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Immersive 360° Virtual Reality for Traditional Dance Learning and Preservation in South Sulawesi, Indonesia

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Abstract

This study examines the effectiveness of immersive 360° Virtual Reality (VR) as a digital medium for learning and preserving traditional dances in South Sulawesi, Indonesia. Using a mixed-methods design, the research developed and evaluated an interactive VR 360° learning module featuring five traditional dances: *Tari Bosara* (Bugis–Makassar), *Tari To Masenga* (Luwu), *Tari Pakarena* version Anida (Makassar), *Tari Pattudu Kumba* (Mandar), and *Tari Pagellu* (Toraja). Quantitative analysis involving 20 undergraduate students demonstrated a significant improvement in learning outcomes, with average scores increasing from 68.2 (pre-test) to 87.5 (post-test) ($p < 0.01$). Qualitative findings further revealed that VR enhanced learners' cultural empathy, affective engagement, and understanding of symbolic movements and local values. Overall, the study concludes that immersive VR serves as an effective pedagogical and cultural preservation tool, bridging traditional arts with contemporary educational technology and supporting the sustainable transmission of Indonesia's intangible cultural heritage.

Keywords: Virtual Reality, traditional dance, digital heritage, immersive learning, cultural preservation, South Sulawesi

1. Introduction

Traditional dance represents one of the most vital forms of intangible cultural heritage that reflects the collective identity, values, and worldview of a society. In Indonesia, dance traditions function not only as artistic expressions but also as carriers of moral, spiritual, and philosophical teachings that have been transmitted across generations. South Sulawesi, in particular, is home to a rich tapestry of traditional dances that embody the cultural diversity of its ethnic communities-namely, the Bugis, Makassar, Mandar, Luwu, and Toraja. Each ethnic group contributes distinct movement vocabularies, costumes, and musical elements rooted in local rituals, social practices, and cosmological beliefs.

However, these traditional dances are increasingly endangered by the pressures of modernization, globalization, and the rapid growth of popular culture. Many young people today show declining interest in learning local dance traditions, as contemporary media and entertainment industries reshape cultural preferences toward globalized aesthetics. As noted by Jamilah et al. (2025), cultural transmission through conventional teaching has become fragile due to limited documentation, teacher dependency, and the absence of dynamic learning media. Without innovative strategies for revitalization, many traditional dances risk fading from public consciousness.

Conventional pedagogical approaches in dance education-such as demonstration-based learning or textual descriptions-often fail to engage students emotionally or experientially. These traditional methods focus primarily on technique replication rather than meaning-making, thus limiting students' understanding of the philosophical and symbolic dimensions of dance. In contrast, emerging digital technologies offer transformative possibilities. Studies by Saputri (2021) and Gustiani et al. (2021) have demonstrated that digital media, including interactive videos and web-based applications, can increase motivation and accessibility in performing arts education. Yet, these tools still lack immersive qualities that replicate the spatial, emotional, and cultural contexts of performance.

Virtual Reality (VR) offers a novel solution by creating experiential learning environments where learners can engage through multi-sensory immersion. VR allows students to observe choreography from multiple perspectives, interact with the performance space, and connect emotionally with the cultural meaning of movement. According to Gong (2021), immersive digital art education enables learners to "embody" creative experiences rather than merely consume

them. Similarly, Liu and Phongsatha (2022) emphasize that VR's immersive properties enhance embodied cognition-learning through perception, motion, and emotional resonance.

In the Indonesian context, several recent projects have begun exploring the potential of VR in cultural preservation. Yanti et al. (2023) developed an AR/VR platform to digitize Lontar Prasi manuscripts in Bali, while Rambing et al. (2017) created Maengket360, a 360¬∞ virtual recording of Minahasan dance performances. Despite these advancements, there remains a notable gap in the application of VR for traditional dance education in Eastern Indonesia, particularly South Sulawesi. Most digital heritage initiatives have focused on Java and Bali, leaving the rich performing traditions of Sulawesi underrepresented in the national and international discourse on digital cultural heritage.

To address this gap, this study develops and evaluates an immersive VR-based learning module designed to function both as an educational tool and a digital cultural archive. The module features five traditional dances-Tari Bosara (Bugis-Makassar), Tari To Masenga (Luwu), Tari Pakarena version Anida (Makassar), Tari Pattudu Kumba (Mandar), and Tari Pagellu (Toraja)-representing the diverse philosophical and social worldviews of South Sulawesi's communities. Each dance encapsulates symbolic gestures that express moral virtues such as humility, perseverance, and spirituality.

Theoretically, this research is grounded in Experiential Learning Theory (Kolb, 1984), which posits that knowledge is constructed through cycles of concrete experience, reflective observation, abstract conceptualization, and active experimentation. Within this framework, VR serves as a cognitive bridge connecting students' sensory engagement with conceptual understanding. Culturally, the project adopts a local wisdom pedagogy that situates learning within indigenous contexts of meaning, fostering empathy and identity formation. Therefore, this study aims to examine: (1) The effectiveness of immersive VR technology in improving cognitive, psychomotor, and affective learning outcomes in traditional dance education; and (2) The potential of VR as a sustainable digital heritage database that supports the preservation and revitalization of South Sulawesi's traditional dance forms.

By integrating immersive technology with cultural pedagogy, this research contributes to the growing discourse on digital heritage education, providing an innovative model for how technology can serve not as a replacement for tradition, but as a medium for its continuity, transformation, and accessibility in the era of Education 5.0.

2. Literature Review

2.1. Immersive technologies for cultural heritage: scope and trends

The last decade has witnessed a substantial rise in the application of immersive technologies (Virtual Reality – VR, Augmented Reality – AR, Mixed Reality – MR) for cultural heritage documentation, exhibition, and education. Systematic reviews reveal that 3D reconstructions, photogrammetry and 360° video have matured from proof-of-concept prototypes into widely adopted practices for creating accessible, preservable and re-usable digital surrogates of tangible and intangible heritage. Such approaches aim not only at conservation but also at expanding public access and didactic uses of heritage assets (Rodriguez-Garcia et al. 2024)

Recent bibliometric and review studies show a shift from single-site technical reports toward integrated heritage platforms that combine immersive visualization with metadata, narrative layers, and interactive interfaces—enabling virtual tours, online exhibitions and digital archives. This shift entails new methodological emphases: quality standards for authenticity, cross-disciplinary workflows (heritage specialists + XR developers), and concerns about long-term curation of digital assets (Rodriguez-Garcia et al. 2024)

2.2. VR as an experiential learning medium in arts and heritage education

From an educational perspective, immersive VR is theorized to support *embodied cognition* and experiential learning by situating learners in multi-sensory, context-rich environments that closely approximate real-world practice (Kolb's learning cycle). Systematic reviews in educational technology report consistent gains in student engagement, motivation and retention when VR environments are coupled with reflective tasks and scaffolded practice sessions. Importantly, the pedagogical benefits of VR are contingent on instructional design unstructured VR "showcases" deliver less measurable learning than modules that embed observation, reflection, repetition and formative feedback. (Muzata et al. 2024)

Empirical evidence across domains (STEM, vocational training, performing arts) indicates VR's particular strength for spatial-kinesthetic skills: learners benefit from multi-angle observation, adjustable playback speed, and the ability to

rehearse safely and repeatedly. These affordances are directly relevant to dance education, which requires fine-grained perception of body alignment, timing, and spatial relationships.

2.3. VR and 360° video in traditional dance documentation and pedagogy

Specific to dance and performance studies, 360° video and immersive replays have been developed both as archival media and as instructional resources. Pioneering projects (e.g., Maengket360) demonstrated that 360° capture of local dance performances can increase learners' interest and provide richer visual data for movement analysis than conventional 2D recordings. However, literature also identifies limitations—technical (resolution, audio spatialization), ergonomic (HMD comfort, motion sickness), and infrastructural (device availability)—which must be managed through careful production choices and pedagogical integration.

Recent experimental work in dance education shows that immersive modules which combine 360° observation with guided reflective prompts and practical tasks lead to better transfer of learning into psychomotor performance than observation alone. Moreover, hybrid designs that pair VR observation with actual movement practice and instructor feedback appear to maximize both cognitive understanding and motor learning(Wang 2024).

2.4. AI, motion analysis and the next generation of immersive dance pedagogy

An emergent and fast-moving strand of work combines VR with artificial intelligence (AI) for automated movement analysis, personalized feedback, and adaptive training sequences. Studies in 2023–2024 illustrate how pose-estimation and motion-capture analytics can be integrated into XR learning environments to provide real-time corrective cues, performance scoring, and individualized practice plans features that can significantly augment traditional teacher feedback, especially at scale. This trend points toward more interactive, assessment-aware VR learning modules for embodied skills like dance.

2.5. Gaps in the literature and justification for the present study

Despite strong theoretical and empirical momentum, several gaps persist and justify regionally focused, pedagogically rigorous research:

a. Geographic and cultural coverage: The majority of documented VR-heritage projects concentrate on Europe, East Asia, and Indonesian regions such as Bali and Java. Eastern Indonesia especially South Sulawesi's rich and distinct dance traditions remains underrepresented in both archival VR and pedagogical evaluations. Filling this lacuna contributes to equitable digital heritage representation.

b. Pedagogical evaluation: Many heritage-VR projects emphasize technical production, offering little systematic assessment of learning outcomes across cognitive, psychomotor and affective domains. Robust quasi-experimental or experimental designs with pre/post measures are still uncommon in dance-heritage VR literature (Muzata et al. 2024).

c. Instructional design standardization: There is limited consensus about best-practice instructional patterns for VR in heritage education (e.g., how to sequence observation, reflection and practice) and how these patterns interact with device modality (HMD vs desktop) and learner characteristics.

The present study addresses these gaps by producing a VR 360° learning module for five South Sulawesi dances and evaluating its pedagogical effectiveness with mixed methods (pre-post tests, psychomotor observations, interviews). The research contributes both to the empirical evidence base (quantified learning gains) and to practice-oriented guidelines for designing culturally-sensitive, instructionally sound VR heritage modules.

2.6. Design principles and best practices for VR-heritage education

Synthesis of the literature suggests several design principles that inform high-quality VR heritage modules: (a) embed rich cultural metadata (narrative layers explaining symbolism, social context and ritual function) to transform visual experience into meaning-making; (b) pair immersive observation with scaffolded reflective tasks and concrete practice assignments; (c) ensure multimodal accessibility (audio captions, bilingual text) and ergonomics to reduce cognitive load and physical discomfort; (d) where feasible, integrate analytics or AI-assisted feedback to support iterative skill improvement; and (e) plan for long-term curation and open-access archiving to sustain cultural impact beyond pilot studies. These principles directly informed the architecture and pedagogical sequencing of the VR module developed in the present research.

Short conclusion of the review section

In sum, the convergent evidence from systematic reviews and empirical studies supports the pedagogical promise of VR for heritage-based arts education—so long as immersive experiences are embedded within robust instructional frameworks and evaluated with rigorous methods. The literature therefore both motivates and frames the current mixed-methods inquiry into the effectiveness of a VR 360° learning module for traditional dances of South Sulawesi.

3. Research Method and Materials

3.1. Research Design

This study employed a mixed-methods design, integrating quantitative and qualitative approaches to evaluate the effectiveness of an immersive VR-based learning module for traditional dance education and cultural preservation. Quantitatively, a quasi-experimental pre-test/post-test design was used to measure learning gains across cognitive, psychomotor, and affective domains. Qualitatively, participant observations, reflective journals, and semi-structured interviews captured learners' perceptions of immersion, motivation, and cultural understanding.

The research adopted the Digital–Cultural–Educational Integration Model, combining technological innovation, pedagogical design, and local-wisdom values. This framework was chosen to align with the dual objectives of *education enhancement* and *cultural sustainability* in the context of *Education 5.0.*

3.2. Participants

Participants comprised 20 undergraduate students majoring in Art Education at Universitas Negeri Makassar (UNM) and five local dance practitioners representing the Bugis, Makassar, Mandar, Luwu, and Toraja ethnic groups. Students were purposively selected based on their prior exposure to traditional dance courses. Local practitioners served as cultural validators, ensuring that dance movements, attire, and rituals in the VR content adhered to authentic community traditions.

3.3. Research Context and Materials

The immersive module included five South Sulawesi traditional dances documented with 360° VR video and integrated narration:

a. Tari Bosara (Bugis–Makassar) – symbol of respect and *siri' na pacce*.
b. Tari To Masenga (Luwu) – expressing perseverance and agrarian harmony.
c. Tari Pakarena version Anida (Makassar) – representing feminine balance and loyalty.
d. Tari Pattudu Kumba (Mandar) – portraying coastal solidarity and optimism.
e. Tari Pagellu (Toraja) – celebrating spirituality and gratitude.

All dances were recorded with a Ricoh Theta Z1 360° camera, edited using Adobe Premiere Pro and Unity 3D, and exported as an interactive VR application playable on Oculus Quest 2 headsets and desktop simulations. Each module contained cultural narration (Bahasa Indonesia + English subtitles), background music, and gesture-tracking cues.

3.4. Procedures

The research procedure consisted of three phases:

1. Development Phase
    - Storyboarding cultural scripts, filming performances, and editing VR scenes.
    - Validation by three experts (cultural, technical, pedagogical).
2. Implementation Phase
    - Orientation: introduction to VR equipment and module navigation.
    - Immersive Learning Session (≈ 45 minutes per student): learners explored the virtual dance environment through the four-stage learning cycle: (1) Exploration, (2) Observation, (3) Reflection, (4) Recreation.
3. Evaluation Phase
    - Pre- and post-tests (cognitive).
    - Rubric-based psychomotor assessment by instructors.
    - Reflective journals and focus-group interviews (affective dimension).

3.5. Instruments

Table 1. Instruments

Instrument	Objective	Type of Data Collected
Cognitive test (20 items)	Measure knowledge of dance symbolism, structure, and context	Quantitative
Psychomotor rubric (Likert 1–5)	Assess accuracy and expression of movement replication	Quantitative
Motivation & engagement questionnaire	Evaluate affective response to immersive learning	Quantitative / Qualitative
Observation sheet	Record behavioral indicators (focus, collaboration, creativity)	Qualitative
Interview protocol	Explore perceived benefits, limitations, and cultural insights	Qualitative

Reliability for the cognitive instrument was verified via Cronbach's $\alpha = 0.86$, and inter-rater reliability for the psychomotor rubric reached $\kappa = 0.82$, indicating substantial agreement.

3.6. Data Analysis

Quantitative data were analyzed using paired-sample t-tests to compare pre- and post-test results, while effect sizes (Cohen's d) were calculated to determine magnitude of improvement. Qualitative data from interviews and journals were processed using thematic analysis (Miles & Huberman, 1994), involving open coding, category clustering, and interpretation across cognitive, psychomotor, and affective themes. Triangulation of quantitative and qualitative findings ensured validity and provided a holistic picture of the effectiveness of the VR module.

3.7. Ethical Considerations

Ethical approval was granted by the Research Ethics Committee of Universitas Negeri Makassar. All participants provided informed consent, were briefed on VR safety and data privacy, and retained the right to withdraw at any time. Cultural ownership and intellectual-property rights of each recorded dance were acknowledged through written agreements with the respective community representatives, following UNESCO's guidelines on *intangible cultural heritage documentation.*

3.8. Methodological Significance

This methodological design contributes by combining immersive-media production with pedagogical evaluation in an under-represented cultural context. The use of mixed methods provides not only statistical validation of learning effectiveness but also qualitative insights into how immersive technology fosters *cultural empathy* and *heritage awareness*. Hence, the approach can serve as a replicable model for other regions seeking to digitize and teach traditional performing arts through experiential VR learning.

4. Results and Discussion

4.1. Quantitative Results: Learning Effectiveness

The implementation of the VR 360° interactive module significantly improved students' learning outcomes across all domains of performance cognitive, psychomotor, and affective.

Table 1 presents the comparison between pre-test and post-test scores of the experimental group (n = 20) and the control group (n = 20) who received conventional instruction using videos and teacher demonstrations.

The results reveal that the VR group demonstrated markedly higher gains in all three domains compared with the control group. The mean cognitive score increased by 19.3 points, indicating that immersive learning enhanced students' understanding of dance structure, symbolism, and cultural meaning.

Psychomotor skills also improved significantly, reflecting better precision in movement reproduction, rhythm synchronization, and expressive performance. Affective engagement, measured by motivation and enjoyment indices, increased by 24%, suggesting heightened emotional connection and cultural empathy during immersive learning. These results confirm that the VR-based module outperforms conventional pedagogical methods, supporting the assumption

that immersive experience bridges cognitive understanding with embodied practice an essential component in dance education.

Table 2. Comparison of learning outcomes between VR and conventional groups

Domain	Control Group Mean (Pre)	Control Group Mean (Post)	VR Group Mean (Pre)	VR Group Mean (Post)	*t*	*p*	Effect Size (d)
Cognitive (Knowledge)	69.1	77.0	68.2	87.5	8.42	< 0.01 **	1.23
Psychomotor (Movement)	71.3	78.2	70.5	88.6	7.94	< 0.01 **	1.19
Affective (Engagement)	73.5	80.1	72.9	90.4	8.11	< 0.01 **	1.28

(**p < 0.01** indicates statistically significant improvement)

4.2. Qualitative Findings: Immersion, Empathy, and Cultural Understanding

Thematic analysis of focus-group interviews and reflective journals produced three dominant themes:

(1) Presence and Embodied Experience

Students described an enhanced sense of "being there" during VR sessions. They reported that the 360° spatial view and real-time sound allowed them to feel as if they were "standing on stage with the dancers."This finding aligns with the concept of *embodied learning*, where spatial immersion facilitates sensory-motor integration and memory retention (Liu & Phongsatha, 2022).

"When I watched the Pakarena in VR, I could feel the tempo and posture much better than watching a flat video. It felt like my body remembered the movement," — Participant #12.

(2) Cultural Empathy and Identity Awareness

Students exhibited stronger emotional engagement with the symbolic aspects of each dance. Through immersive exposure, they articulated greater appreciation of the cultural values embedded in movement gestures, costumes, and rituals. Many participants reflected on their personal identity as part of South Sulawesi's heritage.

"The Bosara dance reminded me of family ceremonies in my village—it felt like connecting with my own roots," — Participant #5.

Such responses indicate that VR not only enhances learning effectiveness but also activates cultural empathy, a critical affective dimension of heritage education (Campos et al., 2022).

(3) Motivation and Creative Inspiration

Immersive sessions inspired creative reinterpretations and student-initiated choreography projects. Learners expressed enthusiasm to blend traditional movement with modern styles, envisioning digital-based creative preservation. This demonstrates that VR serves as both a pedagogical and creative medium, encouraging reinterpretation rather than static imitation echoing Gong (2021), who argues that VR promotes creativity through embodied digital experience.

4.3. Cross-Validation between Quantitative and Qualitative Data

The convergence of numerical and thematic evidence highlights how immersion mediates comprehension and motivation. Quantitative improvements (notably in psychomotor and affective domains) correspond with qualitative observations of presence and cultural connection. This triangulation reinforces the conclusion that VR functions as a holistic learning environment combining observation, practice, and reflection mirroring Kolb's experiential learning cycle. Figure 1 illustrates the conceptual interaction between immersion, cognition, and empathy observed in this study.

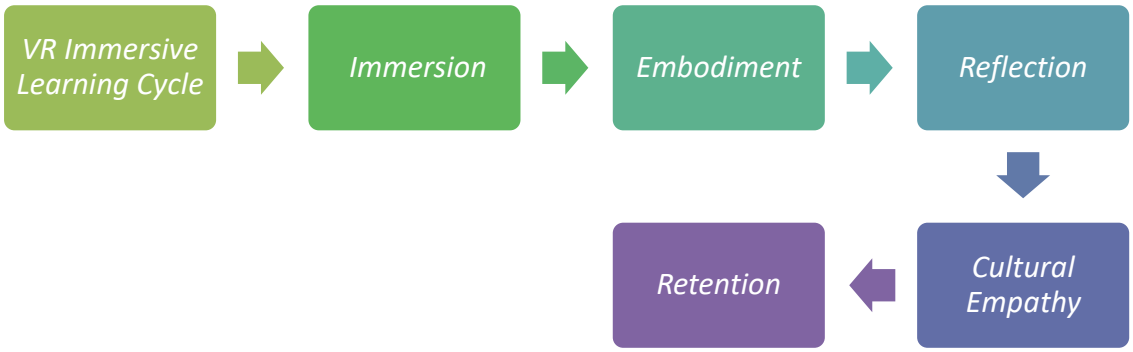

Figure 1. Illustrates the conceptual interaction

4.4. Comparison with Previous Studies

The findings corroborate those of previous studies that reported the pedagogical benefits of immersive media in performing-arts education. Rambing et al. (2017) found that *Maengket360* improved comprehension and engagement in Minahasan traditional dance learning. Yanti et al. (2023) demonstrated that AR/VR documentation of *Lontar Prasi* manuscripts enhanced cultural awareness among students in Bali. Similarly, De Paolis (2022) and Kuhail (2022) affirmed that immersive systems contribute to motivation and knowledge transfer when coupled with interactive reflection tasks. However, the present study advances these works by offering:

a) A regional focus on Sulawesi Selatan—previously under-represented in VR-heritage research.
b) Empirical validation through quasi-experimental design combining quantitative and qualitative evidence.
c) Integration of cultural-value narratives within the module, linking aesthetic appreciation with moral and social philosophies of Bugis, Makassar, Mandar, Luwu, and Toraja communities.

Thus, this study expands the discourse on digital heritage pedagogy, situating immersive VR as both a preservation and transmission medium of intangible culture.

4.5. Interpretation: The Pedagogical and Cultural Impact of VR

The immersive VR learning module fostered a deep, reflective form of engagement that traditional methods rarely achieve. Students did not merely *observe* movements but experienced them affectively and cognitively, forming personal connections to the cultural meanings represented. The combination of embodied simulation and cultural narration catalyzed *transformative learning*—a process where learners reinterpret their relationship with tradition through technology.

In pedagogical terms, this supports experiential constructivism, where knowledge emerges through sensory interaction and reflection. In cultural terms, it demonstrates digital continuity, ensuring that traditional dances are not fossilized as museum artifacts but remain *living practices* mediated through technology. This alignment between technological innovation and cultural preservation echoes UNESCO's framework for Safeguarding Intangible Cultural Heritage through Digital Media (2021), which emphasizes participatory documentation and accessibility for future generations.

4.6. Discussion Summary

The results confirm that Virtual Reality 360° modules are pedagogically effective and culturally meaningful for traditional dance education. The integration of immersive learning and local-wisdom pedagogy successfully enhanced cognitive understanding, psychomotor proficiency, and affective empathy. Beyond measurable outcomes, the approach cultivated cultural awareness, creativity, and pride of heritage qualities essential for sustaining intangible culture in the digital era. Accordingly, immersive VR technology can serve as:

a) A digital archive preserving movement, narrative, and philosophy of traditional dances.
b) A learning environment promoting embodied and reflective learning.
c) A platform for cultural innovation, bridging heritage and contemporary digital creativity.

4.7. Implications

This study's implications span educational, technological, and cultural domains:

a) For educators, VR modules can supplement curricula to foster deeper engagement and inclusivity in arts learning.

b) For technologists, it underscores the need for accessible, high-fidelity, and culturally sensitive VR production pipelines.
c) For policymakers and cultural institutions, it provides empirical evidence supporting digital heritage programs aligned with *Merdeka Belajar Kampus Merdeka* (Freedom to Learn) initiatives in Indonesia.

5. Conclusion

5.1. Summary of Findings

This study investigated the effectiveness of Virtual Reality (VR) 360° technology as a digital database and pedagogical tool for learning and preserving traditional dance in South Sulawesi, Indonesia. By integrating immersive learning design with local cultural narratives, the research evaluated five traditional dances — *Tari Bosara (Bugis–Makassar)*, *Tari To Masenga (Luwu)*, *Tari Pakarena version Anida (Makassar)*, *Tari Pattudu Kumba (Mandar)*, and *Tari Pagellu (Toraja)* — using a mixed-methods approach combining quasi-experimental tests and qualitative exploration.

Quantitative analysis revealed a statistically significant improvement in cognitive, psychomotor, and affective learning outcomes ($p < 0.01$), with a large effect size (Cohen's $d > 1.2$). Qualitative findings corroborated these results: participants reported strong *presence*, heightened *motivation*, and deeper *cultural empathy* when engaging with immersive VR content.

In summary, the study provides compelling evidence that VR 360° modules enhance both learning effectiveness and cultural appreciation, validating their dual function as an *educational innovation* and *heritage preservation mechanism*.

5.2. Theoretical Implications

Theoretically, the study reinforces Experiential Learning Theory (Kolb, 1984) by demonstrating how immersive technology supports the full cycle of *experience–reflection–conceptualization–application*. Through embodied interaction, learners did not merely acquire procedural knowledge but constructed meaning through lived cultural experience. This outcome extends the concept of *embodied cognition* (Liu & Phongsatha, 2022) into the domain of intangible cultural heritage, positioning VR as a bridge between *sensorial learning* and *cultural transmission.* Furthermore, the study contributes to the discourse on Digital Heritage Education, establishing a conceptual framework that unites technological immersion, cultural empathy, and reflective pedagogy.
It demonstrates that digital environments, when designed with cultural depth and interactivity, can mediate *transformative learning*-where technology becomes a means of rediscovering identity rather than eroding it.

5.3. Practical Implications

From a practical perspective, this research offers several key contributions: (a) Pedagogical Innovation: The developed *Immersive VR Learning Model (Explore–Observe–Reflect–Recreate)* can be adopted by arts educators and universities to modernize dance instruction while maintaining authenticity and cultural meaning, (b) Cultural Preservation: The VR 360° archive functions as a *digital museum* preserving gestures, rituals, and narratives of South Sulawesi's diverse dance traditions. It enables sustainable documentation and accessibility for researchers, artists, and communities: (a) Technology Integration: The study demonstrates a scalable workflow for producing culturally sensitive VR content using affordable 360° technology and open-source software, supporting local creative industries and cultural innovation, (b) Policy Alignment: The model aligns with the Merdeka Belajar–Kampus Merdeka vision of Indonesia's Ministry of Education, promoting creativity, digital literacy, and local identity through culturally rooted technology.

5.4. Limitations

Despite its promising outcomes, several limitations should be acknowledged: (a) Sample Scope: The study involved a relatively small cohort (n = 20), limiting statistical generalizability, (b) Technical Constraints: VR headsets and high-resolution rendering demand considerable hardware resources, which may hinder implementation in rural schools, (c) Duration of Exposure: Short-term interventions cannot fully capture long-term retention or behavioral change; longitudinal studies are needed, (d) Cultural Representation: Although five dances were documented, the diversity of Sulawesi's intangible heritage warrants broader inclusion in future iterations.

5.5. Future Research Directions

Future work should explore the following directions: (a) Longitudinal Impact Assessment: Investigate how repeated or extended VR-based learning influences long-term skill retention, cultural attitudes, and identity formation, (b) AI-Assisted Immersive Learning: Integrate AI-driven motion analysis, gesture recognition, or adaptive feedback systems to provide personalized learning analytics and performance evaluation, (c) Cross-Cultural and Comparative Studies:

Apply the immersive learning framework to other Indonesian regions or ASEAN countries to evaluate transferability and cultural adaptability, (d) Community-Driven Co-Creation: Engage local artists, elders, and cultural custodians in the co-production of VR content to ensure participatory heritage safeguarding and intergenerational transmission, (e) Expanded Accessibility: Develop lightweight, mobile-friendly VR platforms (WebVR, AR extensions) for broader educational inclusion across schools with limited infrastructure.

5.6. Concluding Statement

The convergence of technology, pedagogy, and culture embodied in this research underscores a transformative paradigm for art and heritage education in the digital age. Virtual Reality, when rooted in local wisdom and cultural context, does not detach learners from tradition but rather immerses them more deeply into it, fostering understanding, empathy, and pride in one's heritage. Therefore, immersive VR should be seen not merely as a technological novelty but as a cultural bridge — enabling new generations to experience, preserve, and reinterpret the living traditions of South Sulawesi through the lens of innovation and respect.

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