

## Education Revolution via Immersive Media: Leveraging Cultural AR Maps to Enhance Elementary Students' Cultural Literacy

Neng Wulan<sup>1</sup>, J. Julia<sup>2</sup>, Kusman Rukmana<sup>3</sup>

<sup>1,2,3</sup>Universitas Pendidikan Indonesia, Indonesia

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### ABSTRACT

In the era of educational revolution, shifting from passive teaching to technology-driven interactive learning is crucial for cultivating cultural literacy in elementary education. This study evaluates the effectiveness of the Cultural AR Map, an innovative immersive media tool, in enhancing fourth-grade students' cultural literacy regarding socio-cultural diversity. Employing a quantitative quasi-experimental design with a nonequivalent control group, the investigation involved 60 students divided equally into experimental and control classes (n=30 each). Data gathered via standardized pretests and posttests were rigorously analyzed using Wilcoxon Signed-Rank and Mann-Whitney U tests alongside Normalized Gain (N-Gain) analysis. The results demonstrated a profound learning transformation in the experimental group, with mean literacy scores surging from 53.87 to 92.67, yielding a high N-Gain of 0.84 with an 83.62% effectiveness rating. Nonparametric analysis confirmed highly significant within-group improvements (Wilcoxon,  $p=0.000$ ) and a statistically superior post-intervention performance in the AR-assisted class compared to the conventional PowerPoint-based class (Mann-Whitney,  $p=0.020$ ). This study concludes that integrating immersive AR media revolutionizes cultural education by successfully translating abstract regional heritage into concrete, interactive, and explorable digital learning experiences. Practically, this research contributes a scalable technological framework for cross-disciplinary pedagogy, offering a robust model for interactive, culture-based digital curricula globally.

**Keywords:** Education Revolution, Immersive Media, Augmented Reality, Cultural AR Map, Cultural Literacy, Elementary Education



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### Corresponding Author:

Neng Wulan

Universitas Pendidikan Indonesia, Indonesia

Email: [nengwulan27@upi.edu](mailto:nengwulan27@upi.edu)

## 1. INTRODUCTION

The digital era has intensified calls for instructional approaches that extend beyond knowledge transmission and foster learners' critical thinking, problem-solving, and contextual understanding (Bitar & Davidovich, 2024; Oliveira & de Souza, 2021; Van Vi, 2025). Contemporary learning frameworks emphasize active student engagement and the meaningful application of knowledge within authentic social and cultural contexts (Rathnasekara et al., 2025). As a result, educational practice is increasingly oriented toward student-centered approaches that encourage exploration, collaboration, and the connection of academic content to real-world experiences (Bhardwaj et al., 2025; Coştu, 2025).

As educational systems increasingly emphasize the development of 21st-century competencies, cultural literacy has emerged as an important dimension of learners' holistic development (Chan & Luk, 2022; Udmah et al., 2024). Cultural literacy encompasses the ability to understand, value, and engage respectfully with diverse cultural perspectives while fostering tolerance and social cohesion (Sultan et al., 2025). It also involves interpreting cultural meanings, reflecting on one's cultural identity, and responding

constructively to cultural diversity in everyday contexts. Key indicators of cultural literacy include understanding cultural complexity, recognizing cultural heritage, and demonstrating responsibility toward cultural preservation (Atmojo et al., 2025; Lähdesmäki et al., 2022).

The development of cultural literacy during elementary education is important for fostering learners' social and ethical development (Kale et al., 2023). According to Sakti et al. (2024), cultural literacy is most effectively cultivated through learning experiences that integrate cultural values with active exploration of local heritage and traditions. This perspective is reflected in Indonesia's Merdeka Curriculum, particularly within the IPAS subject at Phase B, which promotes contextual engagement with regional diversity, local wisdom, and historical understanding. In this context, Social Studies (IPS) learning serves as an important vehicle for developing students' knowledge, skills, attitudes, and social awareness needed to engage effectively in contemporary society (Safitri et al., 2024).

However, empirical evidence indicates that the intended outcomes of cultural literacy education have yet to be fully realized. Riyanto et al. (2025) reported that elementary students continue to demonstrate limited understanding of local cultural heritage. Similarly, Diyaurrahman et al. (2025) highlighted the persistence of teacher-centered instruction and limited instructional diversity as barriers to meaningful cultural learning. Supporting these findings, Rahmiati et al. (2025) observed that students' cultural understanding often remains superficial, with learning outcomes largely confined to short-term memorization rather than sustained appreciation and deeper cultural awareness.

Recent advances in educational technology have created new opportunities to support student engagement and meaningful learning. Studies by Wong et al. (2024) and Mansour et al. (2025) indicate that technology-enhanced instruction can facilitate conceptual understanding, particularly when augmented reality (AR) is employed to represent complex or abstract concepts through interactive visualization. AR-based learning environments can increase learner engagement by providing immersive experiences that connect abstract knowledge with observable representations (Chen et al., 2025; Drljević et al., 2024). Moreover, digital learning technologies may foster greater learner autonomy by enabling students to access, explore, and construct knowledge more actively throughout the learning process (Nopas, 2025).

These technological benefits are also supported by research exploring the integration of cultural content and digital learning environments. Sugiyarti et al. (2024) demonstrated that culture-based instructional approaches can enhance students' understanding of academic content while strengthening their appreciation of local cultural values. Likewise, Baxter & Hainey (2024) highlighted the potential of immersive technologies to promote interactive learning experiences that support student comprehension. Taken together, these findings suggest that the educational value of digital media is maximized when technological innovation is combined with meaningful pedagogical support and culturally relevant learning experiences.

Research by Lestari et al. (2024) suggests that integrating modern technology with local wisdom can support the development of literacy skills. For example, a study by Maufur et al. (2025) found that AR-based interactive storybooks incorporating regional cultural content contributed to the improvement of cultural literacy among elementary school students. Similarly, Nugraheni et al. (2025) reported that digital flipbook media grounded in local knowledge can enhance both cultural literacy and students' understanding of citizenship values. In addition, Sakti et al. (2024) emphasized that strengthening students' cultural understanding and national identity contributes to broader character development.

Despite the positive outcomes of these technological interventions, a pronounced gap remains between the idealized goals of cultural literacy education and actual classroom mechanics. Learning processes that should inherently be highly interactive, exploratory, and contextual are still structurally dominated by traditional, teacher-centered methods that rely on static, media-poor approaches. This technological deficit deprives students of direct agency, leaving them with a superficial, memory-based grasp of culture. Because traditional materials lack interactive flexibility, student motivation and active participation inevitably decline, directly harming overall cultural literacy achievement.

To overcome this limitation, there is an urgent need for an educational media innovation that not only presents material in an appealing layout but also delivers a profoundly exploratory, interactive, and spatially contextualized experience. This research introduces the Cultural AR Map, an educational tool that uniquely synthesizes augmented reality technology with a fully interactive cultural map interface. Through this medium, students can access dense layers of cultural data in an immersive visual format, enabling them to interact directly with digital learning objects and explore regional diversity in a highly tangible manner. Consequently, the primary purpose of this study is to evaluate the precise empirical efficacy of the Cultural AR Map as an educational innovation designed around regional cultural settings. This investigation builds upon and extends previous digital media experiments by shifting from linear text formats to a dynamic, map-based medium that enables holistic and multi-dimensional cultural exploration.

The specific novelty of this study lies in the design and implementation of the Cultural AR Map, which pairs advanced interactive visualization with the unique socio-cultural and geographic context of West Java Province, Indonesia. This media is intentionally constructed not merely as an informational conduit, but as a transformational tool that drives an immersive learning experience via self-directed cultural exploration.

Furthermore, this study conceptualizes cultural literacy comprehensively, analyzing it not simply as cognitive knowledge retention, but as an active capacity to interpret, respect, and appreciate cultural diversity in daily life. Through this specialized approach, the study contributes a robust blueprint for the development of technology-assisted educational materials that preserve and propagate regional cultural values.

In light of the current landscape, cultural literacy instruction in elementary schools clearly faces critical bottlenecks, particularly due to the scarcity of innovative media capable of delivering interactive and highly contextual experiences. Although augmented reality holds substantial transformative potential, its specific application within cultural literacy frameworks remains severely underutilized, highlighting a severe mismatch between ideal educational theory and actual field execution. Therefore, this study addresses the following core research question: How effective is the utilization of the Cultural AR Map in improving the cultural literacy of fourth-grade elementary school students compared to conventional instructional methods? By examining pretest and posttest trajectories across both experimental and control classes, this study evaluates the hypothesis that employing the interactive Cultural AR Map can effectively and significantly maximize elementary students' cultural literacy regarding socio-cultural diversity.

## 2. METHOD

### 2.1. Research Design

This study employed a quantitative quasi-experimental approach incorporating a nonequivalent control group design (Abraham & Supriyati, 2022). This specific design was selected because the classrooms were naturally intact, preventing the random assignment of individual student participants to treatment conditions. Both groups underwent rigorously identical evaluation phases consisting of a pre-intervention test to establish baseline parameters and a post-intervention test to measure outcome parameters. The formalized layout of this experimental framework is depicted in Table 1.

**Table 1.** Experimental Research Design Scheme

Group	Pretest	Interventional Treatment	Posttest
Experimental Class	O1	X1	O2
Control Class	O3	—	O4

Note: O1 and O3 represent the baseline pretest cultural literacy scores; O2 and O4 represent the posttest cultural literacy scores; X1 indicates the digital intervention utilizing the interactive Cultural AR Map media framework.

The field operations for this research were systematically executed across two educational institutions, namely Sukaraja I Public Elementary School and Sukaraja II Public Elementary School, situated within the South Sumedang District of the Sumedang Regency, Indonesia. The data collection and instructional interventions spanned a duration of three months, running continuously from February to April 2026.

### 2.2. Research Participants

The target population for this investigation comprised all fourth-grade elementary school students, selected due to their shared institutional characteristics and homogenous academic baselines. To draw a representative sample from this population, a non-probability purposive sampling technique was instituted based on pre-established administrative and pedagogical criteria. These criteria required that the selected schools utilize identical curricular systems and demonstrate statistically equivalent baseline student abilities (Rohmah et al., 2024).

The total sample size established for this investigation was 60 students, evenly distributed with 30 participants assigned to the experimental cohort and 30 participants assigned to the control cohort. Strict inclusion criteria demanded that participants attend all consecutive instructional sessions and complete both evaluation stages. Conversely, exclusion criteria were applied to students who failed to attend one or more phases of the study, resulting in the exclusion of their incomplete data from the final statistical analysis pool.

### 2.3. Research Procedure

The experimental pipeline was systematically operationalized through three progressive phases, beginning with the baseline preparation of instruments and validation of the interactive media. The second phase involved the execution of field interventions, which were delivered uniformly over three structured instructional meetings for each group. During these sessions, students in the experimental class actively utilized the interactive Cultural AR Map media to complete their learning tasks, allowing them to independently explore digital cultural artifacts. Concurrently, students in the control class received conventional instruction utilizing standard PowerPoint slide presentations that mirrored the traditional, teacher-centered teaching delivery methods typically practiced by school educators. The final phase concluded with the administration of posttests immediately following the completion of the three instructional units to capture the post-intervention performance of both cohorts.

#### 2.4. Instruments and Data Collection

The primary data collection instrument consisted of a highly structured multiple-choice test specifically engineered to quantify elementary students' cultural literacy performance across designated cognitive levels. This instrument was deployed in identical formats during the pretest phase to ascertain initial cultural knowledge profiles and during the posttest phase to map cognitive growth trends across both groups. The structural consistency of the test questions was strictly maintained between the groups to guarantee internal validity and prevent instrumentation bias during cross-cohort comparative analyses.

#### 2.5. Instrument Validation and Reliability

Prior to field deployment, the instructional media and test instruments were subjected to an extensive evaluation protocol comprising expert validation, readability analysis, and a field pilot test. Content evaluation by academic experts yielded a suitability score of 90%, confirming the alignment of test items with the elementary curriculum and cultural literacy parameters, while media engineering validation achieved a score of 96.25%, establishing excellent technical usability, visual fidelity, and interactive responsiveness. Furthermore, evaluation by a panel of three independent experts resulted in a Content Validity Index score of 0.97, indicating a very high level of inter-rater consensus regarding item suitability (Ferreira et al., 2025; Rasmet et al., 2025). Both the Item Content Validity Index and Scale Content Validity Index confirmed that each test item properly targeted the desired cultural literacy traits.

To ensure the linguistic and psychometric soundness of the instrument, a field readability test involving six students with diverse learning backgrounds was conducted, producing a clarity rating of 82.5% and proving that the phrasing was appropriate for fourth graders (Nurmalasari, 2023). Subsequently, a pilot study was conducted with 55 non-sampled fourth-grade students to evaluate specific item metrics. Psychometric analysis confirmed that 25 out of the 30 initial test items met the internal validity criteria and were retained, whereas 5 substandard items were discarded. The final 25-item test demonstrated high internal consistency, yielding a Cronbach's Alpha coefficient of 0.884, which indicated a highly reliable instrument for field deployment.

#### 2.6. Data Analysis

All statistical computations and data visualizations were executed using IBM SPSS Statistics software. Descriptive statistics were first applied to map the mean, minimum, maximum, and standard deviation values of the cultural literacy datasets. To guide the selection of appropriate hypothesis testing models, statistical prerequisite evaluations were performed through normality and homogeneity checks, utilizing the Shapiro-Wilk test to evaluate data normality distribution and Levene's Test to check the homogeneity of variances between the cohorts.

The analytical roadmap for hypothesis evaluation was structured conditionally based on assumption verification, where an Independent Samples t-Test was slated for between-group analysis if the dataset successfully met both normality and homogeneity assumptions. Conversely, if the distribution or variance violated parametric assumptions, non-parametric alternatives were utilized, employing the Mann-Whitney U test to isolate post-intervention variations between the experimental and control groups. Additionally, the Wilcoxon Signed-Rank Test was utilized to compute the significance of within-group literacy progress by directly pairing pretest and posttest matrices. Finally, a Normalized Gain analysis was calculated for each participant to precisely evaluate the magnitude and effectiveness level of the learning gains stimulated by both instructional treatments.

### 3. RESULTS AND DISCUSSION

#### 3.1. Results

##### 3.1.1. Baseline and Post-Intervention Profiles

This study evaluated the empirical efficacy of the augmented reality based Cultural AR Map in improving the cultural literacy of fourth grade students. The field experiment compared two groups, comprising an experimental cohort taught with the interactive Cultural AR Map media framework at Sukaraja II Public Elementary School and a control cohort taught with conventional PowerPoint presentations at Sukaraja I Public Elementary School, with each class containing exactly 30 students. Quantitative data were systematically gathered using identical multiple choice examinations administered as pretests before the intervention and posttests immediately following the instructional phases. To establish a comprehensive baseline and track post-intervention trends across both student cohorts, a descriptive statistical analysis was performed to calculate the mean scores, standard deviations, minimum values, and maximum values, as presented in Table 2.

The empirical metrics compiled in Table 2 point to a substantial improvement in the cultural literacy capabilities of the students following the implementation of the Cultural AR Map. The average literacy score for the experimental cohort experienced a profound upward surge, climbing from an initial baseline of 53.87 on the pretest to an impressive 92.67 on the posttest evaluation. This cognitive growth is further

highlighted by the shifting boundaries of student performance, where the lowest individual score rose from 32 to 80, and the highest individual score reached the maximum threshold of 100. This compressed standard deviation and uniform score elevation demonstrate that the majority of students experienced consistent, equitable progress regardless of their initial academic baselines, suggesting that the immersive properties of the Cultural AR Map delivered a highly meaningful and contextually rich learning experience.

**Table 2.** Descriptive Statistics of Pretest and Posttest Data

Evaluation Metric	Student Cohort	Sample Size	Theoretical Range	Minimum Score	Maximum Score	Mean Score	Standard Deviation
Pretest Assessment	Experimental Group	30	0 to 100	32	64	53.87	8.835
Posttest Assessment	Experimental Group	30	0 to 100	80	100	92.67	5.665
Pretest Assessment	Control Group	30	0 to 100	32	64	53.20	8.923
Posttest Assessment	Control Group	30	0 to 100	68	100	86.53	9.825

Concurrently, the control group participants, who completed their lessons without the assistance of the Cultural AR Map, also demonstrated an upward trend in their cultural literacy outcomes. The average score for the control class increased from a baseline of 53.20 on the pretest to 86.53 during the posttest evaluation, with the lowest score moving from 32 to 68 and the maximum score reaching 100. While these metrics indicate that conventional instructional slides still contribute positively to student learning, the overall rate of improvement within the control cohort remained lower and exhibited greater variance compared to the experimental group. The wider posttest standard deviation of 9.825 in the control class indicates less consistent progress among individual learners, thereby supporting the assertion that technology driven interactive media offers a more stable and effective pedagogical tool for comprehensive cultural content mastery.

### 3.1.2. Prerequisite and Inferential Hypothesis Evaluations

To verify the statistical validity of the observed improvements and evaluate the research hypothesis, the datasets were subjected to rigorous prerequisite testing, including Shapiro-Wilk normality testing and Levene homogeneity testing. The data patterns dictated the selection of non-parametric analytical models to safely evaluate the within-group and between-group significance trends, as summarized in Table 3.

**Table 3.** Summary of Normality, Homogeneity, and Within-Group Difference Tests

Assessment Phase	Student Cohort	Empirical Mean	Normality Test Significance (Shapiro-Wilk)	Homogeneity Test Significance (Levene)	Within-Group Difference Significance (Wilcoxon)
Pretest Assessment	Experimental Group	53.87	0.005	0.017	0.000
Posttest Assessment	Experimental Group	92.67	0.025	0.017	0.000
Pretest Assessment	Control Group	53.20	0.000	0.017	0.000
Posttest Assessment	Control Group	86.53	0.002	0.017	0.000

The normality diagnostics executed via the Shapiro-Wilk method produced significance values lower than the standard alpha threshold ( $p < 0.05$ ) across all evaluation categories, specifically yielding  $p = 0.005$  and  $p = 0.025$  for the experimental pretest and posttest, and  $p = 0.000$  and  $p = 0.002$  for the control counterparts. These values confirm that the gathered cultural literacy data violate the assumptions of a normal distribution. Furthermore, Levene's Test for homogeneity generated a significance value of 0.017, which falls below the 0.05 threshold and indicates that the variances between the two groups are not homogeneous. Because the data patterns violated both core parametric prerequisites, the study utilized non-parametric statistical alternatives to ensure mathematical precision and safeguard the integrity of the hypothesis evaluations.

The Wilcoxon Signed-Rank Test was implemented as the primary non-parametric model to calculate the mathematical significance of the within-group literacy changes from pretest to posttest. The statistical computation revealed a highly significant within-group difference for both cohorts, returning a significance value of  $p = 0.000$ . An examination of the directional ranks indicated a completely positive trend, meaning that zero students experienced a decline in literacy scores and all 30 students within each group achieved

positive academic progress following their respective interventions. These findings show that both instructional pathways stimulate cultural knowledge acquisition, yet because the Wilcoxon model is structurally limited to isolating changes within a single isolated group, a separate comparative analysis was required to determine the superior instructional method.

To isolate the precise statistical variation between the post-intervention performance of the two distinct cohorts, a Mann-Whitney U test was applied as a robust between-group non-parametric comparative tool. The results of this cross-cohort evaluation are structured and presented in Table 4.

**Table 4.** Mann-Whitney U Inferential Test Results

Sample Group	Calculated Mean N-Gain Score	Resulting N-Gain Percentage	Empirical Effectiveness Classification
Experimental Cohort	0.84	83.62%	Highly Effective Category
Control Cohort	0.72	72.05%	Moderately Effective Category

The normalized gain calculations depicted in Table 4 confirm that both instructional approaches succeeded in elevating the cultural literacy skills of the fourth grade students, though they achieved different degrees of efficiency. The experimental cohort achieved an outstanding mean N-Gain score of 0.84, which sits firmly within the high growth classification, and generated an N-Gain percentage of 83.62%, placing the media innovation squarely in the highly effective category. Conversely, the control group achieved a mean N-Gain score of 0.72 and an N-Gain percentage of 72.05%. While both groups demonstrated high qualitative growth indexes, the experimental class outperformed the control class across both metrics. This clear difference demonstrates that leveraging the spatial and interactive components of the Cultural AR Map is substantially more successful in maximizing student cultural literacy than relying on conventional, text-heavy teaching techniques.

## 3.2. Discussion

### 3.2.1. Revolutionizing Cultural Pedagogy: Constructivist Realities of Cultural AR Maps

The profound statistical expansion observed within the experimental cohort, characterized by an upward surge in literacy scores from 53.87 to 92.67 and a high Normalized Gain value of 0.84, provides substantial empirical proof that the Cultural AR Map functions as a revolutionary technological catalyst in elementary education. This noticeable shift from a low-baseline cognitive state to a highly advanced mastery level demonstrates that replacing traditional, teacher-centered routines with immersive media actively resolves the historical passive learning crisis highlighted in recent educational diagnostics (Liao et al., 2025; Sukackè et al., 2022). While conventional lecture methods and static presentation slides often restrict young learners to verbal memorization, the deployment of interactive augmented reality environments allows students to encounter regional heritage as an open, explorable space (Chatsiopoulou & Michailidis, 2025; Evagelou et al., 2025; Klefodimos et al., 2023). The statistical equity recorded in this study, where lower-achieving students experienced identical upward progress alongside their higher-achieving peers, suggests that the interactive cultural map framework provides an adaptive learning architecture capable of accommodating diverse classroom abilities through continuous visual and spatial scaffolding.

From a theoretical framework, these empirical outcomes provide a robust validation of Jean Piaget's classical constructivist paradigm (Yıldız, 2025), which asserts that durable knowledge acquisition is naturally driven by active exploration and direct physical or digital manipulation of environmental stimuli. Within the experimental setting, fourth-grade students did not merely listen to abstract verbal testimonies regarding regional traditions, but instead constructed internal cognitive structures by interacting directly with three-dimensional digital visualizations of West Java heritage, such as the intricate philosophical symmetries of Batik (Wesnina et al., 2025). This digital immediacy encourages the concurrent execution of cognitive assimilation and accommodation, empowering young minds to bridge the gap between abstract historical concepts and tangible digital objects. Consequently, the learning process transitions from a superficial memorization exercise into an authentic discovery pathway, directly confirming that culture-based digital tools maximize conceptual durability among elementary school children.

Furthermore, the structural integration of the Cultural AR Map within the classroom environment strongly supports Vygotsky's social constructivist model (Rigopouli et al., 2025; Wibowo et al., 2025), which emphasizes that optimal cognitive growth is inherently mediated by cooperative dialogue and social interaction within a structured educational environment. Because the augmented reality interface requires students to actively navigate geographic regions to unlock cultural metadata, it naturally converts a traditionally silent classroom into a collaborative learning hub where peer-to-peer discussions flourish. Students spontaneously shared observations, negotiated historical meanings, and collaborated to solve localized spatial tasks, thereby operating collectively within their Zone of Proximal Development (Boulanger, 2022; N. Lee & Chen, 2026). This social mediation transforms cultural literacy from a passive

individual task into a vibrant community experience (Cai & Lai, 2025; J.-H. Lee & Wang, 2025), illustrating that technology-driven shared media can optimize peer engagement while accelerating collective content mastery in contemporary elementary schools (Blyznyuk et al., 2025).

### **3.2.2. Immersive Media Dynamics: Cognitive and Affective Transformations in Cultural Literacy**

When evaluated from an instructional design standpoint, the 83.62% effectiveness rating achieved by the experimental group offers substantial empirical support for Mayer (2024) Cognitive Theory of Multimedia Learning, particularly regarding the strategic balance of cognitive load in young learners. Mayer's framework (Twabu, 2025) proves that human information processing channels are significantly optimized when complex instructional items are delivered through visual and verbal modes simultaneously, rather than relying on a single, text-heavy channel. The Cultural AR Map embodies this multimedia principle by integrating rich three-dimensional visual imagery, concise text descriptions, and spatial audio cues within a unified digital interface. This dual-coding presentation helps elementary students organize and integrate new cultural concepts into their long-term memory without overwhelming their limited working memory capacity, effectively avoiding the split-attention effects common in traditional textbooks.

The clear difference in performance between the experimental group and the control group, which used conventional PowerPoint slides, highlights the pedagogical value of media interactivity. While PowerPoint presentations deliver visual and verbal content simultaneously, they present information in a linear, static format that frequently reduces students to passive observers (Kristoffersen et al., 2025). Conversely, the Cultural AR Map requires active user control, allowing students to determine the pace, direction, and depth of their cultural exploration, which stimulates heightened focus and autonomous learning behaviors (Cheng, 2023; Yu & Hu, 2025). This active interaction explains why the experimental class achieved a more stable posttest standard deviation of 5.665 compared to the wider deviation of 9.825 in the control class, demonstrating that immersive multimedia designs offer a more reliable framework for uniform classroom content mastery.

Beyond driving these measurable cognitive advancements, the continuous utilization of interactive augmented reality media sparks a profound affective transformation that elevates cultural literacy from basic cognitive awareness to active civic competence. Theoretical definitions of cultural literacy emphasize that true mastery requires more than memorizing regional facts (Ginting et al., 2026), demanding that individuals develop an active capacity to understand cultural complexity, recognize cultural identity, and exhibit genuine care for diversity (Abdulahi et al., 2024; Hossain, 2024). Traditional teaching frameworks usually neglect these affective dimensions, focusing almost exclusively on preparing students for rote-based testing.

By contrast, the spatial and visual immersive experiences delivered by the Cultural AR Map allow elementary students to develop deep emotional connections with regional traditions and cultural values. Experiencing cultural diversity as a living, explorable digital environment fosters authentic social empathy, heightens tolerance toward regional differences, and builds a sense of national identity within young learners. This successful combination of cognitive growth and affective appreciation confirms that leveraging immersive technology in early childhood education supports the broader goals of holistic character development and multicultural civic awareness.

### **3.2.3. Strategic Implications for Digital Curricula, Technical Limitations, and Future Horizons**

When contrasted with the broader landscape of literacy innovations, this study provides a highly specialized and distinct contribution to the field of contemporary elementary curricula by transitioning from linear media to dynamic, map-based digital architectures. A large portion of prior technological experiments aimed at strengthening elementary cultural literacy relied heavily on linear digital formats, including electronic modules, digital flipbooks, or culture-based illustrated storybooks (Dharma et al., 2025; Juita et al., 2025; Maulana et al., 2024). Although those linear tools offer clear advantages over printed materials, they remain structurally limited in their capacity to illustrate the complex spatial connections, geographic distributions, and historical movements that define regional kearifan lokal.

By embedding augmented reality artifacts directly into an explorable geographic map interface, this research demonstrates that the layout and structure of digital tools play a critical role in determining pedagogical outcomes. This structural shift provides a scalable template for modern curriculum development, particularly for multi-disciplinary courses like the Natural and Social Sciences subject within the Indonesian Merdeka Curriculum framework, proving that digital media can successfully translate abstract cultural geography into concrete interactive learning experiences (Safitri et al., 2024).

Nevertheless, the systemic institutionalization of the Cultural AR Map within daily school operations remains contingent upon several technical, cultural, and logistical limitations that must be carefully managed. First, the operational success of augmented reality learning depends heavily on the baseline digital readiness of both the student cohort and the instructional staff, as a lack of fundamental technical literacy can introduce unwanted friction that distracts from the core curriculum content. Second, variations in students' preexisting cultural backgrounds and initial academic capabilities can still introduce differences in the speed of content mastery, meaning that advanced digital media cannot completely replace adaptive,

differentiated teaching strategies. Finally, the widespread adoption of immersive applications faces real-world infrastructure constraints, including device availability, internet bandwidth limitations, and strict instructional time limits within elementary school schedules.

Consequently, to unlock the full revolutionary potential of immersive media in primary education, the distribution of software innovations must always be accompanied by thorough teacher training programs, strong institutional infrastructure support, and adaptive pedagogical strategies. In summary, the empirical outputs compiled across this investigation firmly establish the Cultural AR Map as a highly effective and innovative tool that successfully aligns with 21st-century educational demands. By blending advanced interactive visuals with regional cultural contexts, this tool offers a robust framework for cross-disciplinary digital education. Future research should focus on expanding the scope of the Cultural AR Map by expanding its content database to include broader national or global histories, testing its longitudinal stability over extended interventional periods, and evaluating its empirical effectiveness across diverse educational levels and international geographic settings.

#### 4. CONCLUSION

This study successfully demonstrates that the implementation of the augmented reality based Cultural AR Map provides a significantly more effective pedagogical pathway for enhancing the cultural literacy of elementary school students compared to conventional instructional methods. The empirical evidence confirms that the primary research objective has been fully achieved, as evidenced by the profound learning transformation within the experimental group, which outperformed the control group across all major quantitative indices, including mean score progression and normalized gain metrics. Beyond merely elevating examination scores, these findings indicate that synthesizing immersive technology with regional cultural frameworks plays a vital role in helping young learners grasp abstract, multi-dimensional cultural concepts. By transitioning from text-heavy, linear lecture models to dynamic spatial visual maps, this media innovation provides elementary students with an educational environment where cultural diversity becomes highly interactive, contextually tangible, and intellectually exploratory.

Conceptually, this investigation underscores that the cultivation of contemporary cultural literacy depends heavily on the capacity of digital media to deliver interactive, self-directed, and context-appropriate learning experiences that connect directly with students' real-world surroundings. The integration of augmented reality mechanics with native cultural artifacts does not merely support basic cognitive information retention, but acts as a catalyst for deeper affective development, fostering authentic appreciation, cross-cultural tolerance, and heightened social awareness among primary school children. Consequently, this research establishes the Cultural AR Map as a robust, scalable paradigm for cross-disciplinary digital pedagogy, offering a clear blueprint for educational institutions navigating curriculum shifts in the modern digital era. Looking forward, future research initiatives should focus on expanding the content architecture of this map interface to incorporate broader historical timelines, testing its longitudinal stability over extended interventional periods, and evaluating its empirical efficacy across diverse educational levels and international geographic settings to examine its full transformative value globally.

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#### REFERENCES

- Abdulahi, A., Andishmand, V., Bahreinizadeh, A., & Zeinaddiny Meymand, Z. (2024). Examining the Components of a Curriculum Based on Cultural Literacy in Education. *Iranian Journal of Educational Sociology*, 7(4), 21–30. <https://doi.org/10.61838/kman.ijes.7.4.3>
- Abraham, I., & Supriyati, Y. (2022). Desain Kuasi Eksperimen Dalam Pendidikan: Literatur Review. *Jurnal Ilmiah Mandala Education*, 8(3), 2476–2482. <https://doi.org/10.58258/jime.v8i3.3800>
- Atmojo, S. E., Anggriani, M. D., Rahmawati, R. D., Skotnicka, M., Wardana, A. K., & Anindya, A. P. (2025). Bridging STEM and Culture: The Role of Ethnoscience in Developing Critical Thinking and Cultural Literacy. *Jurnal Pendidikan IPA Indonesia*, 14(2), 251–266. <https://doi.org/10.15294/jpii.v14i2.23505>
- Baxter, G., & Hainey, T. (2024). Using immersive technologies to enhance the student learning experience. *Interactive Technology and Smart Education*, 21(3), 403–425. <https://doi.org/10.1108/ITSE-05-2023-0078>
- Bhardwaj, V., Zhang, S., Tan, Y. Q., & Pandey, V. (2025). Redefining learning: student-centered strategies for academic and personal growth. *Frontiers in Education*, 10.

- <https://doi.org/10.3389/feduc.2025.1518602>
- Bitar, N., & Davidovich, N. (2024). Transforming Pedagogy: The Digital Revolution in Higher Education. *Education Sciences*, 14(8), 811. <https://doi.org/10.3390/educsci14080811>
- Blyznyuk, O., Kachak, T., Blyznyuk, T., & Katarzyna Nazaruk, S. (2025). Quality Education in the Digital Age: Adapting to 21st Century Primary School Learners. *Journal of Vasyl Stefanyk Precarpathian National University*, 12(1), 58–68. <https://doi.org/10.15330/jpnu.12.1.58-68>
- Boulanger, D. (2022). The Concept of Dialogical CO-Zone of Proximal Development: Intergenerationality in the Making. *Integrative Psychological and Behavioral Science*, 56(1), 34–57. <https://doi.org/10.1007/s12124-022-09676-6>
- Cai, S., & Lai, C. (2025). Leveraging critical literacy on social media interaction in acculturation. *Journal of Adolescent & Adult Literacy*, 68(5), 481–494. <https://doi.org/10.1002/jaal.1379>
- Chan, C. K. Y., & Luk, L. Y. Y. (2022). A four-dimensional framework for teacher assessment literacy in holistic competencies. *Assessment & Evaluation in Higher Education*, 47(5), 755–769. <https://doi.org/10.1080/02602938.2021.1962806>
- Chatsiopoulou, A., & Michailidis, P. D. (2025). Augmented Reality in Cultural Heritage: A Narrative Review of Design, Development and Evaluation Approaches. *Heritage*, 8(10), 421. <https://doi.org/10.3390/heritage8100421>
- Chen, G., Wang, H., Liang, A., Oubibi, M., & Zhou, Y. (2025). From detached observer to immersive participant: An augmented reality-based experiential learning approach to promote academic performance and learning behaviors in science education. *Computers in Human Behavior Reports*, 19, 100756. <https://doi.org/10.1016/j.chbr.2025.100756>
- Cheng, C. (2023). A study on learning analytics of using mobile augmented reality application to enhance cultural competence for design cultural creation in higher education. *Journal of Computer Assisted Learning*, 39(6), 1939–1952. <https://doi.org/10.1111/jcal.12855>
- Coştu, F. (2025). Exploring augmented reality (AR) in science education: Perspectives from gifted students. *The Journal of Educational Research*, 118(1), 19–36. <https://doi.org/10.1080/00220671.2024.2431681>
- Dharma, I. M. A., Dantes, N., Lasmawan, I. W., & Suastika, I. N. (2025). Effectiveness of digital storybooks based on Balinese culture for enhancing cultural-civic literacy and Pancasila education outcomes. *Journal of Education and E-Learning Research*, 12(2), 165–178. <https://doi.org/10.20448/jeelr.v12i2.6749>
- Diyaurrehman, R. N. F., Laila, A., Mukmin, B. A., Baharudin, B., & Dharin, A. (2025). Enhancing Cultural Literacy: Developing the Tombak Kiai Folklore Book for Elementary Students. *AL-ISHLAH: Jurnal Pendidikan*, 17(1), 1136–1148. <https://doi.org/10.35445/alishlah.v17i1.6694>
- Drljević, N., Botički, I., & Wong, L. H. (2024). Observing student engagement during augmented reality learning in early primary school. *Journal of Computers in Education*, 11(1), 181–213. <https://doi.org/10.1007/s40692-022-00253-9>
- Evangelou, A., Kleftodimos, A., Grigoriou, M., & Lappas, G. (2025). Augmented Reality for Natural Heritage Education: A Design Framework for Enhancing Indoor Experiences. *Heritage*, 8(6), 191. <https://doi.org/10.3390/heritage8060191>
- Ferreira, A. D. D. S., Silva, M. S., Monteiro, E. M. L. M., & Barros, M. B. S. C. (2025). Development and Content Validation of a Manga-Based Educational Technology on Child Sexual Abuse: A Nursing Tool for Health Literacy in Brazil. *International Journal of Nursing Information*, 4(2), 32–42. <https://doi.org/10.58418/ijni.v4i2.171>
- Ginting, N., Wuryandani, W., Kawuryan, S. P., Mustadi, A., Firdaus, F. M., & Sitorus, J. (2026). Factors influencing students' critical skills and cultural literacy skills: including the factors of educational environment, culture openness, socio-cultural interactions, and information access. *Frontiers in Education*, 11, 1723815. <https://doi.org/10.3389/feduc.2026.1723815>
- Hossain, K. I. (2024). Reviewing the role of culture in English language learning: Challenges and opportunities for educators. *Social Sciences & Humanities Open*, 9, 100781. <https://doi.org/10.1016/j.ssaho.2023.100781>
- Juita, H. R., Widiyanto, S., Apriliyani, N. Y. A., Megayanti, W., Ati, A. P., & Sumadyo, B. (2025). Literature Learning to Instill Local Culture Using Digital Flipbooks for Elementary School Students. *Journal of Innovation in Educational and Cultural Research*, 6(2), 420–426. <https://doi.org/10.46843/jiecr.v6i2.1583>
- Kale, M., Deretarla Gül, E., & Tohma, M. (2023). Cultural literacy of preschool teachers teaching children from different cultures. *Early Child Development and Care*, 193(4), 506–518. <https://doi.org/10.1080/03004430.2022.2108025>
- Kleftodimos, A., Moustaka, M., & Evangelou, A. (2023). Location-Based Augmented Reality for Cultural Heritage Education: Creating Educational, Gamified Location-Based AR Applications for the Prehistoric Lake Settlement of Dispilio. *Digital*, 3(1), 18–45. <https://doi.org/10.3390/digital3010002>
- Kristoffersen, C. S. M., Ziesler, C. E. Ø., Thune, N. H., Kristensen, A. T., Sehic, A., Utheim, T. P., & Khan, Q. (2025). Towards a Modernized Framework of Histology Teaching to Integrate Genetics:

- Pedagogical Perspectives for Oral Histology. *Genes*, 16(5), 512. <https://doi.org/10.3390/genes16050512>
- Lähdesmäki, T., Baranova, J., Ylönen, S. C., Koistinen, A.-K., Mäkinen, K., Juškiene, V., & Zaleskiene, I. (2022). *Learning Cultural Literacy through Creative Practices in Schools*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-89236-4>
- Lee, J.-H., & Wang, C. Y. (2025). Revitalizing Rural Heritage Through an Intergenerational Alternate Reality Game: A Mixed-Methods Study in Taiwan. *Sustainability*, 18(1), 338. <https://doi.org/10.3390/su18010338>
- Lee, N., & Chen, C.-H. (2026). Constructive alignment in studio-based learning: enhancing design education through the zone of proximal development. *International Journal of Technology and Design Education*, 36(2), 753–775. <https://doi.org/10.1007/s10798-025-10021-2>
- Lestari, N., Paidi, P., & Suyanto, S. (2024). A systematic literature review about local wisdom and sustainability: Contribution and recommendation to science education. *Eurasia Journal of Mathematics, Science and Technology Education*, 20(2), em2394. <https://doi.org/10.29333/ejmste/14152>
- Liao, C.-W., Wang, C.-C., Wang, I.-C., Lin, E.-S., Chen, B.-S., Huang, W.-L., & Ho, W.-S. (2025). Integrating Virtual Reality into Art Education: Enhancing Public Art and Environmental Literacy Among Technical High School Students. *Applied Sciences*, 15(6), 3094. <https://doi.org/10.3390/app15063094>
- Mansour, N., Aras, C., Staarman, J. K., & Alotaibi, S. B. M. (2025). Embodied learning of science concepts through augmented reality technology. *Education and Information Technologies*, 30(6), 8245–8275. <https://doi.org/10.1007/s10639-024-13120-0>
- Maufur, S., Aspandi, A., & Salam, A. (2025). AR Media Development to Improve Cultural Literacy and Language Skills in Elementary Schools. *EDUKASIA Jurnal Pendidikan Dan Pembelajaran*, 6(2), 1053–1066. <https://doi.org/10.62775/edukasia.v6i2.1686>
- Maulana, A., Subyantoro, S., Yuniawan, T., & Pristiwati, R. (2024). Development of Electronic Media Assisted Language Learning Modules with Cultural Literacy. *Ingénierie Des Systèmes d'Information*, 29(4), 1283–1295. <https://doi.org/10.18280/isi.290404>
- Mayer, R. E. (2024). The Past, Present, and Future of the Cognitive Theory of Multimedia Learning. *Educational Psychology Review*, 36(1), 8. <https://doi.org/10.1007/s10648-023-09842-1>
- Nopas, D. (2025). Algorithmic learning or learner autonomy? Rethinking AI's role in digital education. *Qualitative Research Journal*. <https://doi.org/10.1108/QRJ-11-2024-0282>
- Nugraheni, D., Wuri Wuryandani, Purnomo, & Agus Purwanto. (2025). Developing a Digital Cultural Flipbook to Enhance Understanding Concept of Diversity and Tolerance. *Jurnal Ilmiah Sekolah Dasar*, 9(2), 290–299. <https://doi.org/10.23887/jisd.v9i2.83192>
- Nurmalasari, W. (2023). Penilaian Autentik Pada Membaca Pemahaman Siswa Kelas IV Sekolah Dasar. *Jurnal Pendidikan DEWANTARA: Media Komunikasi, Kreasi Dan Inovasi Ilmiah Pendidikan*, 9(1), 30–43. <https://doi.org/10.55933/jpd.v9i1.488>
- Oliveira, K. K. de S., & de Souza, R. A. C. (2021). Digital Transformation towards Education 4.0. *Informatics in Education*, 21(2), 283–309. <https://doi.org/10.15388/infedu.2022.13>
- Rahmiati, D., Suharini, E., & Widiyatmoko, A. (2025). Pengaruh Pembelajaran Kearifan Lokal di Jawa Barat dalam Melestarikan Budaya Tradisional bagi Siswa SD. *FONDATIA*, 9(2), 318–339. <https://doi.org/10.36088/fondatia.v9i2.5720>
- Rasmet, R. R., Shaafi, N. F., & Sharif, S. (2025). Content Validity of Needs Analysis Questionnaire Instrumentation for the Development of EduComic Model. *Sains Humanika*, 18(1), 01–12. <https://doi.org/10.11113/sh.v18n1.2235>
- Rathnasekara, K., Yatigamma, K., & Suraweera, N. (2025). Innovative pedagogical framework in K12 education: enhancing productivity and engagement of digital natives within resource-constrained environments. *Quality Education for All*, 2(1), 415–440. <https://doi.org/10.1108/QEA-11-2024-0129>
- Rigopouli, K., Kotsifakos, D., & Psaromiligkos, Y. (2025). Vygotsky's Creativity Options and Ideas in 21st-Century Technology-Enhanced Learning Design. *Education Sciences*, 15(2), 257. <https://doi.org/10.3390/educsci15020257>
- Riyanto, D. M. R., Setiawan, R., & Anindya Syam Choudhury. (2025). Cultural Literacy in Elementary School Students: A Systematic Study on Character Building. *DIDAKTIKA: Jurnal Pendidikan Sekolah Dasar*, 8(1), 24–32. <https://doi.org/10.21831/didaktika.v8i1.87570>
- Rohmah, Z., Hamamah, H., Junining, E., Ilma, A., & Rochastuti, L. A. (2024). Schools' support in the implementation of the Emancipated Curriculum in secondary schools in Indonesia. *Cogent Education*, 11(1). <https://doi.org/10.1080/2331186X.2023.2300182>
- Safitri, I. S., Noviyanti, S., Chan, F., Kesya Malika, N., & Andre Patoman, S. (2024). Analisis Kesulitan Siswa dalam Pembelajaran IPS Muatan IPAS di Sekolah Dasar. *Ainara Journal (Jurnal Penelitian Dan PKM Bidang Ilmu Pendidikan)*, 5(1), 77–81. <https://doi.org/10.54371/ainj.v5i1.331>
- Sakti, S. A., Endraswara, S., & Rohman, A. (2024). Integrating Local Cultural Values into Early Childhood

- Education to Promote Character Building. *International Journal of Learning, Teaching and Educational Research*, 23(7), 84–101. <https://doi.org/10.26803/ijlter.23.7.5>
- Sugiyarti, S., Mukminan, M., & Sujarwo, S. (2024). Designing a Culture-Based Learning Model: A Qualitative Exploration for Strengthening Local Identity in Primary Education. *Jurnal Penelitian Ilmu Pendidikan*, 17(2), 163–176. <https://doi.org/10.21831/jpip.v17i2.91847>
- Sukackè, V., Guerra, A. O. P. de C., Ellinger, D., Carlos, V., Petronienè, S., Gaižiūnienè, L., Blanch, S., Marbà-Tallada, A., & Brose, A. (2022). Towards Active Evidence-Based Learning in Engineering Education: A Systematic Literature Review of PBL, PjBL, and CBL. *Sustainability*, 14(21), 13955. <https://doi.org/10.3390/su142113955>
- Sultan, Y., Dautova, G., & Dalle, J. (2025). Examining the Relationship Among Artificial Intelligence Literacy, Cultural Literacy, and Intercultural Communication Proficiency of Philology Students. *Journal of Ethnic and Cultural Studies*, 12(5), 345–362. <https://doi.org/10.29333/ejecs/2839>
- Twabu, K. (2025). Enhancing the cognitive load theory and multimedia learning framework with AI insight. *Discover Education*, 4(1), 160. <https://doi.org/10.1007/s44217-025-00592-6>
- Udmah, S., Wuryandini, E., & Mahyasari, P. (2024). Analisis Desain Pembelajaran Culturally Responsive Teaching dalam Konteks Penguatan Literasi Humanistik di Sekolah Dasar. *Jurnal Studi Guru Dan Pembelajaran*, 7(2), 749–758. <https://doi.org/10.30605/jsgp.7.2.2024.4272>
- Van Vi, T. (2025). Critical thinking and digital adaptation in philosophy teaching: an innovative model to develop students' soft skills in the context of digital transformation. *SN Social Sciences*, 5(11), 205. <https://doi.org/10.1007/s43545-025-01236-0>
- Wesnina, W., Prabawati, M., & Noerharyono, M. (2025). Integrating traditional and contemporary in digital techniques: the analysis of Indonesian batik motifs evolution. *Cogent Arts & Humanities*, 12(1). <https://doi.org/10.1080/23311983.2025.2474845>
- Wibowo, S., Wangid, M. N., & Firdaus, F. M. (2025). The relevance of Vygotsky's constructivism learning theory with the differentiated learning primary schools. *Journal of Education and Learning (EduLearn)*, 19(1), 431–440. <https://doi.org/10.11591/edulearn.v19i1.21197>
- Wong, J. Y., Azam, A. B., Cao, Q., Huang, L., Xie, Y., Winkler, I., & Cai, Y. (2024). Evaluations of Virtual and Augmented Reality Technology-Enhanced Learning for Higher Education. *Electronics*, 13(8), 1549. <https://doi.org/10.3390/electronics13081549>
- Yıldız, T. (2025). From Constructivism To Cultural Cognition: A Comparative Analysis Of Piaget, Vygotsky, And Tomasello's Theories Of Cognitive Development. *HUMANITAS - Uluslararası Sosyal Bilimler Dergisi*, 13(25), 411–429. <https://doi.org/10.20304/humanitas.1601228>
- Yu, Y., & Hu, W. (2025). Three-Dimensional Modeling and AI-Assisted Contextual Narratives in Digital Heritage Education: Course for Enhancing Design Skill, Cultural Awareness, and User Experience. *Heritage*, 8(7), 280. <https://doi.org/10.3390/heritage8070280>