

International Journal of Learning, Teaching and Educational Research
Vol. 25, No. 3, pp. 1146-1169, March 2026
<https://doi.org/10.26803/ijlter.25.3.51>
Received Dec 16, 2025; Revised Feb 20, 2026; Accepted Feb 23, 2026

Augmented Reality for Cultural Awareness Education: Design, Validation, and Impact on Elementary School Students in Indonesia

Pamungkas Stiya Mulyani* 

Sebelas Maret University, Surakarta, Indonesia
Universitas Sains Al-qur'an, Central Java, Indonesia

Muhammad Akhyar , Munawir Yusuf  and Agus Efendi 

Sebelas Maret University
Surakarta, Indonesia

Abstract. This study set out to develop augmented reality (AR) for learning media, focusing on determining how a valid product design impacts the cultural awareness of elementary school students in Indonesia. The product was assessed in terms of improvement in learning outcomes, practicality of the product during use, and an in-depth analysis of student attitudes and behaviors that reflect cultural awareness. The research was based on the Borg and Gall research and development model, with media development following the SDLC (system development life cycle) method. A mixed-methods sequential explanatory design was adopted. Product revisions were based on quantitative and qualitative analyses through a literature review. The research was conducted through validation tests by experts with expertise in the fields of learning, digital media, and media product use, while testing was carried out on a sample of 80 fourth-grade elementary school students in Indonesia. The study used extensive participant observation, questionnaires, and student assessment sheets. Data analysis entailed descriptive statistics, *n*-gain, normality test, and correlation tests. The results showed that the developed product obtained an approval percentage of 81.25% and 86.25% from expert validators, with input for improvements in audio, color integration, and visual clarity. The *n*-gain score was 0.45, with an average increase per indicator of 41.20 points, practicality achievement of 81.13%, and the level of influence of AR media on cultural awareness at 48.12%. The qualitative analysis showed that the students demonstrated attitudes and behaviors that reflected an increase in cultural awareness within themselves.

Keywords: augmented reality; cultural awareness; media design; elementary school students; validation

*Corresponding author: Pamungkas Stiya Mulyani; pamungkasstiya@student.uns.ac.id

1. Introduction

Quality student learning results in students having cultural sensitivity as well as respect and support for cultural identity and integrity (UNESCO, 2018). As a nation's wealth, students have a role as the next generation to be able to realize promotional actions for cultural knowledge sources in the 21st century (Constantin et al., 2015; Pevec-Zimmer et al., 2024; UNESCO, 2017; Zheng et al., 2021). Cultural awareness can shape a moderate attitude in interacting as a nation (Carlson et al., 2025; Catana, 2014; Yusri & Afrida, 2024). Indonesia is a country rich in cultural diversity, varying in tribes, languages, cultures, races, groups, ethnicities, customs, social status, and physical differences, a truly unique national heritage (Halida et al., 2024; Sazali et al., 2025).

Integrating cultural awareness into the curriculum to prepare students to face the 21st century in a sustainable manner is important, but its implementation in Indonesia is still at odds with the materials for national exams in the curriculum (Anwar & Sukirman, 2024). In Sweden, this gap can continue into higher education, with healthcare students demonstrating a cultural awareness that makes them willing to care for people from different cultural backgrounds, even though this learning is not always available in formal lecture-based education (Hultsjö et al., 2019). Thus, it is important to have learning media as a link that can create cultural awareness in the curriculum, but where students can learn outside the classroom and practice it directly without disrupting the national curriculum.

The development of mass media and digital communication technology has made cultures from various parts of the world more easily accessible and has been adopted by local communities, unfortunately causing the erosion of local cultural identity and a decline in cultural diversity (Taptiani et al., 2024). Initial observations of elementary school students in Indonesia have indicated that globalization has a significant impact on local culture, such as the loss of local languages and traditions, the commercialization of culture, and the dominance of foreign cultures. Data from various sources demonstrate a weakening of cultural awareness among Indonesian students, as shown in Table 1.

Table 1: Data on cultural awareness of students aged ten years and older

Aspect	Percentage (%)
Use of local languages (BPS, 2025)	74.32
Appreciation of local arts (BPS, 2025)	55.30
Understanding of local wisdom values (BPS, 2025)	62.76
Enthusiasm for folktales (BPS, 2025)	53.09
Enthusiasm for popular foreign culture (Wijirahayu et al., 2024)	58.30

The preservation of national culture in the digital era encourages inclusive technological practices (Alsaleh, 2024). Developing technology as a means of strengthening cultural awareness in elementary school students, as the next generation, is crucial. One approach is the use of augmented reality (AR) technology. The use of AR in elementary school has been proven effective (Chang et al., 2022; Tarmidzi et al., 2025). Augmented reality has been proven to be practical and effective in improving students' abilities, understanding, and learning skills and memory, and promoting students' higher-order thinking skills,

which are reflected in their daily life attitudes (Rosita et al., 2025). Augmented reality is technology that enhances the real-world environment by superimposing computer-generated content over it (Al-Ansi et al., 2023). In Indonesia, cultural awareness as a learning objective is not a priority at the elementary school level because learning prioritizes National Examination standards as these predominantly contribute to achievements, such as science skills (Ariesta, 2025; Budiharti et al., 2024; Elia et al., 2024; Fitriani et al., 2025; Hariyati et al., 2020; Latifa et al., 2025; Pangestu et al., 2024), mathematics (Misqa et al., 2024), religion (Wantini et al., 2023), and languages (Rambe & Erika, 2025). Augmented reality research on increasing cultural awareness in Indonesia is limited to the needs analysis stage (Andayani et al., 2025), with no research having been done on the development of AR to increase cultural awareness in elementary school students.

Several literature studies fortify the results of the above VOSViewer analysis, showing that the development of AR for cultural awareness is carried out on high school and college students only (Chin et al., 2020; Pattaufi et al., 2025; Shuang et al., 2025). Conversely, at the elementary school level, AR is used as a tool for the purposes of cultural tourism and introduction to cultural heritage (Chatsiopoulou & Michailidis, 2025; Guo et al., 2025; Jung et al., 2025; Songhong et al., 2024), as a medium for students' knowledge about one aspect of culture, especially local culture, and to be used in other subjects, such as science (Di Fuccio et al., 2024; Rizqia et al., 2024; Sudarmilah et al., 2020; Sudrajat et al., 2024). These findings raise the question: How can AR be developed to increase the cultural awareness of elementary school students in terms of its design, validity, and impact on students after implementation? The overview of this research concept is shown in the conceptual framework diagram for the gap analysis in Figure 1.

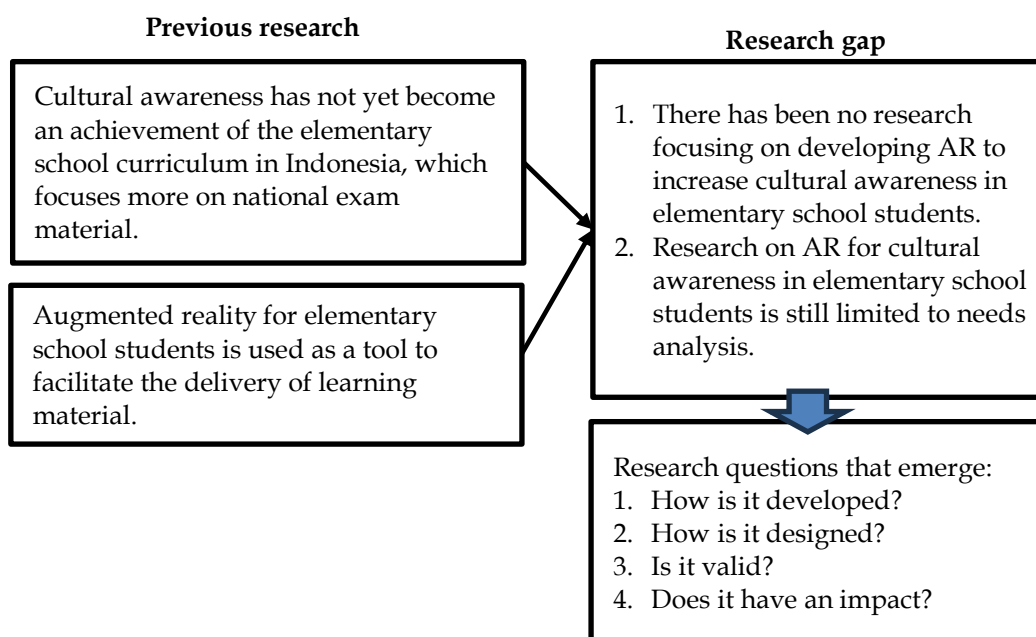


Figure 1: Conceptual framework diagram of gap analysis

Cultural awareness refers to an individual's ability to understand, appreciate, and adapt to cultural differences in social interactions (Djono et al., 2025). Cultural awareness includes the ability to know, understand, act, and behave in ways that reflect cultural values (Kamila et al., 2024). Augmented reality can foster students' curiosity, thereby creating motivation within themselves. This makes students enthusiastic, increasing their understanding and higher-order thinking skills (Kaur et al., 2020; Prasetya et al., 2024). This high-level thinking forms an awareness among students that they can apply in their daily lives (Karwadi et al., 2024).

This necessitates research into whether AR can also enhance cultural awareness. The novelty of this research is the development of an AR learning media product that can enhance cultural awareness in elementary school students. This achievement is not limited to knowledge but includes awareness, a manifestation of a meaningful and enjoyable higher-level thinking process that can foster cultural awareness in students. The development phase utilized the assistance of digital literature studies to provide appropriate development steps.

2. Research Methods

This study conducted development research employing the Borg and Gall model (Gall et al., 2002), with media development following the system development life cycle (SDLC) method (Langer, 2008; Sudarmilah et al., 2020). A mixed-methods research approach with a sequential explanatory design was adopted to obtain the results (Emzir, 2019; Pane et al., 2021). The research procedure is illustrated in Figure 2, and the stages of product development are shown in Figure 3.

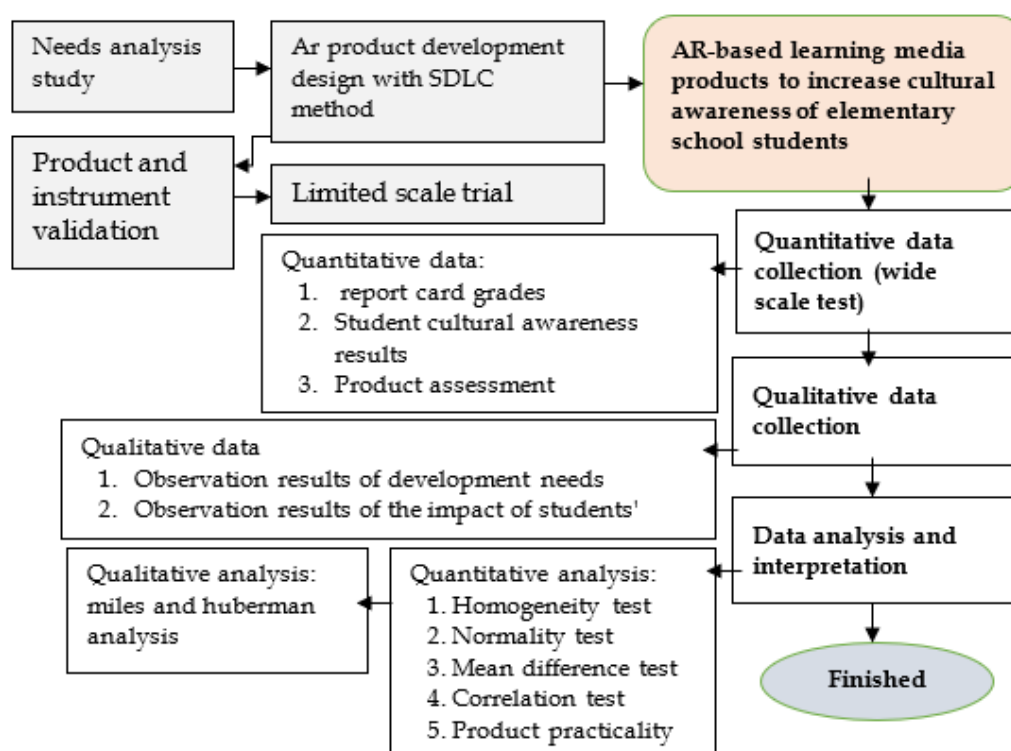


Figure 2: Research procedure flowchart

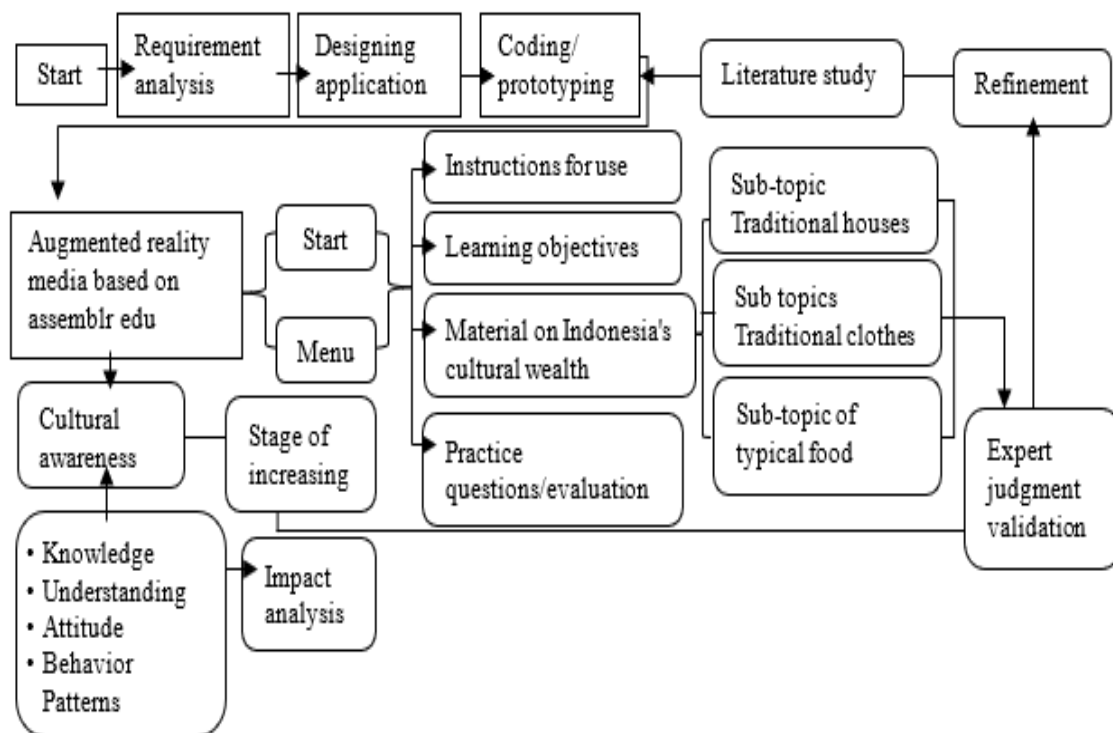


Figure 3: Stages of augmented reality media product development

The AR product prototype design that was prepared based on the needs analysis was validated by three expert validators (learning experts, media experts, and expert users), with expertise in assessment aspects, including relevance to the curriculum, materials, language, evaluation, display, text, images, colors, layout, and audio.

The experts had expertise in the operation and use of a Likert scale questionnaire with 4 rubrics (scale: 1 = "Very Poor"; 2 = "Poor"; 3 = "Good"; 4 = "Very Good"), consisting of 20 questions with 11 indicators adopted from research (Georgiou & Kyza, 2017; Hatmojo et al., 2025; Nikou et al., 2024; Utama & Margunayasa, 2024) (see Table 7 below), as well as an instrument to measure product practicality through a Likert scale questionnaire with 5 rubrics (scale: 1 = "Strongly Disagree"; 2 = "Disagree"; 3 = "Neutral"; 4 = "Agree"; 5 = "Strongly Agree"), consisting of 15 questions with 4 indicators, adopted from the AR product validation instrument source. The indicators and questions are shown in Table 2.

Table 2: Table of indicators and practicality questions of AR products

Aspect	Questions	Code
Content and purpose suitability	1. The material on cultural diversity in the AR media aligns with the learning objectives of fourth-grade social studies.	Q1
	2. The depth of the material (such as an introduction to traditional houses, traditional clothing, and traditional games) is easy for students to understand.	Q2
	3. The questions or assignments in the AR media (evaluation) align with the cultural material presented.	Q3
Appearance and design eligibility	4. The visual display (3D models, animations) of this AR media is engaging and motivates students to learn.	Q4
	5. The interface design (menu buttons) is appropriate for the characteristics and abilities of fourth-grade students.	Q5
	6. The text (font size and type) used is easy for students to read.	Q6
	7. The images and 3D models of cultural objects (e.g., traditional houses) are clear and easily recognizable.	Q7
	8. The color selection in the interface and AR objects is harmonious and does not distract from learning.	Q8
	9. The layout of buttons, text, and objects on the screen is consistent and organized.	Q9
Audio and interactivity aspects	10. The audio used is appropriate to the cultural theme and is not distracting.	Q10
	11. The instructions given are easy for students to understand and follow.	Q11
	12. The interaction with AR objects (e.g., rotating, clicking, or placing objects) is easy for students to do.	Q12
Ease of use	13. The AR application/media is easy for students to operate (open and close).	Q13
	14. The process of scanning markers to display AR objects is smooth and fast.	Q14
	15. Overall, AR media is practical and easy to use for classroom learning.	Q15

The instrument for measuring cultural awareness cognitively was in the form of descriptive questions, consisting of 4 indicators with 15 questions adopted from research (Mahendra et al., 2025; Nasution & Fauzan, 2025; Takiddin et al., 2025; Tardif-Grenier et al., 2024). The distribution of questions for each indicator is shown in Table 3.

Table 3: Indicators of question instruments to measure students' cultural awareness

Indicator	Sub-indicators	Questions
Cultural knowledge	<ol style="list-style-type: none"> 1. Identifying one's own cultural identity. 2. Naming various forms of material and non-material culture. 3. Recognizing cultural symbols and artifacts from various regions in Indonesia. 4. Recognizing the names of national heroes from various regions and their contributions to the nation's diversity. 	<ol style="list-style-type: none"> 1. Name the ethnic group and local language spoken by your family. 2. Name three traditional games and one folk song from your hometown. 3. What is the name of the traditional house from your hometown? Try to describe it simply. 4. Mention one national hero from a region other than yours.
Cultural understanding	<ol style="list-style-type: none"> 5. Understanding the simple meaning of a ritual or tradition. 6. Being able to explain why it is important to respect other people's cultures. 7. Understanding the concept of unity in diversity (<i>bhinneka tunggal ika</i>). 	<ol style="list-style-type: none"> 5. Name a tradition in your region and what is the meaning of this activity? 6. Why should we respect other people's cultures? 7. What is the meaning of the motto "<i>bhinneka tunggal ika</i>" and give one example.
Attitudes toward culture	<ol style="list-style-type: none"> 8. Demonstrating respect and empathy when interacting with people from different cultural backgrounds. 9. Demonstrating pride and willingness to preserve one's own local culture without denigrating other cultures. 10. Demonstrating open-mindedness and curiosity about learning new cultures and traditions. 11. Demonstrating intolerance toward bullying or teasing due to cultural, ethnic, or religious differences. 12. Demonstrating willingness to cooperate and socialize with all peers regardless of their cultural background. 	<ol style="list-style-type: none"> 8. If you saw your friend performing a cultural ritual, what would you do? 9. What would you do to ensure that the dance/song is unforgettable? 10. If a new friend moved from another region and brought a traditional game you've never seen before, how would you react? 11. How would you feel if you heard a friend make fun of your accent or the name of another friend from a certain region? 12. How would you feel if you were in a group with friends from different regions and ethnicities who spoke different languages?
Cultural behavior patterns	<ol style="list-style-type: none"> 13. Actively participating in class or school activities that celebrate cultural diversity. 14. Willing to make friends and play with friends from all cultural, ethnic, and religious backgrounds. 15. Demonstrating respectful behavior when others are performing religious services or cultural rituals. 	<ol style="list-style-type: none"> 13. Have you ever performed or been interested in watching a performance from another region? 14. Would you make friends and invite them to play without discrimination based on ethnicity or religion? Why? 15. If the prayer room of a religion other than what you upheld was near your classroom, what would you do?

Before using the instrument, a validity test was carried out using the Pearson product-moment correlation coefficient (r_{xy}) and KR-21 reliability coefficient (Arikunto, 2018) with 30 elementary school students; the results are shown in Table 4. The results show that the questions on the instrument used in the research were proven valid, with an instrument reliability of 0.89 with “very high” criteria.

Table 4: Results of instrument validity and reliability

No	Code	Question Number										Question Number						Y	Y ²
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
1	UC-30	10	8	8	10	9	10	10	10	10	8	10	10	8	9	8	138	19044	
2	UC-02	10	8	8	10	9	10	10	10	10	8	10	9	8	9	8	137	18769	
3	UC-06	10	10	10	10	10	10	10	10	10	10	6	8	6	6	8	134	17956	
4	UC-11	6	8	8	8	4	8	10	10	10	10	10	10	8	10	10	130	16900	
5	UC-01	8	9	8	8	8	8	10	10	8	10	10	10	10	10	6	133	17689	
6	UC-24	8	8	8	8	8	8	8	6	6	6	8	10	10	10	8	120	14400	
7	UC-10	4	2	2	4	4	4	6	8	6	6	6	8	6	8	10	84	7056	
8	UC-04	8	6	6	6	8	7	8	10	6	8	8	10	6	6	6	109	11881	
9	UC-14	4	6	8	8	4	4	6	6	4	6	6	6	6	6	6	86	7396	
10	UC-25	8	6	8	6	4	4	4	6	4	6	6	6	4	4	6	80	6400	
11	UC-12	4	8	8	6	4	4	4	4	4	6	4	6	4	4	4	74	5476	
12	UC-22	8	6	6	6	2	4	4	6	4	6	6	6	4	4	4	76	5776	
13	UC-21	6	6	4	4	2	4	4	4	4	4	4	4	4	4	4	62	3844	
14	UC-09	6	8	6	6	4	6	6	4	4	4	4	4	4	4	4	74	5476	
15	UC-16	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6	62	3844	
16	UC-15	6	6	6	4	4	4	4	4	4	4	4	4	4	4	4	66	4356	
17	UC-07	6	6	6	2	2	2	2	4	4	4	4	4	4	6	4	60	3600	
18	UC-08	8	4	8	4	4	4	4	4	4	4	4	4	4	4	4	68	4624	
19	UC-29	6	6	6	4	2	4	10	4	4	2	2	4	4	6	6	70	4900	
20	UC-23	6	4	4	4	4	4	6	4	4	4	2	6	6	6	2	66	4356	
21	UC-17	6	6	4	4	4	4	4	4	4	4	4	4	6	4	4	66	4356	
22	UC-05	6	6	6	2	2	2	2	4	4	2	4	4	4	4	4	56	3136	
23	UC-20	8	6	4	4	2	4	2	4	2	4	4	4	2	2	6	58	3364	
24	UC-28	6	4	4	4	2	2	2	4	4	4	2	6	6	6	6	62	3844	
25	UC-18	6	4	4	4	4	4	4	4	4	4	4	4	2	2	4	58	3364	
26	UC-03	8	6	6	6	6	6	6	4	4	4	6	4	4	4	2	76	5776	
27	UC-13	2	2	2	2	4	4	4	8	2	6	6	2	4	4	4	56	3136	
28	UC-19	2	4	4	2	2	4	2	2	2	4	2	2	2	2	4	40	1600	
29	UC-26	4	4	6	4	2	2	2	4	2	4	2	4	2	4	2	50	2500	
30	UC-27	4	4	4	4	4	2	2	4	2	2	2	2	4	4	4	48	2304	
JUMLAH (X)		188	175	176	158	132	147	160	170	144	160	154	165	152	160	158	2399	217123	
Validitas	ΣX	188	175	176	158	132	147	160	170	144	160	154	165	152	160	158	k	15	
	ΣX^2	1312	1133	1152	996	750	889	1096	1148	864	992	980	1113	896	1014	964	$\Sigma \sigma_i^2$	140,98	
	ΣXY	16278	15207	15258	14480	12307	13657	14988	15486	13484	14430	14240	15273	13636	14467	13932	σ^2	842,77	
	r_{xy}	0,68	0,72	0,68	0,91	0,85	0,92	0,89	0,88	0,94	0,87	0,88	0,91	0,83	0,83	0,71	KR-21	0,89	
Criteria	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Very High		

The population of this study consisted of 320 fourth-grade elementary school students in Wonosobo City, Indonesia, divided into 8 classes. One of these classes was later selected as a limited-scale trial class, and two classes were selected for a large-scale trial. The class selection was carried out using random sampling, for which a homogeneity test was carried out using the Bartlett Test with the previous semester’s report card data (Sudjana, 1996). The results are shown in Table 5.

Table 5: Results of the homogeneity test

<i>n</i>	<i>S</i> ²	<i>Log S</i> ²	<i>B</i>	<i>X</i> ² <i>Cnt</i>	<i>X</i> ² <i>Tab</i>	<i>Inf.</i>
8	0.1556	-0.808	-187.482	7.859	14.07	Homogenous

There was no variance in the eight classes, so two classes were randomly selected as the experimental and control classes, each composed of 40 members. The large-scale trial was conducted using a true experimental design (TDR) with a one-group pretest-posttest design (Sugiyono, 2021). The design is shown in Table 6.

Table 6: Research design

Experiment group	Pretest	Learning using AR media	Posttest
Control group	Pretest	Conventional learning	Posttest

The following statistical analyses were employed to analyze the large-scale test data (Haryanti, 2023; Idris, 2009; Sudjana, 1996; Sugiyono, 2021):

1. descriptive statistical analysis to present the results of expert validators and product practicality;
2. normality test using the Shapiro Wilk test to determine the next step using parametric or non-parametric statistics ($N < 50$);
3. comparative test of average differences using the separate variance *t*-test ($n_1 = n_2$);
4. *n*-gain test to determine the increase in cultural awareness;
5. correlation test to determine the effect of AR media on cultural awareness; and
6. Miles and Huberman's qualitative analysis to analyze the results of participant observations of development needs as well as literature studies to obtain solutions for improving AR media and also gain an in-depth understanding of the impact shown by students after experiencing increased cultural awareness.

3. Results and Discussion

3.1 Results

Based on a needs analysis through participant observation, we found that the students were more familiar with modern foreign cultures than their own and less interested in local arts and social activities. We designed the AR product to address these issues. Development began with a media design flowchart and formulating the objectives of the media product. The design development diagram is shown in Figure 4.

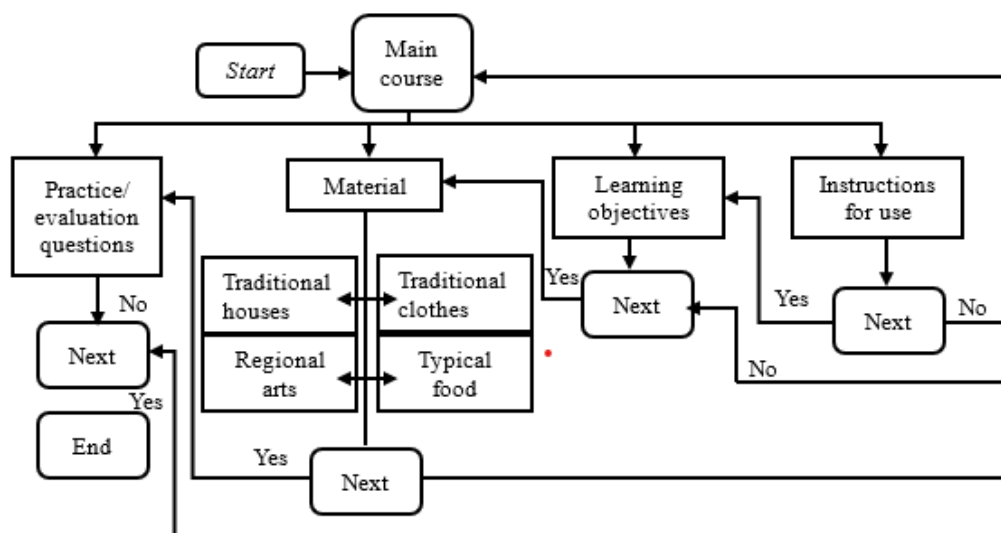


Figure 4: Media development product design diagram

In the next development stage, we validated the product we had developed with three expert validators, whose expertise was described in the research methods section. The product validation results are shown in Table 7.

Table 7: Validation results of the augmented reality-based learning media product

Indicator	Assessment components	1	2	3
Curriculum	1) Suitability of the material to the learning outcomes.	4	4	4
	2) Suitability of the material to the learning objectives.	4	4	4
Material	3) Depth of material	2	2	3
	4) Recency of material	4	4	4
Language	5) Accuracy of sentence structure	4	4	4
	6) Ease of understanding sentences	4	4	4
Evaluation	7) Suitability of evaluation to material	2	3	3
Appearance	8) Attractiveness of the product's appearance	3	3	3
	9) Suitability of the design to student characteristics	3	3	3
Text	10) Appropriate font size on the product	4	4	4
	11) Readability of text on the product	4	4	4
	12) Appropriate font type on the product	4	4	4
Image	13) Clarity of product images	2	2	3
	14) Matching the image to the product	3	3	3
Color	15) Text color matching on the product	2	2	3
	16) Image color matching on the product	3	3	3
Layout	17) The text layout is consistent across every product page	4	4	4
	18) The component layout is consistent across every product page	4	4	4
Audio	19) Suitability of the background sound used in the animated video	1	1	1
Operational aspect	20) Ease of use of the product	4	3	4
Average achievement (%)		81.25	81.25	86.25

The results of the expert validation of the product were declared good because the achievement score was between 81.25% and 86.25%. The findings of product improvements included audio, color integration, image enhancement, material deepening and enrichment, and evaluation models. The product was first tested on a limited scale as a basis for improvement before being implemented on a larger scale. The results of cultural awareness based on the cognitive and practical assessments are shown in Figures 5 and 6.

As seen in Figure 5, the media did not fully improve students' cultural understanding and cultural behavior patterns. The highest achievement was 64.8% for students' attitudes toward culture, but the participant observation results indicated that this achievement was due to the environment, not the impact of AR use. This finding was reinforced by the results of the practicality of the product, shown in Figure 6. The students were less interested and motivated to use the AR product; they were still confused about its operation, necessitating improvements.

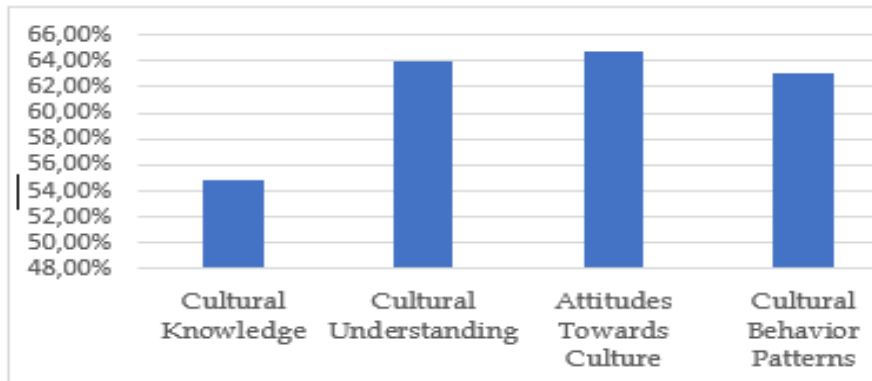


Figure 5: Cognitive achievement of cultural awareness



Figure 6: Practicality achievement of the augmented reality product

Figure 7 displays the results of the improvements in the development of the AR learning media to increase students' cultural awareness.



Figure 7: Augmented reality media display resulting from the development

The purpose of this large-scale testing was to determine the impact that the use of the AR product had. In this study, the impact was demonstrated by an increase in the students' cultural awareness, the practicality of the AR product, the difference in average scores between the experimental class and the control class, and the magnitude of the influence of the AR media on the students' cultural awareness. The increase in the students' cultural awareness before and after the experimental and control classes is shown in Table 8.

Table 8: N-gain test results showing the increase in students' cultural awareness

Data	\bar{x}_{Pretest}	$\bar{x}_{\text{Posttest}}$	$\langle g \rangle$	Inf.
Cultural awareness of experimental class	40.46	55.58	0.44	Currently
Cultural awareness of control class	39.04	39.85	0.2	Low

The increase in cultural awareness of the experimental class was greater than that of the control class, with an increase in the moderate category (0.44). This proves that the use of AR media can increase students' cultural awareness. Figure 8 presents more detailed analysis results for each indicator.

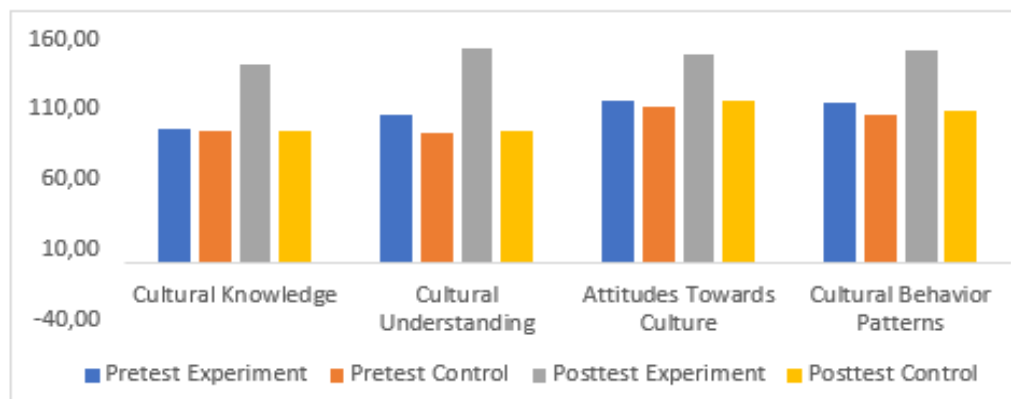


Figure 8: Cultural awareness results

The cultural awareness posttest scores in the experimental class were higher than those in the other cultural awareness tests. The highest scores were for students' cultural understanding and cultural behavior patterns. A product practicality test was conducted to ensure that the developed AR product was effective, efficient, and easy to use for elementary school students. The results are shown in Figure 9. The AR media product developed obtained practicality results for question items ranging from 79.5% to 84.5%, with an average of 81.13%, showing that students could operate the product easily, effectively, and efficiently.

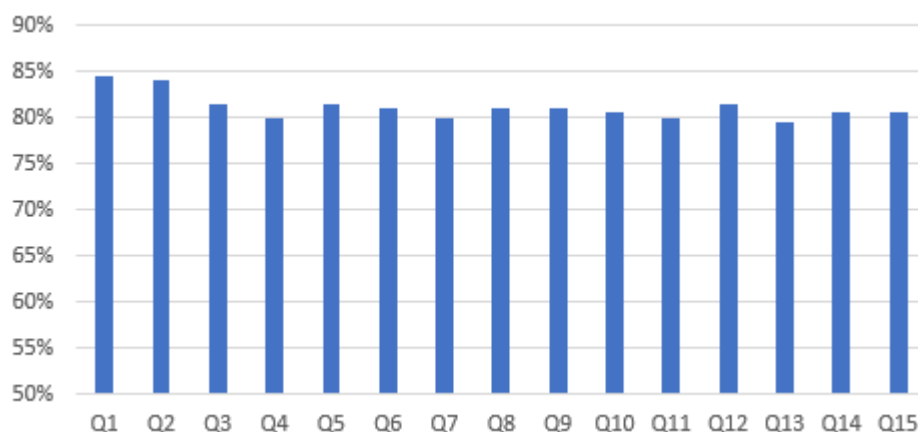


Figure 9: Product practicality results

The results of the average difference test with the control class and the magnitude of the correlation of the influence of the AR product on the cultural awareness of the students are shown in Table 9. A normality test was conducted first to determine whether parametric or non-parametric analyses were appropriate. The data are normally distributed (Table 9), so parametric statistical testing was conducted. The data show that the learning outcomes using the AR product had a different (better) impact than conventional learning, and that the AR product had an influence on cultural awareness of 48.12%.

Table 9: Results of normality, average difference, and correlation tests

Data	<i>n</i>	\bar{x}	b^2	SS	W_{Count}	W_{Table}	Inf.
Practicality of AR media	40	60.77	229.700	263.10	1.040	0.940	Normal
Experimental class	40	55.85	369.185	421.10	1.184	0.940	Normal
Control class	40	39.43	461.030	477.78	0.965	0.940	Normal
Mean difference test (<i>t</i> -test)		\bar{x}	S^2	S	t_{Count}	t_{Table}	Inf.
		55.58 (Exp)	8.775	2.96	21.88	1.99 (α : 5%)	H ₀ rejected
	39.85 (Cont)	11.900	3.45				
Correlation test		Σxy	Σx^2	Σy^2	r	KD (%)	Inf.
		231.7	263.1	424	0.693	48.12	Currently

The results of participant observations showed that learning using the AR media product had an impact on the students' awareness. The results are shown in Table 10.

Table 10: Results of participant observation

Observation indicators	Student results
Cultural knowledge	<ul style="list-style-type: none"> • Students could name the dances and heroes, along with their regions of origin, featured on the Indonesian rupiah banknotes. • Students could distinguish between typical weapons from each region, such as <i>keris</i>, <i>rencong</i>, and <i>kujang</i>. • Students could distinguish between various traditional houses from each region. • Students could distinguish between the carving or <i>batik</i> motifs from each region, such as those of the Dayak, Papuan, Javanese, and Balinese tribes.
Cultural understanding	<ul style="list-style-type: none"> • Students understood the meaning of politeness toward elders regardless of their ethnicity, such as Javanese students always having to say, "<i>matur nuwun</i> (thank you), <i>nyuwun sewu</i> (excuse me), <i>inggih</i> (yes), <i>dalem</i> (I am)". • Students understood that the purpose of every cultural ritual and ceremony was an expression of gratitude to the Creator for all the goodness given, not constituting worship of ancestral spirits. • Students understood that Indonesia's cultural diversity is influenced by many factors, such as its many islands and the history of local cultures that formed it. Therefore, it is obligatory to uphold all existing cultures without denigrating any of them.
Attitudes toward culture	<ul style="list-style-type: none"> • Students demonstrated empathy and compassion and took the initiative to donate to disaster victims in the provinces of Aceh and North Sumatra, Indonesia, which have cultures and ethnicities different from their own. • Students did not participate in insults or denigrate other cultures, as has gone viral on social media. • Students showed pride when wearing a <i>batik</i> on Saturdays, even with <i>blangkon</i> (a traditional Javanese headdress), <i>kopiah</i> (a traditional cap), or <i>songkok</i> (a traditional Javanese headdress). • Students were no longer awkward about inserting their native language into informal communication, demonstrating pride in their linguistic identity. • Students demonstrated a willingness to learn other cultural dances, such as the <i>enggang</i> and <i>mandau</i> dances from Kalimantan, the <i>piring</i> dance from Minangkabau, and the <i>sajojo</i> dance from Papua. They also enjoyed discussing folklores from other cultures and learning moral lessons from them, even though they are Javanese. • Students felt proud of children their age who come from the East Nusa Tenggara and Papua regions who have become champions of the international mathematics Olympiad, and were enthusiastic about emulating them.
Cultural behavior patterns	<ul style="list-style-type: none"> • Students volunteered to help clean the classroom or assist a friend in need without being asked. • Students fundraised for natural disaster relief in Aceh and West Sumatra. • Students demonstrated calm behavior when passing by a house of worship of another religion. • Students shared food with students from other ethnic groups from both eastern and western Indonesia, when they met during a study tour to Yogyakarta.

The data in Table 10 show that the use of the developed AR media in learning had an impact on the students' cultural awareness, which they applied in their daily lives.

3.2 Discussion

Fourth-grade elementary school students are in the concrete operational phase, where they can think logically about an object or event but are not yet fully able to solve abstract problems (Piaget, 2013; Slavin, 1994; Wiles & Joseph, 1993). Augmented reality media could be a mediation tool to connect abstract cultural awareness for students, without which they only learn from theoretical teaching without experiencing it directly. This finding developed the results of research (Hidajat, 2024; Koumpouros, 2024; Marques et al., 2023; Radu et al., 2023) on the role of AR in the 21st century as a concept visualizer.

Based on literature studies, there are several solutions to increase students' motivation and interest in operating AR media:

- 1) *Meaningful gamification* – giving points to students after completing their exploration of existing cultural aspects (Ateş & Polat, 2025; Ivarson et al., 2025; Ponis et al., 2020; Wang et al., 2025).
- 2) *Spatial audio and visual elements* – audio enhancements and also guidance with clear sound, and the integration of colors, objects, and texts in the media so that students are more interested (Cliffe, 2024; Dam et al., 2024; Deacon & Barthet, 2023; Mills et al., 2025; Privitera et al., 2024).
- 3) *Operational rule instruction* – refinement of the instruction so that students find it easier to use the media (Chimienti et al., 2010; Laviola et al., 2024; Mohammadhossein et al., 2025).
- 4) *Assessment and evaluation mechanisms* – improving the forms of assessment and evaluation so that it is easier to see an increase in cultural awareness (Chen et al., 2025; Kim & Kim, 2024; Li et al., 2025; Udeozor et al., 2023).

The AR media design developed in this study attracts students' attention as well as creates motivation and enthusiasm to accept the challenge of learning about cultural richness and its meaning, as shown by the research results (Annail et al., 2025; Kaur et al., 2020; Putra et al., 2024; Yusa et al., 2023). Augmented reality media could be a link in the development of students' learning phases. They could construct knowledge of Indonesian cultural diversity, which is an abstract concept, into real examples that they could get just by scanning the AR barcode, making it possible for them to see concrete examples that enrich their knowledge (Rizqia et al., 2024; Zhao & Wang, 2024).

This finding strengthens the innovative design of educational technology resulting from research (Giannakos et al., 2025; Haleem et al., 2022), which states that learner-centered educational technology design could make learning more meaningful and enjoyable and help students prepare for learning all the time. In other words, AR media invites students to manipulate virtual experiences into real forms so that they can be involved with full awareness and meaning, allowing them to have a deep and enjoyable impression as well as direct experiences (Durchon et al., 2022; Estrada et al., 2022; Gupta et al., 2023).

The integrative phase was demonstrated by students delving deeper into Indonesia's rich cultural heritage through other media, such as YouTube. They began to see the moral messages conveyed by the rich culture. Use of the AR media encourages students to develop positive attitudes (Çetin & Türkan, 2022; Marín-Marín et al., 2023; Sökmen et al., 2024), such as mutual respect, mutual cooperation, and caring for their surroundings.

The contextual form of the learning outcomes from the AR media manifests in student actions in daily life, such as anti-bullying, enthusiastically cleaning the classroom together, showing politeness in their actions, respecting elders, and using local or Indonesian languages politely. Augmented reality media provides an immersive and interactive experience (AlGerafi et al., 2023; Amal et al., 2025; Crogman et al., 2025; Du et al., 2024; Ngo et al., 2025). These results could be used as a consideration for effective solutions to multicultural education needs, which have not yet been incorporated into the standard curriculum in Indonesia (Anwar & Sukirman, 2024).

The results of the validity, effectiveness, practicality, and exploration related to changes in student attitudes and behavior as indicators of cultural awareness indicate that the AR-based media design developed meets the criteria as a good learning medium. Therefore, these findings contribute practically to increasing awareness of Indonesian culture in elementary school students. The research process also contributed to the development of a research method approach, namely a combination of research and development, SDLC, and mixed-methods research, to offer a comprehensive learning media development model.

4. Conclusion

This research designed an AR media product for elementary school learning. We adopted an R and D (research and development) approach that included the SDLC model and a mixed-methods sequential explanatory design. This has proven effective in creating AR media that could truly increase students' cultural awareness. What makes our research different is that the refinement of the AR media product was based on the results of observations, expert validation, and literature studies, all of which were implemented in the development process.

The AR product we developed is effective in increasing cultural awareness – not only knowledge and understanding of culture as in previous research but also the realization of attitudes and behaviors that reflect the embodiment of culture in students. The practicality of AR media could increase students' cultural awareness, student attitudes, and behavior, such as increased appreciation for cultural diversity, polite use of regional languages, mutual respect, especially for elders, as well as mutual cooperation and anti-bullying attitudes. This is crucial in a globalized world that thrives on coexistence and upholds the nation's cultural heritage.

The limitations of this research include a lack of time, funding, and supporting equipment, preventing the resulting objects and images from being fully refined. Achieving high-quality images requires purchasing a "Pro" account. The research

recommends that the government and stakeholders play a key role in establishing cultural awareness as a crucial part of the curriculum, reflecting the nation's identity, and ensuring equitable digital access in every elementary school, thereby increasing student access to AR media.

5. Acknowledgments

The authors would like to thank Deepseek AI, which contributed to providing considerations and an overview of this research. The final decisions were entirely under the authors' control.

6. References

- Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. *Social Sciences & Humanities Open*, 8(1), Article 100532. <https://doi.org/10.1016/j.ssaho.2023.100532>
- AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the potential: A comprehensive evaluation of augmented reality and virtual reality in education. *Electronics*, 12(18), Article 3953. <https://doi.org/10.3390/electronics12183953>
- Alsaleh, A. (2024). The impact of technological advancement on culture and society. *Scientific Reports*, 14(1), Article 32140. <https://doi.org/10.1038/s41598-024-83995-z>
- Amal, A., Rusmayadi, & Tri Sugiarti. (2025). The effectiveness of augmented reality-based learning media in improving vocabulary mastery of early childhood in Makassar City. *Jurnal Pendidikan Anak Usia Dini Undiksha*, 13(1), 154–159. <https://doi.org/10.23887/paud.v13i1.86193>
- Andayani, Anam, K., & Prabowo, S. (2025). Optimizing cultural awareness through augmented reality: An analysis of educational media needs in Indonesian elementary schools. *EduBase: Journal of Basic Education*, 6(2), 204–214. <https://doi.org/10.47453/edubase.v6i2.417>
- Annail, B., Aminullah, A. A., & Ghafur, A. (2025). The impact of using augmented reality-based interactive media on students' learning motivation. *Journal of Education and Social Science*, 2(1), 13–18. <https://doi.org/10.70716/jess.v2i1.181>
- Anwar, A., & Sukirman, D. (2024). The impact of local content curriculum on students' cultural awareness and identity in Indonesian elementary schools. *Education 3-13*, 1–17. <https://doi.org/10.1080/03004279.2024.2402572>
- Ariesta, F. W. (2025). Optimizing elementary student learning outcomes through differentiated instruction based on learning styles. *Jurnal Ilmiah Sekolah Dasar*, 9(2), 356–364. <https://doi.org/10.23887/jisd.v9i2.94754>
- Arikunto, S. (2018). *Dasar-dasar evaluasi pendidikan* [Fundamentals of educational evaluation] (3rd ed.). Bumi Aksara.
- Ateş, H., & Polat, M. (2025). Leveraging augmented reality and gamification for enhanced self-regulation in science education. *Education and Information Technologies*, 30(12), 17079–17110. <https://doi.org/10.1007/s10639-025-13481-0>
- BPS. (2025). *Budaya: Statistik yang berhubungan dengan kegiatan budaya dalam masyarakat, seperti teater, bioskop, museum, perpustakaan, media massa, produksi buku, olahraga, dll., termasuk pengeluaran dan pembiayaan budaya* [Culture: Statistics relating to cultural activities in society, such as theatre, cinema, museums, libraries, mass media, book production, sports, etc., including cultural expenditure and financing]. Accessed on 03/11/2025, from <https://www.bps.go.id/id/statistics-table?subject=527&sortBy=date%2Ctitle&sortOrder=desc%2Casc>

- Budiharti, U. S., Nurhayati, & Anitra, R. (2024). Analysis of social studies learning outcomes of elementary school students based on learning motivation. *JUDIKDAS: Jurnal Ilmu Pendidikan Dasar Indonesia*, 3(4), 175–187. <https://doi.org/10.51574/judikdas.v3i4.1373>
- Carlson, E., Chan, E. A., Kumlien, C., Leung, D. Y., & Bish, M. (2025). Perspective transformation of cultural awareness: A qualitative study on research students' experiences of international cross-institutional webinars. *Journal of Transformative Education*, 23(1), 119–135. <https://doi.org/10.1177/15413446241263772>
- Catana, S. E. (2014). Teaching cross-cultural communication issues: A way of successfully integrating into the multicultural knowledge society. *Procedia – Social and Behavioral Sciences*, 128, 343–348. <https://doi.org/10.1016/j.sbspro.2014.03.168>
- Çetin, H., & Türkan, A. (2022). The effect of augmented reality based applications on achievement and attitude towards science course in distance education process. *Education and Information Technologies*, 27(2), 1397–1415. <https://doi.org/10.1007/s10639-021-10625-w>
- Chang, H.-Y., Binali, T., Liang, J.-C., Chiou, G.-L., Cheng, K.-H., Lee, S. W.-Y., & Tsai, C.-C. (2022). Ten years of augmented reality in education: A meta-analysis of (quasi-) experimental studies to investigate the impact. *Computers & Education*, 191, Article 104641. <https://doi.org/10.1016/j.compedu.2022.104641>
- Chatsiopoulou, A., & Michailidis, P. D. (2025). Augmented reality in cultural heritage: A narrative review of design, development and evaluation approaches. *Heritage*, 8(10), Article 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, Article 100756. <https://doi.org/10.1016/j.chbr.2025.100756>
- Chimienti, V., Iliano, S., Dassisti, M., Dini, G., & Failli, F. (2010). Guidelines for implementing augmented reality procedures in assisting assembly operations. In S. Ratchev (Ed.), *Precision assembly technologies and operations* (pp. 174–179). Springer. https://doi.org/10.1007/978-3-642-11598-1_20
- Chin, K.-Y., Kao, Y.-C., & Wang, C.-S. (2020). Effects of augmented reality technology in a mobile touring system on university students' learning performance and interest. *Australasian Journal of Educational Technology*, 37(1), 27–42. <https://doi.org/10.14742/ajet.5841>
- Cliffe, L. (2024). Interfacing with history: Curating with audio augmented objects. *Museum Management and Curatorship*, 41(1), 143–161. <https://doi.org/10.1080/09647775.2024.2431899>
- Constantin, E. C., Cohen-Vida, M.-I., & Popescu, A. V. (2015). Developing cultural awareness. *Procedia – Social and Behavioral Sciences*, 191, 696–699. <https://doi.org/10.1016/j.sbspro.2015.04.228>
- Crogman, H. T., Cano, V. D., Pacheco, E., Sonawane, R. B., & Boroan, R. (2025). Virtual reality, augmented reality, and mixed reality in experiential learning: Transforming educational paradigms. *Education Sciences*, 15(3), Article 303. <https://doi.org/10.3390/educsci15030303>
- Dam, A., Lee, Y., Siddiqui, A., Lages, W. S., & Jeon, M. (2024). Audio augmented reality using sonification to enhance visual art experiences: Lessons learned. *International Journal of Human-Computer Studies*, 191, Article 103329. <https://doi.org/10.1016/j.ijhcs.2024.103329>
- Deacon, T., & Barthet, M. (2023). Spatial design considerations for interactive audio in virtual reality. In M. Geronazzo & S. Serafin (Eds.), *Sonic interactions in virtual environments* (pp. 181–217). https://doi.org/10.1007/978-3-031-04021-4_6

- Di Fuccio, R., Kic-Drgas, J., & Woźniak, J. (2024). Co-created augmented reality app and its impact on the effectiveness of learning a foreign language and on cultural knowledge. *Smart Learning Environments*, 11(1), Article 21. <https://doi.org/10.1186/s40561-024-00304-x>
- Djono, D., Purwanta, H., Pelu, M., Herimanto, H., Sutiyah, S., & Ashari, H. (2025). Cultivating global citizens: Cultural awareness, critical thinking, and intercultural competence in high school education. *Jurnal Kependidikan : Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran, dan Pembelajaran*, 11(3), 1143–1151. <https://doi.org/10.33394/jk.v11i3.16811>
- Du, Z., Wang, T., Wang, F., & Wang, S. (2024). Augmented reality experience: An examination of viewer responses to sports videos. *Journal of Consumer Behaviour*, 23(3), 1307–1328. <https://doi.org/10.1002/cb.2280>
- Durchon, H., Preda, M., Zaharia, T., & Grall, Y. (2022). Challenges in applying deep learning to augmented reality for manufacturing. *27th International Conference on 3D Web Technology*, 13, 1–4. <https://doi.org/10.1145/3564533.3564572>
- Elia, R., Solfema, S., Miaz, Y., & Zen, Z. (2024). Improving concept understanding and learning outcomes of elementary school students through science textbooks based on learning cycle 7E model. *Jurnal Penelitian Pendidikan IPA*, 10(7), 4433–4441. <https://doi.org/10.29303/jppipa.v10i7.7662>
- Emzir. (2019). *Metodologi penelitian pendidikan: Kuantitatif dan kualitatif* [Educational research methodology: Quantitative and qualitative] (1st ed., Vol. 11). Rajawali Pers.
- Estrada, J., Paheding, S., Yang, X., & Niyaz, Q. (2022). Deep-learning-incorporated augmented reality application for engineering lab training. *Applied Sciences*, 12(10), Article 5159. <https://doi.org/10.3390/app12105159>
- Fitriani, F., Syahrin, A., & Dewi, S. L. (2025). Enhancing students' motivation and learning outcomes through the problem-solving learning model at elementary school. *AL-ISHLAH: Jurnal Pendidikan*, 17(3), 4171–4180. <https://doi.org/10.35445/alishlah.v17i3.7003>
- Gall, M. D., Borg, W. R., & Gall, J. P. (2002). *Educational research: An introduction* (7th ed.). Pearson.
- Georgiou, Y., & Kyza, E. A. (2017). The development and validation of the ARI questionnaire: An instrument for measuring immersion in location-based augmented reality settings. *International Journal of Human-Computer Studies*, 98, 24–37. <https://doi.org/10.1016/j.ijhcs.2016.09.014>
- Giannakos, M., Horn, M., & Cukurova, M. (2025). Learning, design and technology in the age of AI. *Behaviour & Information Technology*, 44(5), 883–887. <https://doi.org/10.1080/0144929X.2025.2469394>
- Guo, W., Husain, A., & Jamali, S. S. (2025). Augmented reality in graphic design education: The proposition of cultural heritage tourism AR design pattern. *Cogent Education*, 12(1), Article 2551177. <https://doi.org/10.1080/2331186X.2025.2551177>
- Gupta, Y. P., Mukul, & Gupta, N. (2023). Deep learning model based multimedia retrieval and its optimization in augmented reality applications. *Multimedia Tools and Applications*, 82(6), 8447–8466. <https://doi.org/10.1007/s11042-022-13555-y>
- Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275–285. <https://doi.org/10.1016/j.susoc.2022.05.004>
- Halida, H., Syaputra, Y. D., Monalisa, M., Syawaluddin, S., Saputra, R., & Gusman, E. (2024). Increasing students' awareness of cultural diversity through symbolic modeling techniques based on the art of Syair Gulung. *Journal of Innovation in Educational and Cultural Research*, 5(1), 155–162. <https://doi.org/10.46843/jiecr.v5i1.1079>

- Hariyati, Budi Jatmiko, & Raharjo. (2020). Development of online science learning devices cooperative model type STAD assisted by video media to improve learning outcomes of elementary school students. *IJORER: International Journal of Recent Educational Research*, 1(3), 301–313. <https://doi.org/10.46245/ijorer.v1i3.39>
- Haryanti, S. (Ed.). (2023). *Statistika pendidikan* [Educational statistics]. Media Sans Indonesia.
- Hatmojo, Y. I., Azis, S. M., & Fauzan, M. N. (2025). The expert validation of virtual reality-based learning media of flexible manufacturing systems (FMS). *International Journal of Artificial Intelligence Research*, 9(1). <https://doi.org/10.29099/ijair.v9i1.1470>
- Hidajat, F. A. (2024). Augmented reality applications for mathematical creativity: A systematic review. *Journal of Computers in Education*, 11(4), 991–1040. <https://doi.org/10.1007/s40692-023-00287-7>
- Hultsjö, S., Bachrach-Lindström, M., Safipour, J., & Hadziabdic, E. (2019). “Cultural awareness requires more than theoretical education”: Nursing students’ experiences. *Nurse Education in Practice*, 39, 73–79. <https://doi.org/10.1016/j.nepr.2019.07.009>
- Idris, M. (2009). *Metode penelitian ilmu sosial: Pendekatan kualitatif dan kuantitatif* [Social science research methods: Qualitative and quantitative approaches (2nd ed., Vol. 2)]. Erlangga.
- Ivarson, E., Erlandsson, V., Faraon, M., & Khatib, S. (2025). Augmented reality and gamification in higher education: Designing mobile interaction to enhance students’ motivation and learning. *E-learning and Digital Media*, 22(6), 571–590. <https://doi.org/10.1177/20427530241239981>
- Jung, K. S., Lee, Y. E., & Chock, T. M. (2025). Cultural differences in the use of augmented reality smart glasses (ARSGs) between the U.S. and South Korea: Privacy concerns and the technology acceptance model. *Applied Sciences*, 15(13), Article 7430. <https://doi.org/10.3390/app15137430>
- Kamila, Wilujeng, I., & Rahmawati, L. (2024). Profile of science literacy and cultural awareness of students and the need for science teaching materials integrated with local potential of STEAM-PBL based petis in Sumenep. *Jurnal Penelitian Pendidikan IPA*, 10(9), 6677–6689. <https://doi.org/10.29303/jppipa.v10i9.7578>
- Karwadi, K., Zakaria, A. R., & Syafii, A. (2024). A review of the effects of active learning on high order thinking skills: A meta-analysis within Islamic education. *Journal of Education and Learning (EduLearn)*, 18(1), 97–106. <https://doi.org/10.11591/edulearn.v18i1.20895>
- Kaur, D. P., Mantri, A., & Horan, B. (2020). Enhancing student motivation with use of augmented reality for interactive learning in engineering education. *Procedia Computer Science*, 172, 881–885. <https://doi.org/10.1016/j.procs.2020.05.127>
- Kim, K.-S., & Kim, C.-S. (2024). Development and usability evaluation of augmented reality content for light maintenance training of air spring for electric multiple unit. *Applied Sciences*, 14(17), Article 7702. <https://doi.org/10.3390/app14177702>
- Koumpouros, Y. (2024). Revealing the true potential and prospects of augmented reality in education. *Smart Learning Environments*, 11(1), Article 2. <https://doi.org/10.1186/s40561-023-00288-0>
- Langer, A. M. (2008). *Analysis and design of information systems* (3rd ed.). Springer.
- Latifa, H. L., Saptono, S., & Isdaruanti, B. (2025). Cognitive learning outcomes of elementary school students through differentiated problem-based learning. *Journal of Primary Education*, 14(1), 16–27. <https://doi.org/10.15294/jpe.v14i1.36825>
- Laviola, E., Uva, A. E., & Gattullo, M. (2024). The minimal AR authoring approach: Validation in a real assembly scenario. *Computers in Industry*, 154, Article 104026. <https://doi.org/10.1016/j.compind.2023.104026>

- Li, M., Li, C., Chen, Y., & Hwang, G.-J. (2025). Effects of an automated evaluation mechanism on students' writing performance and higher-order thinking in an AR-based formative-peer-assessment learning mode. *Education and Information Technologies*, 30(15), 21889–21928. <https://doi.org/10.1007/s10639-025-13611-8>
- Marín-Marín, J.-A., López-Belmonte, J., Pozo-Sánchez, S., & Moreno-Guerrero, A.-J. (2023). Attitudes towards the development of good practices with augmented reality in secondary education teachers in Spain. *Technology, Knowledge and Learning*, 28(4), 1443–1459. <https://doi.org/10.1007/s10758-023-09671-9>
- Marques, A. B., Branco, V., Costa, R., & Costa, N. (2023). Immersive unit visualization with augmented reality. *Multimodal Technologies and Interaction*, 7(10), Article 98. <https://doi.org/10.3390/mti7100098>
- Mills, K. A., Brown, A., & Moro, C. (2025). Virtual and augmented reality text environments support self-directed multimodal reading. *Interactive Learning Environments*, 33(9), 5460–5479. <https://doi.org/10.1080/10494820.2025.2482594>
- Misqa, L., Oviana, W., Hayati, Z., & Jannah, M. (2024). Improving student learning outcomes in mathematics learning through a contextual teaching and learning approach in elementary schools. *Journal of Indonesian Primary School*, 1(2), 19–26. <https://doi.org/10.62945/jips.v1i2.34>
- Mohammadhossein, N., Richter, A., Richter, S., & Thatcher, J. (2025). Navigating augmented reality: A practice-oriented guide to identifying and overcoming implementation obstacles. *Business Horizons*, 69(2), 229–240. <https://doi.org/10.1016/j.bushor.2025.03.003>
- Mahendra, M. V. E., Kristiantari, M. G. R., & Wibaba, I. M. C. (2025). Enhancing elementary school students' cultural awareness through the Siat Tipat Bantal cultural observation activity. *Mimbar Ilmu*, 30(2), 220–231. <https://doi.org/10.23887/mi.v30i02.96065>
- Nasution, S. I., & Fauzan, A. (2025). Building students' social awareness through multicultural education. *Jurnal Iqra': Kajian Ilmu Pendidikan*, 10(1), 151–164. <https://doi.org/10.25217/ji.v10i1.4999>
- Ngo, T. T. A., Tran, T. T., An, G. K., & Nguyen, P. T. (2025). Investigating the influence of augmented reality marketing application on consumer purchase intentions: A study in the e-commerce sector. *Computers in Human Behavior Reports*, 18, Article 100648. <https://doi.org/10.1016/j.chbr.2025.100648>
- Nikou, S. A., Perifanou, M., & Economides, A. A. (2024). Development and validation of the Teachers' Augmented Reality Competences (TARC) Scale. *Journal of Computers in Education*, 11(4), 1041–1060. <https://doi.org/10.1007/s40692-023-00288-6>
- Pane, I., Akbar, H., Vidya, A. H., Lilis Maghfuroh, Uslan, Rotua, S. S., Zubaedah, W. L., Aulia, P. G., Pikir, W. W., Waluyo, Uslan, & Ulfah, A. (2021). *Desain penelitian mixed method* [Mixed method research design] (Vol. 1). Yayasan Penerbit Muhammad Zaini. <https://www.researchgate.net/publication/365486401>
- Pangestu, K., Malagola, Y., Robbaniyah, I., & Rahajeng, D. (2024). The influence of project based learning on learning outcomes, creativity and student motivation in science learning at elementary schools. *Jurnal Prima Edukasia*, 12(2), 194–203. <https://doi.org/10.21831/jpe.v12i2.63208>
- Pattaufi, Makawi, F. E., Aswan, D., & Cahyadi, D. (2025). Developing augmented reality as a teaching material to enhance cultural awareness in secondary schools. *JOIV: International Journal on Informatics Visualization*, 9(5), Article 1845. <https://doi.org/10.62527/joiv.9.5.4540>
- Pevce-Zimmer, S., Juang, L. P., & Schachner, M. K. (2024). Promoting awareness and self-efficacy for culturally responsive teaching of pre-service teachers through the Identity Project: A mixed methods study. *Identity*, 24(4), 288–306. <https://doi.org/10.1080/15283488.2024.2344086>

- Piaget, J. (2013). *The moral judgment of the child*. Routledge.
<https://doi.org/10.4324/9781315009681>
- Ponis, S. T., Plakas, G., Agalianos, K., Aretoulaki, E., Gayialis, S. P., & Andrianopoulos, A. (2020). Augmented reality and gamification to increase productivity and job satisfaction in the warehouse of the future. *Procedia Manufacturing*, 51, 1621–1628.
<https://doi.org/10.1016/j.promfg.2020.10.226>
- Prasetya, F., Fortuna, A., Samala, A. D., Rawas, S., Mystakidis, S., Syahril, Waskito, Primawati, Wulansari, R. E., & Kassymova, G. K. (2024). The impact of augmented reality learning experiences based on the motivational design model: A meta-analysis. *Social Sciences & Humanities Open*, 10, Article 100926.
<https://doi.org/10.1016/j.ssaho.2024.100926>
- Privitera, A. G., Fontana, F., & Geronazzo, M. (2024). The role of audio in immersive storytelling: A systematic review in cultural heritage. *Multimedia Tools and Applications*, 84(16), 16105–16143. <https://doi.org/10.1007/s11042-024-19288-4>
- Putra, M. A., Madlazim, M., & Hariyono, E. (2024). Exploring augmented reality-based learning media implementation in solar system materials. *IJORER: International Journal of Recent Educational Research*, 5(1), 29–41.
<https://doi.org/10.46245/ijorer.v5i1.440>
- Radu, I., Huang, X., Kestin, G., & Schneider, B. (2023). How augmented reality influences student learning and inquiry styles: A study of 1-1 physics remote AR tutoring. *Computers & Education: X Reality*, 2, Article 100011.
<https://doi.org/10.1016/j.cexr.2023.100011>
- Rambe, J. A., & Erika, E. (2025). The use of learning media to improve student learning outcomes at elementary schools. *ALACRITY: Journal of Education*, 5(1), 452–460.
<https://doi.org/10.52121/alacrity.v5i1.660>
- Rizqia, N., Fathurrahman, M., & Mahroini, Z. (2024). Development of augmented reality learning media based on culturally responsive teaching (CRT) to improve learning outcomes in science material. *Studies in Learning and Teaching*, 5(2), 453–465. <https://doi.org/10.46627/silet.v5i2.432>
- Rosita, D., Dewamti, S. S., & Ibrahim, I. (2025). The impact of augmented reality-based learning media on primary students' retention of human sensory system concepts. *Journal of Integrated Elementary Education*, 5(2), 407–420.
<https://doi.org/10.21580/jieed.v5i2.25276>
- Sazali, H., Matondang, A. R., Zuhriah, Z., & Hadipramana, J. (2025). Cultural awareness and government support as determinants of tourism village sustainability: Evidence from Bali. *Jurnal Ilmiah Peuradeun*, 13(3), 1775–1804.
<https://doi.org/10.26811/peuradeun.v13i3.1771>
- Shuang, C., Li, B., & Zhou, Q. (2025). We are inspired: How augmented reality empowers cultural communication through self-authenticity and subjective well-being. *Technological Forecasting and Social Change*, 221, Article 124353.
<https://doi.org/10.1016/j.techfore.2025.124353>
- Slavin, R. E. (1994). *Educational psychology: Theory and practice* (4th ed.). Allyn and Bacon.
- Sökmen, Y., Sarikaya, İ., & Nalçacı, A. (2024). The effect of augmented reality technology on primary school students' achievement, attitudes towards the course, attitudes towards technology, and participation in classroom activities. *International Journal of Human-Computer Interaction*, 40(15), 3936–3951.
<https://doi.org/10.1080/10447318.2023.2204270>
- Songhong, C., Tian, Y., & Pei, S. (2024). Technological use from the perspective of cultural heritage environment: Augmented reality technology and formation mechanism of heritage-responsibility behaviors of tourists. *Sustainability*, 16(18), Article 8261.
<https://doi.org/10.3390/su16188261>
- Sudarmilah, E., Irsyadi, F. Y. A., Purworini, D., Fatmawati, A., Haryanti, Y., Santoso, B., Bakhtiar, D. N., & Ustia, N. (2020). Improving knowledge about Indonesian

- culture with augmented reality gamification. *IOP Conference Series: Materials Science and Engineering*, 830(3), Article 032024. <https://doi.org/10.1088/1757-899X/830/3/032024>
- Sudjana. (1996). *Metoda statistika* [Educational statistics methods] (6th ed.). Tarsito.
- Sudrajat, A., Darajat, O., Kustandi, C., Purwatiningsih, A. S. E., Mikdar, S., & Thalib, J. B. A. (2024). Learning model of local cultural values based on augmented reality for social science education in elementary school. *International Journal of Social Learning (IJSL)*, 5(1), 235–246. <https://doi.org/10.47134/ijsl.v5i1.345>
- Sugiyono. (2021). *Statistika untuk penelitian* [Statistics for research] (31st ed.). Alfabeta.
- Takiddin, Slam, Z., & Waliyadin. (2025). The role of cultural literacy on elementary school students' attitudes of tolerance: A case in Indonesia. *IJORER: International Journal of Recent Educational Research*, 6(4), 1068–1080. <https://doi.org/10.46245/ijorer.v6i4.906>
- Taptiani, N., Mahadi, A., Romadhon, I. F., Pratama, A. M., Muhammad, R., Purwanto, E., Dian Sari, N., & Isbandi, F. S. (2024). The impact of globalization on local culture. *International Journal of Progressive Sciences and Technologies (IJPSAT)*, 45(1), 92–102. <https://ijpsat.org/index.php/ijpsat/article/view/6233/0>
- Tardif-Grenier, K., Goulet, M., Archambault, I., & McAndrew, M. (2024). Elementary school teachers' openness to cultural diversity and professional satisfaction. *Journal of Education*, 204(1), 29–43. <https://doi.org/10.1177/00220574221101376>
- Tarmidzi, T., Andari, K. D. W., Sari, A., Nuryanti, M., Arfiyanti, R., & Noto, M. S. (2025). Augmented reality and its use in elementary school education: A systematic literature review. *Jurnal Prima Edukasia*, 13(1), 128–145. <https://doi.org/10.21831/jpe.v13i1.75094>
- Udeozor, C., Chan, P., Russo Abegão, F., & Glassey, J. (2023). Game-based assessment framework for virtual reality, augmented reality and digital game-based learning. *International Journal of Educational Technology in Higher Education*, 20(1), Article 36. <https://doi.org/10.1186/s41239-023-00405-6>
- UNESCO. (2017). *Education for Sustainable Development Goals: Learning objectives*. UNESCO. <https://doi.org/10.54675/CGBA9153>
- UNESCO. (2018). *Policy on engaging with Indigenous peoples*. United Nations Educational, Scientific and Cultural Organization.
- Utama, K. G. S., & Margunayasa, I. G. (2024). Augmented reality based student worksheets to improve understanding of 3D-shapes concepts for fifth grade of elementary schools. *Thinking Skills and Creativity Journal*, 7(1), 106–114. <https://doi.org/10.23887/tscj.v7i1.76998>
- Wang, Y., Jiang, T., Jiang, J., Huang, Y., & Chen, N. (2025). Gamification design of AR filters: The influence of key factors on user experience and strategies. *International Journal of Human-Computer Interaction*, 1–22. <https://doi.org/10.1080/10447318.2025.2553777>
- Wantini, W., Waharjani, W., Wijayanti, C. S., & Suyatno, S. (2023). Improving learning outcomes of Islamic religious education for elementary school students with the application of the talking stick learning model. *Al-Ta'Lim Journal*, 30(2), 157–169. <https://doi.org/10.15548/jt.v30i2.808>
- Wijirahayu, S., Ananda, S., Ringo, N., Yunus, G. A., & Sari, Y. Y. (2024). The scholars' perceptions of integrating popular culture into academic speaking and writing. *English Franca: Academic Journal of English Language and Education*, 8(2), 303–318. <https://journal.iaincurup.ac.id/index.php/english/article/view/11400/3327>
- Wiles, J. W., & Joseph, C. B. (1993). *Curriculum development: A guide to practice*. Merrill.
- Yusa, I. W., Wulandari, A. Y. R., Tamam, B., Rosidi, I., Yasir, M., & Setiawan, A. Y. B. (2023). Development of augmented reality (AR) learning media to increase

- student motivation and learning outcomes in science. *Jurnal Inovasi Pendidikan IPA*, 9(2), 127-145. <https://doi.org/10.21831/jipi.v9i2.52208>
- Yusri, F., & Afrida, Y. (2024). The development of students' cultural awareness through an Indonesian cross-cultural counseling. *Jurnal Konseling dan Pendidikan*, 12(1), 98-108. <https://doi.org/10.29210/173200>
- Zhao, Y., & Wang, Q. (2024). Applying augmented reality multimedia technology to construct a platform for translation and teaching system. *Heliyon*, 10(7), e28700. <https://doi.org/10.1016/j.heliyon.2024.e28700>
- Zheng, X., Wang, R., Hoekstra, A. Y., Krol, M. S., Zhang, Y., Guo, K., Sanwal, M., Sun, Z., Zhu, J., Zhang, J., Lounsbury, A., Pan, X., Guan, D., Hertwich, E. G., & Wang, C. (2021). Consideration of culture is vital if we are to achieve the Sustainable Development Goals. *One Earth: A Cell Press Journal*, 4(2), 307-319. <https://doi.org/10.1016/j.oneear.2021.01.012>