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Android-Based Augmented Reality for Traditional Sports Learning

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Keywords

Augmented Reality; Android; Traditional Sports; Elementary School; Physical Education

Abstract

This development study aimed to produce an Android-based augmented reality (AR) application for introducing traditional sports to students of SD Muhammadiyah Malawili, Sorong Regency, and to evaluate its feasibility, practicality, and preliminary effectiveness. The study used the ADDIE research and development model, consisting of analysis, design, development, implementation, and evaluation. The participants were one physical education teacher, two expert validators, and 28 fifth-grade students. Data were collected through observation, interviews, validation sheets, response questionnaires, and comprehension tests. The application contains marker cards, three dimensional visualizations, audio narration, short videos of basic movements, and interactive quizzes on egrang, gobak sodor, bakiak, kasti, jump rope, and engklek. Expert validation produced a mean feasibility score of 87.41% (highly valid), while teacher and student responses produced a practicality score of 90.11% (highly practical). In a one class pre-test post-test field trial without a control group, the mean comprehension score increased from 56.79 to 82.14, with an N-gain of 0.59 (medium). These findings indicate that the application is feasible and practical and has promise as an introductory learning medium. However, the evidence of effectiveness remains preliminary; because the trial involved one class in one school and no control group, the findings cannot be interpreted causally or generalized broadly.

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INTRODUCTION

Physical education, sports, and health learning in elementary schools is not only oriented toward motor skill mastery, but also toward strengthening character, fitness, and appreciation of national culture. One relevant topic for these aims is traditional sports. Through traditional sports, students can learn cooperation, sportsmanship, courage, discipline, and pride in local games inherited across generations. However, the introduction of traditional sports in elementary schools often still depends on teachers' oral explanations, static pictures, or limited field demonstrations. This condition causes some students to have an incomplete understanding of game rules, equipment, basic movement sequences, and the cultural values contained in the games (Bacca et al. 2014).

Digital technology development provides opportunities to present learning media that are more visual, interactive, and close to students' learning experiences. Technology-enhanced learning provides added value when it clarifies concepts, broadens learning experiences, and helps students interact with learning materials (Kirkwood and Price 2014). Augmented reality (AR) is a technology that combines virtual objects with the real environment in real time so that users can observe digital objects as if they exist in real space. In education, AR can support visualization, increase engagement, and facilitate meaningful learning when it is designed according to learning objectives and learner characteristics (Klopfer and Squire 2008).

The use of AR in physical education has the potential to help students recognize equipment, play areas, movement patterns, and game procedures before field practice. An Android-based application was selected because the device is relatively accessible, portable, and flexible for use in the classroom and outside the classroom (Garzón and Acevedo 2019). AR media can also bridge limitations in teacher demonstrations when student numbers are large, practical time is limited, or traditional sports facilities are incomplete (Billinghurst, Clark, and Lee 2015). By displaying three-dimensional models, audio explanations, short videos, and interactive quizzes, students are expected to obtain enjoyable initial experiences before engaging in real physical activity (Kamarainen et al. 2013).

Studies of traditional games show that integrating local games into physical education can develop student character, increase physical literacy, and enrich elementary students' movement experiences (Lubis et al. 2023). However, the development of AR-based digital media for introducing traditional sports in the elementary school context of Sorong Regency remains limited. The novelty of this research lies in developing an Android AR application that specifically presents traditional sports content with language, interface, and activities adjusted to students of SD Muhammadiyah Malawili, Sorong Regency.

Based on these considerations, this study aimed to develop an Android-based augmented reality application for introducing traditional sports at SD Muhammadiyah Malawili, Sorong Regency. Specifically, the study investigated product feasibility according to experts, practicality according to the teacher and students, and preliminary effectiveness in improving students' understanding of traditional sports. By addressing development quality and initial learning outcomes together, the study responds to the need for pedagogically grounded AR research (Cheng and Tsai 2013; Cai et al. 2014). The results are expected to provide an alternative supportive medium for physical education, strengthen cultural movement literacy, and provide an initial reference for developing AR media for other traditional sports topics.

METHODS

This research used a research and development method with the ADDIE model (Nevitaningrum, Mulyatno, and Nopembri 2023). The model was selected because it provides systematic stages from needs analysis to product evaluation. The research was carried out at SD Muhammadiyah Malawili, Sorong Regency, during the even semester of the 2025/2026 academic year. The research subjects consisted of one physical education teacher, 28 fifth-grade students, one learning media expert, and one physical education material expert. Student subjects were selected purposively based on involvement in physical education

learning and the availability of Android devices for guided trials.(Yuen, Yaoyuneyong, and Johnson 2011)

The analysis stage was conducted through learning observation, interviews with the physical education teacher, and identification of traditional sports content suitable for elementary school students. The design stage produced a material map, application flowchart, storyboard, marker design, quiz blueprint, and user interface design. The development stage produced an Android application containing usage instructions, a list of traditional sports, an AR camera, audio narration, basic movement videos, quizzes, and a developer profile. Traditional sports included in the application were egrang, gobak sodor, bakiak, kasti, jump rope, and engklek.(Sudarwo et al. 2023)

The implementation stage consisted of individual, small-group, and field trials. The individual trial involved three students to obtain initial feedback on readability, navigation, and AR camera response. The small-group trial involved nine students to assess ease of use and display attractiveness. The field trial involved 28 fifth-grade students to determine practicality and initial effectiveness. Learning was carried out with a scenario in which the teacher introduced learning objectives, students scanned markers, read and listened to explanations, observed basic movements, discussed the material, completed quizzes, and practiced simple movements under teacher guidance (Hsiao, Chen, and Huang 2012)

The instruments consisted of media expert validation sheets, material expert validation sheets, teacher response questionnaires, student response questionnaires, observation guidelines, interview guidelines, and traditional sports comprehension tests. Media validation aspects included display, navigation, readability, AR object quality, interactivity, and application performance. Material validation aspects included alignment with learning objectives, information accuracy, clarity of language, correctness of movement sequences, and relevance of evaluation. Quantitative data were analyzed using feasibility and practicality percentages. Initial effectiveness was analyzed by comparing pre-test and post-test scores and calculating the N-gain. Qualitative data from experts, teacher, and students were analyzed descriptively to revise the product (Wu et al. 2013)

Ethical considerations, before data collection, formal permission was obtained from the administration of SD Muhammadiyah Malawili. The classroom-based development trial involved minimal-risk, age-appropriate learning activities conducted under the supervision of the physical education teacher. Student identities were not included in the analysis or reporting, and the collected data were used only for research and product-evaluation purposes.

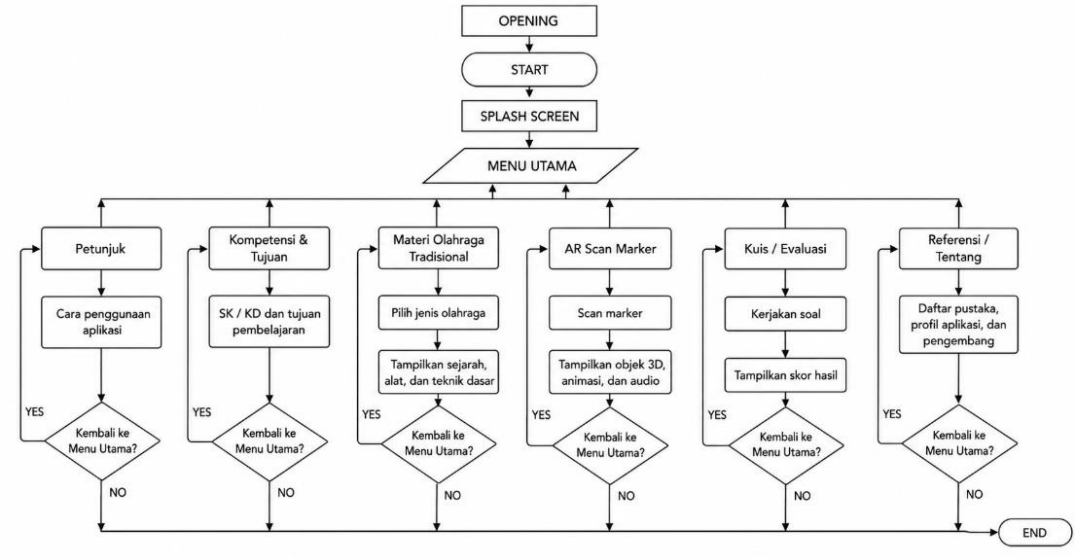

Figure 1. Android-Based Augmented Reality for Traditional Sports Learning

RESULTS AND DISCUSSION

The study was conducted at SD Muhammadiyah Malawili, Sorong Regency, during the even semester of the 2025/2026 academic year. The development and trial process involved one physical education teacher, two expert validators, and 28 fifth-grade students. Implementation included expert validation, an individual trial with three students, a small-group trial with nine students, and a field trial with 28 students. The results below describe the needs analysis and product revisions, feasibility, practicality, and preliminary changes in student comprehension.

Needs analysis showed that the physical education teacher required supportive media that could present game forms, basic rules, and examples of traditional sports movements more concretely. Students showed interest in moving-image media and activities using Android devices. Based on these findings, the application was developed with simple operating principles, age-appropriate language, and continued orientation toward real movement practice in the field.

The product was named AR Traditional Sports. The application contains six marker cards that can be scanned using an Android camera. When a marker is scanned, the application displays visual objects and brief information about the selected traditional sport. Each topic contains definitions, equipment, number of players, simple rules, character values, examples of basic movements, and comprehension quizzes. Revisions during development included increasing font size, clarifying navigation icons, adding a back button on each page, improving audio narration, and simplifying quiz items for elementary students.

Table 1. Expert validation results for the traditional sports AR application

Validator	Assessment aspect	Percentage	Category
Media expert	Interface display	87.50	Highly valid
Media expert	Navigation and access	90.00	Highly valid
Media expert	AR object quality and performance	85.00	Highly valid
Media expert	Media interactivity	88.75	Highly valid
Material expert	Alignment with physical education content	90.00	Highly valid
Material expert	Accuracy of rules and basic movements	88.00	Highly valid
Material expert	Clarity of language	86.00	Highly valid
Material expert	Relevance of evaluation	84.00	Valid
Average	All aspects	87.41	Highly valid

Table 1 shows that the application obtained an average feasibility score of 87.41% in the highly valid category. This result indicates that the display, navigation, AR object quality, and content completeness met the basic needs of learning. The main suggestions from the media expert were to clarify marker scanning instructions and reduce the application file size. Suggestions from the material expert were to emphasize character values, such as cooperation, courage, discipline, and sportsmanship, in each traditional sport.

Table 2. Practicality results during the application trial stage

Data source	Respondents	Percentage	Category
Physical education teacher	1 person	91.67	Highly practical
Individual trial	3 students	87.78	Highly practical
Small-group trial	9 students	88.54	Highly practical
Field trial	28 students	90.12	Highly practical
Overall score	-	90.11	Highly practical

The overall practicality score reached 90.11% in the highly practical category. The teacher considered the application helpful for opening lessons, explaining game rules, and motivating students before practice. Students reported that the interface was attractive, the buttons were easy to recognize, and the AR objects made the material easier to imagine. Scanning problems in dim classroom lighting and slower loading on several devices were addressed by adding lighting instructions, improving marker contrast, and optimizing visual asset size.

Table 3. Comparison of students' pre-test and post-test comprehension scores

Component	Pre-test	Post-test	Description
Number of students	28	28	-
Mean score	56.79	82.14	Improved
Standard deviation	8.91	7.84	More homogeneous
Lowest score	40.00	65.00	Improved
Highest score	75.00	95.00	Improved
N-gain	-	0.59	Medium

The field trial showed improvement in students' understanding after using the application. The mean pre-test score of 56.79 increased to 82.14 in the post-test. The N-gain score of 0.59 was in the medium category. This improvement indicates that the AR application helped students understand traditional sport names, equipment, simple rules, basic movement sequences, and character values. However, this result should be interpreted as initial effectiveness because the trial was conducted in one class and did not use a control group.

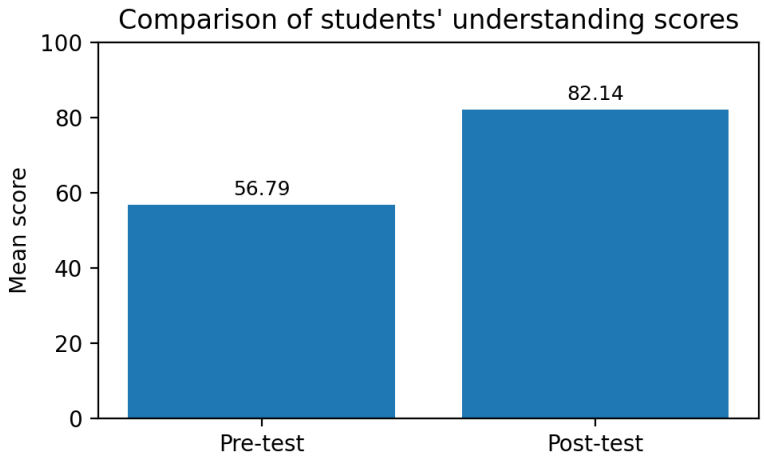

Figure 2. Comparison of students' pre-test and post-test comprehension scores

The feasibility findings should be interpreted as evidence of design alignment rather than proof of learning effectiveness. High expert ratings suggest that the interface, navigation, AR objects, and content were broadly consistent with the instructional objectives and characteristics of fifth-grade learners. This alignment is important because AR is educationally useful when digital representations make otherwise abstract or difficult-to-demonstrate information more observable in the learner's real context (Yuen et al. 2011; Wu et al. 2013). Nevertheless, validation involved only one media expert and one material expert; therefore, the stability of the feasibility judgment should be examined with a larger and more diverse expert panel.

The features that appear most helpful were marker-based visualization, concise audio and text explanations, basic-movement videos, and a simple menu. Student feedback that AR objects made the material easier to imagine suggests that the marker-to-object interaction supported spatial understanding of equipment, player positions, and movement directions. Audio and short text may have reinforced key rules, while quizzes provided immediate opportunities to retrieve information. This interpretation is consistent with multimedia learning: complementary verbal and visual representations can support knowledge construction when extraneous information is limited (Mayer 2009; Radu 2014). However, the study did not collect feature-level effectiveness scores, so it cannot determine which feature contributed most to the observed gain.

Practicality depended not only on interface simplicity but also on the classroom's technical conditions. Clear icons, a back button, and brief scanning instructions reduced procedural demands, whereas dim lighting, weak cameras, slower devices, and large visual assets disrupted scanning and loading. These weaknesses show that AR practicality is conditional: the media can be easy to use while still requiring adequate lighting, compatible devices, high-contrast markers, and teacher assistance. Similar implementation constraints have been identified in reviews of educational AR, which emphasize usability and technical support alongside engagement benefits (Bacca et al. 2014; Billinghurst et al. 2015). A device-readiness check and printed non-AR backup materials would make classroom use more reliable.

The increase in mean comprehension score and medium N-gain suggests that the learning sequence was associated with better understanding of sport names, equipment, rules, movements, and character values. This pattern is consistent with evidence that AR can support learning gains by linking digital information to contextualized visual experiences (Garzón and Acevedo 2019). However, the one-group pre-test–post-test design cannot isolate the application's effect from repeated testing, teacher explanation, group discussion, or direct practice. The score difference should therefore be treated as preliminary evidence of promise, not as a causal estimate of effectiveness.

This study differs from many educational AR applications centered on science simulations or location-based inquiry (Kamarainen et al. 2013; Cai et al. 2014) by using AR as a bridge from digital observation to real physical activity and local cultural learning. It also extends work on traditional games in physical education, which has mainly emphasized character and physical literacy outcomes (Sudarwo et al. 2023; Lubis et al. 2023), by providing a preparatory medium for recognizing rules, equipment, movement sequences, and cultural values before field practice. Its distinctive contribution is thus not replacing movement with screen use, but structuring students' initial orientation so practice can begin with a clearer shared understanding.

The study remains limited by its single-school sample, small number of validators, aggregated practicality measures, lack of a control group, and reliance on a cognitive comprehension test. It did not measure whether students performed movements more accurately, became fitter, retained knowledge over time, or demonstrated character values in authentic play. Future studies should compare AR-assisted and conventional instruction across several schools, analyze each feature separately, assess delayed retention, and include validated measures of motor performance, engagement, and character-related behavior.

Technical testing across device specifications and lighting conditions is also needed before wider implementation.

CONCLUSION

The study achieved its objective of developing an Android-based AR application for introducing traditional sports and established that the product was highly feasible according to expert review and highly practical in guided classroom trials. The one-class field trial also showed a medium preliminary improvement in students' comprehension. These findings support the application's use as an introductory aid before direct physical practice; they do not establish causal effectiveness or broad generalizability. Further controlled, multi-school research is required to test learning retention, motor-skill outcomes, character development, and technical reliability.

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