currently, none of AI technology within the eight analyzed Nusantara cultural applications. All of the applications remain static, having pre-determined content and features that cannot yet respond dynamically to user behavior (See: Table 2). The table evidently shows that while some applications have potentials to integrate AI, most of them are operating under a very traditional setting without the use of learning algorithms, natural language processing- or any sort of general AI-enhanced mechanism. For example, Belajar Bahasa Jawa + Suara offers a static learning experience with audio clips and interactive quizzes with a manual script, which does not permit any AI-driven customization. An AI speech recognition service to grade and assist with Javanese pronunciation would be a huge

improvement for this app. Furthermore, an NLP-based chatbot for active conversation practice would greatly increase engagement and effectiveness in learning a language. Similarly, Aksara Jawa is still based on a rule-based transliteration algorithm, having no adaptive learning capabilities at all. The existing transliteration system executes its work based on given rules without adapting to different writing styles or user preferences. AI integration with the support of optical character recognition (OCR) and machine learning algorithms could greatly enhance automatic recognition of Javanese script even if handwritten, so as to render the app very intuitive and user-friendly. Another case is *Menulis Aksara Jawa,* where it seems some basic pattern recognition is in use for handwriting exercises. Elsewise, lack of AI adaptability inhibits the application from enriching the user experience. Incorporating AI-powered handwriting recognition would allow the application to learn from users' writing patterns and improve its correction system to provide a personalized and adaptive approach to learning Javanese script. Kamus Jawa Lengkap (Offline) today runs on a basic static database with basic word search features without AI upgrades. Integrating semantic search AI would provide contextual word recommendations and personalized vocabulary suggestions based on users' search histories—greatly improving overall usability for language learners needing precise definitions and contextual meaning of Javanese words. Regarding cultural education, applications like Belmain - Belajar Budaya Nusantara and Marbel Gim Belajar Budaya rely heavily on static quizzes and educational games developed from human intellect. None of them have AI-moderated adaptive gamification engines that could flexibly adjust the quiz difficulty to the individual performance of students. The introduction of AI in these apps would engender a personalized learning journey, consequently maximizing their engagement and retention of knowledge. Belajar Budaya Indonesia + Suara and Complete Indonesian Culture are simply babysitting static repositories of cultural information with no AI-modulated content personalization. AI recommendation systems could support tailoring content based on preferences, thereby making cultural learning interactive and user-centric. Likewise, by incorporating AI, the Complete Indonesian Culture could also allow automated content updates from a cultural archive engine, guaranteeing the up-to-dateness of information and an infinite enlargement of the information pool with newer data.

Reflections on Opportunities and Challenges

While there are many opportunities that AI could harness in improving cultural education and preservation, adaptations would have to be made through progressive

technologies such as Natural Language Processing, Computer Vision, and Machine Learning with AI-enabled archiving, which leads to adaptive personalized learning experiences. NLP has heavily contributed to regional language education through enabling students' engagement via interactive and personalized-mediated learning experiences that speeds up language learning acquisition (Arani, 2024; Liu & Fu, 2024). AI machine learning applications for language learning like CILS-Cross-Cultural Intelligent Language Learning System primarily work with NLP for inputting knowledge relevant to learners' cultural situations, developing language-and culture-harmonized overall competencies in learning (Xia et al., 2024). The Regional Language Character Mapper in Education (RLCME) is another real illustration of how NLP can map information among closely related languages for multilingual text and speech processing (Jawanda, 2011). It is not only to collect user corpora for processing through integrated speech technologies and linguistic resources but also to analyze where the additions of language learnings take place that is used to develop platforms such as An Scéalaí for Irish (Chiaráin et al., 2022). Parallel Alpaca corpus building and mining from webpages also involves language documentation and preservation through reinterpretation of the Chinese-Mongolian language documentation because this activity is geared at the automatic identification of parallel texts valuable at sustainability for minority languages (Zhu et al., 2012). AI has been put into practice in preserving indigenous languages like Bambara from one generation to the next: efficient documentation and translation (Daou & Mohanty, 2024). Benefits for recognizing cultural objects extend not just digitization and study of artifacts, but also include actual AI systems creating tangible environments that may enhance the study of heritage, as shown in Tang Dynasty costumes preserved as historical artifacts and the interactive tools like AsasaraBot for Minoan Civilization education (Du, 2024; Mageira et al., 2022). Personalization of cultural education through learning content adaptation according to individual learners' needs for specific challenges with real-time adaptation and dynamic content changes improves outcomes and increases effectiveness (Thingom et al., 2023). AI gamification provides immersive environments for learning in which personalized interaction is constituted by AI-driven 3D characters while preserving the cultural document value of digitized content for posterity and public access through ML-based archiving techniques such as OCR (Afshar et al., 2024; Kaur & Rai, 2024). AI had great promise for education and cultural preservation around the world, such as with Pakistan, which adopted AI to narrow education gaps, or Greece, which introduced teaching via language and cultural content using AI chatbots (Khurshid et al., 2024; Mageira et al.,

2022). Data privacy and security challenges, as well as cultural authenticity, however, must be overcome to ethically and fairly use AI in cultural education, with frameworks that secure data and honor cultural sensitivities (Du, 2024). ML promises flexibility in learning environments, cross-cultural education, lessened bias, and enhanced skills attainment, thus making it an important agent for adaptive cultural education and preservation of cultural heritage (Christian et al., 2024).

However, one of the biggest challenges in using AI for cultural digitalization in Indonesia is poor infrastructure, digital, human resource, and cultural resistance toward technology. The digital divide is still a huge hurdle because the differences in digital infrastructure tend to be so great, especially urban differences from rural areas. For example, Java Island is quite interconnected and easy to access for any digital communication, while eastern Indonesia faces restricted accessibility (Jaya et al., 2024; Jurriëns & Tapsell, 2017). This inequality limits application opportunities for AI for cultural purposes in regions with limited access, thus restricting its areas of influence. This remains a challenge even after the government's serious effort to connect rural areas: it fell short of being a truthful and consistent approach in terms of policy and infrastructure (Saputra et al., 2023). There are also the usual bottlenecks of bureaucracy and laws to be solved, since having slow reforms and missing AI policies do not complement the other critical cultural-societal terrain (Farliana et al., 2023; Wagola et al., 2023). Another issue is that the absence of data integration systems and established protocols inhibits building strong AI solutions for cultural preservation and education (Aminah & Saksono, 2021).

Human resource constraints indeed constitute yet another salient problem characterized by a grievous dearth of digital skills and ICT competencies, especially in rural areas, where educational institutions commonly do not possess the capabilities to train teachers and students on AI tools and technologies (Lubis et al., 2024). This lack of skilled human resources further limits the development, operation, and maintenance of AI-based cultural applications, widening the digital divide. Economic disparities deepen the situation, as considerable investments are required to create and support digital infrastructures that are often constrained by limited financial resources and competing national priorities (Junaidi, 2017; Jurriëns & Tapsell, 2017). By denying investment into cultural infrastructures, these funds would have otherwise been directed toward enhancing digital literacy and technical competence within the populace, thereby ensuring the subsequent level of human capital in AI innovation efforts geared toward cultural preservation.

Cultural resistance to new technologies is equally a potential mountain-sized barrier against AI-based implementation in cultural digitalization. Many communities reject AI and digital technologies, suspecting that the cultural interventions of technology may disrupt their heritage (Pansoni et al., 2023). Such resistance usually arises from concerns of historical obfuscation, where AI systems might be regarded as perpetrating the alteration or misrepresentation of cultural narratives leading to possibly unauthorized meanings and reduction of authenticity and integrity in cultural representation (Pansoni et al., 2023). To pile things on, if AI can produce convincing but fabricated cultural objects, that raises yet another ethical issue with respect to cultural heritage preservation: Are we, in this case, engineering cultural hoaxes? (Ingram et al., 2023). Getting past this stage will require AI systems that are culturally informed, support, and would protect the distinctive identities of diverse cultural groupings; hence, inclusive development processes must be in place that both involve local communities and cultural stakeholders (Aggarwal, 2020; Lennerfors & Murata, 2023).

Policy Recommendations for the Responsible and Sustainable Use of AI in Cultural Heritage Preservation

To translate artificial intelligence (AI) for the cultural digitalization, a suitable policy framework that would address ethical, legal, infrastructural, and socio-cultural issues must be in place. The opportunities are tremendous for AI in cultural preservation, yet there are also associated risks of fairness and bias, data privacy, transparency, cultural sensitivity, and limitations of digital infrastructure specifically in countries such as Indonesia where the digital divide is a constant concern (Ashok et al., 2022; Ibrahim et al., 2024; ÓhÉigeartaigh et al., 2020). Properly articulated and implemented policies should be in place to ensure that AI becomes a benefit for culture than a tool of exploitation or misrepresentation. To begin, sector-specific ethical guidelines applicable to cultural heritage are a must. These must contain principles of joint accountability, participatory meaning, explainability, accessibility, sustainability, reliability, and dignity, thus ensuring respect for cultural integrity and, above all, inclusion in AI applications to cultural heritage (Pansoni et al., 2023). Algorithmic parameters would be encouraged to be fairness-aware for mitigating algorithmic unfairness, which has been a significant concern in AI applications around the world that enabled unfair marginalization of some cultural narratives (Ashok et al., 2022). With regards to transparency and accountability, policies must stipulate that developers and users provide clear explanations of the processes behind AI-related decisions and, furthermore, that they are held accountable for any harm caused

by their systems (Ghandour & Woodford, 2023; Pansoni et al., 2023). On top of these ethics, legal regimes should set these ethics into motion such as algorithm impact assessments that evaluate and mitigate threats posed by AI in cultural heritage. Legal frameworks that have a touch of protection for human rights and ethical principles confer legitimacy and integrity to AI governance, such as seen in the cases of eminent guidelines on AI adopted in the European Union (Brand, 2022; González-Martín, 2024). In Indonesia, therefore, the adaptation of such frameworks to local contexts would be relevant and of utmost importance so that whatever AI applications in cultural preservation are lawfully sound and culturally respectful. Public-private partnerships are genuine means for instilling AI in cultural preservation as part of education policies (Sajida & Kusumasari, 2023, 2023) . The partnership would put private sector actors to work in concert with their academia and government counterparts to see shared resources, expertise, and investments materialize to fast-track in setting the digital infrastructure and necessary AI competencies for the cultural sector (Farliana et al., 2023; Saputra et al., 2023). The successful U.S. model provided interdisciplinary answers to bias, privacy, and accountability in AI systems. Such collaboration in Indonesia may actuate change and innovation, ensuring protection for cultural data and ethical deployment of AI applications .

Past investment targets for digital infrastructure are indispensable to closing the digital divide that stops AI implementation in Indonesia, particularly in territories of a rural nature and places with poor economic perspectives. Policies must ensure getting digital technologies into an equitable regime by allowing all areas of AI advancements in the field of cultural preservation (Jaya et al., 2024; Saputra et al., 2023). Investments will be done in internet booster systems, data integration systems, and cybersecurity for protecting any information on sensitive matters that AI engages in (Pucelj & Bohinc, 2024).This policy includes further improving digital literacy through comprehensive education and training programs. Build a competent workforce to drive AI innovation in cultural preservation through investments in digital literacy and technical skills training for educators, cultural heritage professionals, and local communities (Lubis et al., 2024). These programs foster acceptance of AI technologies by empowering local stakeholders to actively participate in cultural digitalization initiatives and ensure that such AI applications would reflect and respect local cultural contexts (ÓhÉigeartaigh et al., 2020).

Cooperation and cross-cultural dialogue are significant for developing inclusive, nondiscriminatory AI systems that would conceivably articulate their local context and produce narratives representing diverse cultures. In this regard, academia plays one of the

most important roles by undertaking interdisciplinary research linking technological innovation closely with cultural studies to warrant a culturally and technologically advanced AI application (ÓhÉigeartaigh et al., 2020). Ethical frameworks must support responsible AI use in cultural preservation, such as data privacy, intellectual property right, and proper treatment of cultural artifacts (Pansoni et al., 2023).This means aligning applications of AI toward the Sustainable Development Goals of the United Nations, which would ensure that cultural digitalization supports environmental, social, and economic sustainability (Bakirman et al., 2023; Miedes-Ugarte et al., 2020). AI-generated cultural products enhancing cultural identity and perceived value could significantly preserve intangible heritage, making it imperative for policies to endorse such initiatives (Zhang et al., 2023).

Finally, these must include continuous monitoring mechanisms, as well as feedback loops to ensure that proper ethical standards are adhered to in the application of AI and its continued effectiveness. Thus, the policies must support regular audits of AI systems and associate the stakeholders in the evaluation process and their feedback for the improvement of AI operations (Almeida et al., 2023; Tao et al., 2024). This kind of iterative process guarantees that technologies evolve keeping in mind the cultural needs and ethical considerations for the conservation of culture for the future generations. Thus, by implementing these policy recommendations, Indonesia can exploit AI to enhance cultural preservation and education but not at the cost of such technological advancement compromising cultural integrity as well as authenticity. These policies will derive from global best practices and thus provide a roadmap in developing ethical, inclusive, and sustainable AI-fueled cultural communication platforms that would promote cultural heritage sustainability in the digital age.

4. CONCLUSION

This integration of AI in digital cultural communication is opening up possibilities never foreseen in the preserving and sustaining of Indonesia's extensive cultural heritage. Such an evaluation of Nusantara cultural applications illustrates the salience of both potentials and challenges that AI adoption poses within the cultural sector. The present applications certainly show diverse contents and designs but lack integration with AI, thus underscoring a major gap in the harnessing of AI technologies for cultural preservation. This would require a huge investment in digital infrastructure, particularly for underserved regions, to ensure that there is no inequity of access or reliability of connectivity. Ethical

frameworks that begin with the descriptions of fairness and data privacy and end with openness and cultural sensitivity should accompany AI deployment. Government agencies, the private sector, academia, and local communities must cooperate in developing AI solutions that are culturally relevant and state-of-the-art technology. Enhancing digital literacy through targeted education and training programs is a key requirement to building a capable workforce for the AI-driven innovation in cultural preservation. Sustainable policies aligned to the United Nations Sustainable Development Goals (SDGs) are necessary for AI applications to be part of the solution toward environmental, social and economic sustainability. Continuous monitoring and a stakeholder feedback mechanism are vital in maintaining ethical AI practices and improving cultural digitalization initiatives over time. With these policies and guidelines, Indonesia can harness the transformative power of AI to enhance cultural education, preserve its diverse cultural narratives, and capacitate digital goose management where no technological advancement diminishes its integrity in the digital world.

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