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LOCAL CULTURE-BASED PHYSICS SMARTBOARD LEARNING FOR PROBLEM-SOLVING SKILL DEVELOPMENT: "NGADA" INDONESIAN TRIBE CASE STUDY

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Abstract
Physics is often considered difficult due to its abstract nature, lack of student training in problem solving, and limited school resources, especially in Ngada Regency, Indonesia. This study aims to develop and evaluate the feasibility of the Physics SmartBoard application based on the local culture of "Ngada," focusing on product validity, practicality, and effectiveness in improving students' problem-solving abilities. The study used the Research and Development (R&D) method with the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The instruments included validation sheets, user response questionnaires, and student problem-solving ability tests. The quantitative data were obtained from expert validation results, user trials, and analysis of problem-solving abilities before and after using the application. The results showed that the application met the criteria for high validity, according to experts, with a level of practicality that was considered very good by teachers and students. In addition, the effectiveness of the application in improving students' problem-solving abilities was in the high category, with a standard gain value of 0.12 in the control group and 0.455 in the experimental group. This application has the potential to be an innovative solution for physics learning in areas with limited resources.

Keywords: Ngada, Learning, Physics, Problem Solving, SmartBoard

Introduction

High school students are required to take physics as a mandatory subject. Physics education is significant as it allows students to understand the natural phenomena around them and fosters problem-solving (Worku, Ejigu, Gebremeskal, & Kassa Gogie, 2025), thereby enhancing their critical (Ma, Zhang, & Luo, 2023), analytical (Christopoulos, Mystakidis, Pellas, & Laakso, 2021), and creative thinking (Brahmia et al., 2021) skills. In addition, physics is a discipline that utilizes concepts extensively relevant to everyday life, making problem-solving skills essential (Satriawan, Rosmiati, Saputra, & Habibbulloh, 2022; Simeon, Samsudin, & Yakob, 2022). Nonetheless, the abstract and intricate nature of physics concepts continues to hinder the understanding of numerous students.

Prior to this research, we conducted preliminary investigation and according to its results of a questionnaire administered to 24 teachers and 75 students from 12 high schools in Ngada Regency, 78.2% of students found it challenging to comprehend physics concepts without direct experience, while 70.8% of teachers encountered difficulties in connecting physics concepts with everyday life. Furthermore, 75.8% of students acknowledged that they were not yet proficient in the application of problem-solving strategies, which are essential components of the physics curriculum. This results are in line with the study results of Wangchuk et al. (2023) which show that, limited learning resources, including the absence of laboratory equipment and high-quality interactive learning media, are additional factors that impede learning.

The Ruangguru Science Competition results indicate that Indonesian students continue to demonstrate a lack of proficiency in the field of physics on a national scale. From a total of over 20,000 participants, only 8.1% selected physics as the field of competition, and the highest score achieved was only 13% of the maximum score (Kristina, 2021). This condition demonstrates the necessity of a more contextual, relevant, and engaging learning approach to pique students' interest in the field of physics. The integration of technology-based learning media with technological advancements in the Industrial Revolution 4.0 era is a potential solution to address this challenge (Adel, 2024; Rosak-Szyrocka, Żywiołek, Nayyar, & Naved, 2023; Wilde & Hsu, 2019). The Physics SmartBoard is an interactive device that enables the visual and dynamic delivery of material through text, images, videos, animations, and simulations (Akar, 2020; Aldalalah, 2021; Yalman & Basaran, 2021). Users can interact with learning materials by writing, drawing, or manipulating visual elements on the screen (Abdullah et al., 2021; Hussein, Ahmed, Shawkat, & Kamil, 2022). Meanwhile, SmartBoard has been demonstrated to enhance student engagement, learning outcomes, and collaboration skills in prior research (Aktas & Aydin, 2016; Jammeh, Karegeya, & Ladage, 2022). SmartBoard has the potential to transform the manner in which teachers and students interact, learn, and teach virtually (Aldalalah, 2021; Olugbade, Dare, & Tolorunleke, 2023). Nevertheless, all of those investigation results relied on the technology for learning must be modified to be more pertinent to the cultural context and daily life of students.

Incorporating local wisdom into the educational process effectively enhances student motivation and the relevance of physics studies. Ngada Regency, located on Flores Island, boasts a wealth of cultural heritage that can provide a valuable learning context. The principles of hydrodynamics and mechanics can be illustrated through the traditional game *Wela Maka* (Dolo & Kua, 2023) and the method of constructing *Sa'o* (traditional houses) (Weebly, 2025). The fabrication of a machete (*Topo*) pertains to Newton's laws and the principle of force. The customary practice of *Dhoro Api* and the formulation of traditional beverages (*Moke*) can provide a framework for understanding the principles of heat and temperature (Laksana, Seso, & Riwu, 2019). Moreover, traditional carvings related to potential energy and mechanics, along with the weaving process that incorporates pressure and force, can serve as educational tools (Centillas, Inocian, Amper, & Bacalso, 2024; Durville, 2010; Lawer, Ntewusu, Addo, Aidoo, & Mba, 2025; Xin et al., 2023; Zabulis et al., 2024). Therefore, this research by a novel approach is conducted to improve the significance of education and allows students to adopt their cultural identity and indigenous knowledge.

Alongside cultural significance, constructivism theory is further strengthened by technology-enhanced physics education that incorporates local wisdom. The local wisdom approach in physics education enables students to correlate the concepts they have acquired with real-world experiences (Dwi Saputra, Niethammer, & Adi Putra, 2024; Maulani, Hariani, & Puspitawati, 2024; Putri & Turaqulov, 2022; Rahman, Wiranata, Haifaturrahmah, & Liswijaya, 2025). It allows students to develop their problem-solving skills through participation in significant contextual experiences (Agustina, Akhdinirwanto, & Fatmaryanti, 2022; Arjaya, Subagia, Redhana, & Hermawan, 2024; Hikmawati & Suastra, 2023; Mahir & Martawijaya, 2025; Setiaji, Tri Adiningsih, Nurita Pebriana, & Supahar, 2025; Susanto, Husen, & Lajis, 2023). Developing problem-solving skills is essential in physics education, as the problem-solving skills improve one's understanding of physics concepts through their application in real-world contexts (Karamustafaoğlu & Pektaş, 2023; Marcinauskas, Iljinas, Čyvienė, & Stankus, 2024; Maries & Singh, 2023). Furthermore, they facilitate the enhancement of students' critical thinking, analytical, and evaluative skills (Xu, Wang, & Wang, 2023), equip students to tackle intricate real-world challenges (Musengimana, Yadav, Uwamahoro, & Nizeyimana, 2025), and inspire students to assume responsibility and cultivate greater autonomy in their learning (Kotsis, 2024; Setyarini, Imam Supardi, & Elok Sudibyo, 2021). Centillas et al. (2024), Dimitriadou and Lanitis (2023), Haleem, Javaid, Qadri, and Suman (2022) have shown that the incorporation of technology, such as SmartBoard, can improve students' critical thinking skills, equip them for real-world challenges, and augment their problem-solving capabilities.

However, there are shortcomings in the existing approach, such as the lack of integration of materials with local contexts and the absence of in-depth visualization to support physics learning. This study aims to develop and evaluate the Physics SmartBoard application based on the local culture "Ngada" as an innovative solution to improve students' problem-solving skills. This media is designed to improve students' problem-solving skills by combining technology and local values, thus creating more interactive and meaningful physics learning. By integrating technology and local culture, this study is expected to provide significant contributions in creating more relevant, interactive, and contextual physics learning.

Purpose of the Study

This study aims to develop and evaluate the feasibility and measure the effectiveness of the Physics SmartBoard application integrated with the local culture of "Ngada" in improving students' problem-solving abilities. By combining technology and local culture, learning is expected to be more interactive, relevant, and contextual. Therefore, the formulations of the research problem are:

1. How valid is the Physics SmartBoard application integrated with "Ngada" culture in improving students' problem-solving?
2. How practical is this application in being implemented in schools in Ngada Regency?
3. How effective is the application in improving students' problem-solving skills?

Methods

Research Design

This type of research was Research and Development (R&D). The product developed in this research was the Physics SmartBoard application integrated with the “Ngada” culture to improve students' problem-solving skills in physics learning. This application was developed using the ADDIE model by Dick & Carry which consisted of five stages, namely: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. Figure 1 illustrates the research design.

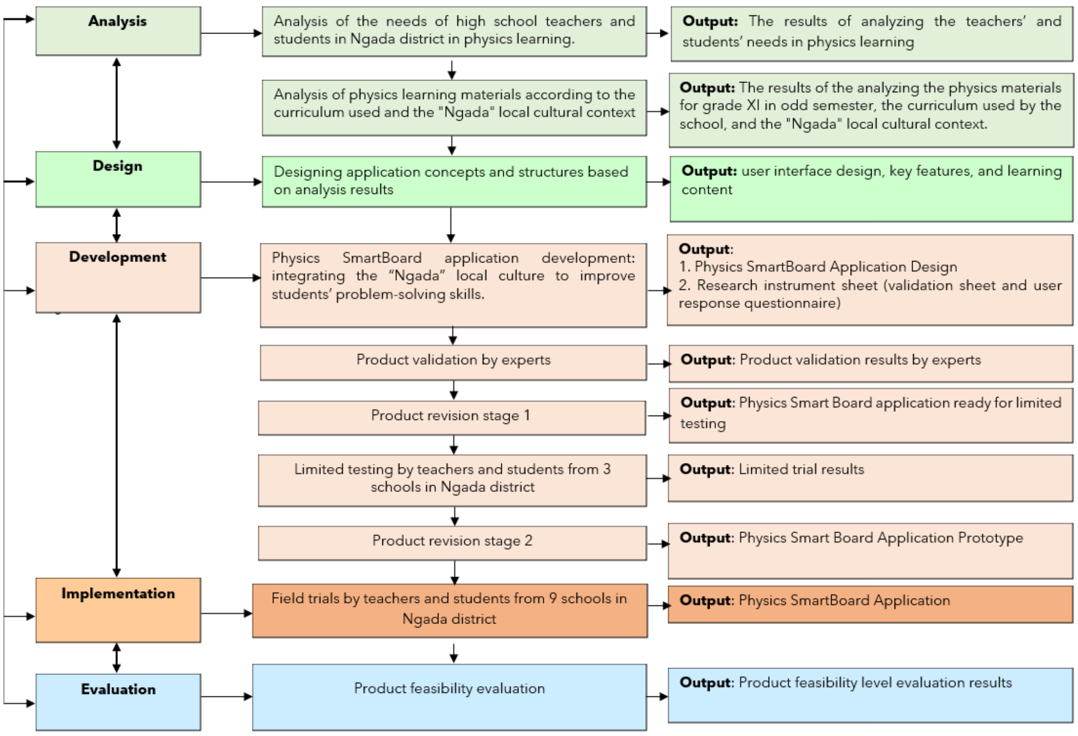

Figure 1. Research design chart with the ADDIE model

Participants

This study was conducted in 12 high schools in Ngada district, East Nusa Tenggara, Indonesia, involving 30 teachers and 150 students using a purposive sampling technique. The participants were prospective users of the research product, namely physics teachers and grade XI high school students from each school.

Physics Smartboard Application Development

The digital learning media in the form of the Physics SmartBoard application in this study was developed using the ADDIE model which consists of five steps, namely:

Analysis

The development of the Physics SmartBoard application began with the analysis stage. A needs analysis questionnaire was completed by the research team during this stage to identify the physics learning needs of both teachers and students, as well as to analyze the issues in physics learning. The questionnaire was completed by 60 students and 12 physics teachers from 12 high schools in Ngada Regency. This instrument was employed to gather data regarding the application of a contextual approach in learning, the challenges associated with physics learning, and the development of problem-solving skills. As a reference for researchers in the development of applications that address the needs of users, specifically teachers and students, the results of the questionnaire analysis have been presented in the Introduction section. The results of this analysis also offer a comprehensive overview of the physics material for the odd semester of grade XI, which includes Vectors, Kinematics, and Dynamics, as well as the curriculum that is implemented in schools, specifically the Merdeka Curriculum. In addition, this analysis identifies the local cultural context of "Ngada" that can be incorporated into the physics learning material.

Design

During the design stage, the research team established a conceptual and theoretical framework that was informed by the results of the needs and materials analysis. This framework includes components that facilitate the integration of physics education with the local culture of "Ngada" in a practical, interactive, and enjoyable manner, with the objective of enhancing the problem-solving abilities of high school students. At this stage, the user interface was designed, the primary features of the application were developed, and learning content that was integrated with local culture was compiled. The primary navigation menu that was developed in this application and designed with user needs in mind is as follows:

No	Feature Types	Feature Description	Usage
1	Interactive Whiteboard	To helps visualize physics concepts through interactive images, diagrams, and animations.	As tools, such as pens, erasers, and measuring tools to draw, diagram, and collaborate. As the work to be saved and shared.
2	Learning Module	To present integrated learning content of local “Ngada” culture in various formats (text, images, audio, video).	For each module which contains text, images, videos, and animations based on local “Ngada” culture.
3	Virtual Simulation	To present virtual physics simulations to understand physics concepts through examples based on local “Ngada” culture.	To conduct virtual simulations on each material
4	Discussion Forum	To provide a space for sharing knowledge about physics concepts and “Ngada” culture, stimulating problem solving and collaboration skills.	For users to ask questions or answer existing questions with teachers and fellow students.
5	Quizzes	To present a “Ngada” culture-based quiz to test physics understanding and problem-solving skills.	For users to complete the quizzes with a standard score before proceeding and to retry to achieve the desired score.

Table 1. Application features

Development

The development team at the development stage implemented the application design, which involved software development and the creation of integrated learning content for the local culture of "Ngada" by referencing indicators of problem-solving abilities. Flutter 3.24 and Dart 3.5 were employed to develop the application. The Laravel framework was employed in the backend technology. Additionally, this application offered services, such as: 1) offline access which students were expected to view certain application content offline, allowing them to learn without requiring an internet connection; 2) ability to access font customization options; 3) multiplatform support which enabled the application to function on a variety of devices, including smartphones, tablets, and laptops. During this phase, researchers also conducted: 1) the development of research instruments; 2) the initial testing by experts, followed by product

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revision based on validation results; and 3) the limited testing by three physics teachers and thirty students from three schools in the Ngada district, followed by product revision based on user trial results.

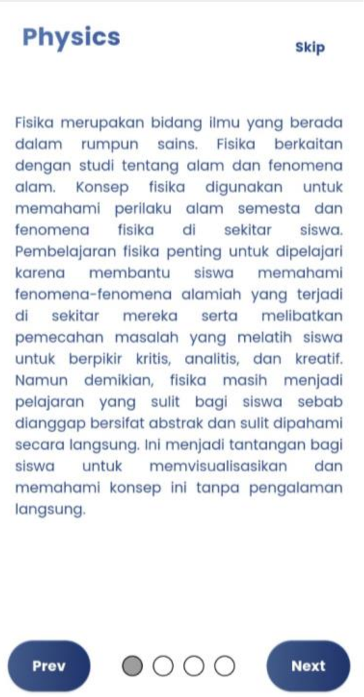

Figure 1. Application Introduction

Figure 2. Discussion Forum

Figure 3. Interactive Whiteboard

Figure 4. Learning Module

Figure 5. Virtual Simulation

Figure 6. Quizzes

Implementation

At the implementation stage, the application was ready to be introduced and implemented in the learning environment through field trials by 27 physics teachers and 120 high school students from 9 schools in Ngada district.

Evaluation

The final stage was evaluation. At this stage, an evaluation of the application's feasibility was carried out based on the results of trials by experts and prospective users. The analysis of the evaluation results was carried out to evaluate the strengths and weaknesses of the product, as well as improving students' problem-solving abilities in using the product in learning.

Data Collection Tools

The assessment sheets for validation results, prospective user response questionnaires, and student problem-solving ability tests comprised the instruments employed in this investigation. 9 validators, including 3 material experts, 3 media experts, and 3 learning design experts, evaluated the application. 3 physics teachers and 30 students from three schools in the Ngada district conducted restricted testing using the prospective user response questionnaire. 27 physics teachers and 120 high school or Islamic high school students from 9 schools in Ngada district conducted field trials using the student response questionnaire. A declaration of validity and reliability has been made for this instrument. In the implementation of Virtual Physics Media from Kua et al.'s research (2022), the instrument was modified from the validation sheet instrument and user response questionnaire. The validity of the instrument was retested using the product moment approach, and all items with a value of 0.05 were deemed valid. Additionally, the Cronbach's Alpha formula was implemented during the instrument's reliability assessment. All instruments were declared reliable because their Cronbach's Alpha value exceeds 0.600. 120 high school students from 9 schools in the Ngada district participated in the problem-solving ability test.

No	Assessment Aspect	Number of Item
	Material Experts	
1	Depth of Physics Materials	5
2	Scientific Accuracy	5
3	Relation of Physics Concepts to "Ngada" Local Culture	5
4	Clarity of Material Explanation	3
5	Relevance of Material to the Independent Curriculum	3
6	Conformity with "Ngada" Local Culture	4
	Media Experts	
1	Cover	3
2	Typography	3
3	Appearance	3
4	Visual Communication Components	3
5	Software Engineering	4
6	Presentation Supports	4
	Learning Design Expert	
1	Alignment with Learning Objectives	3
2	"Ngada" Local Culture Integration	4
3	Relation to Problem-Solving Steps	4
4	Interactivity and SmartBoard Technology	3
5	Feedback in Problem-Solving	3
6	Navigation Ease and Usability	3

Table 2. Validation sheet instrument grid

No	Assessment Aspect	Number of Item
1	Access Ease and Navigations	2
2	Compliance with Curriculum and Problem-Solving Objectives	3
3	"Ngada" Local Culture Integration	3
4	Substance Quality of Physics Materials	3
5	Problem-Solving-based Learning Design	3
6	Interactivity and SmartBoard Technology	2
7	Presentation of Information and Media Supporting Problem-Solving	2
8	Providing Feedbacks	2
9	Evaluation of Students' Problem-Solving Abilities	3
10	Practicality and Reliability of Application	2

Table 3. Teacher response questionnaire grid

No	Assessment Aspect	Number of Item
1	Access Ease and Application Use	2
2	Information Clarity and Material Presentation	2
3	Relevance of Material to Problem-Solving	2
4	"Ngada" Local Culture Integration	2
5	Student Engagement in Problem-Solving Activities	2

6	Application Interactivity	2
7	Providing Feedbacks	2
8	Easy Access to Offline Materials	2
9	Media Comfort and Design	2
10	Impacts on Physics Understanding and Problem-Solving	2

Table 4. Student response questionnaire grid

Learning Objective	**Problem Solving Indicator**	**"Ngada" Local Wisdom Aspect**	**Cognitive Level**	**Question Form**	**Number of Questions**	**Information**
Vector						
Students are able to analyze vector operations	Identifying the direction and magnitude of two force vectors acting on the main pillar of *Sa'o* ("Ngada" traditional house).	The style of the *Sa'o* pillars that support the structure of a traditional house.	C4 (Analysis)	Multiple choice	2	The *Sa'o* pole is used as an illustration in the problem diagram.
	Determining the resultant vector force of the *Ata Sagi* (boxer) at the Sagi event (traditional boxing of the "Ngada" people).	The traditional event of the "Ngada" tribe, namely *Sagi*, which is a real context.	C4 (Analysis)	Multiple choice	3	The illustration involves the "Ngada" tribe's traditional event, namely *Sagi*.
	Evaluating the strategy of direction and magnitude of force in maintaining the	*Tiang Sa'o* in the "Ngada" geographical conditions.	C5 (Evaluation)	Multiple choice	2	The scenario takes into account wind direction, force distribution,

	balance of the *Sa'o* mast against strong winds.					and structural stability.
Kinematics						
Students are able to analyze straight motion	Calculating the average speed of a person walking uphill carrying the harvest to the traditional village.	Climbing to the "Ngada" traditional village.	C3 (Application)	Multiple choice	2	The question covers the geographical context and "Ngada" traditional activities.
	Determining the distance traveled based on the position-time graph in the traditional journey of bringing building materials to the traditional house.	The context of the trip which brings building materials to renovate a traditional house.	C4 (Analysis)	Multiple choice	3	The graphics involve real scenarios, such as hilly terrain.
	Evaluating the fastest route with a safe terrain gradient on the journey to bring the harvest to the	The activity of bringing the harvest to the "Ngada" traditional village.	C5 (Evaluation)	Multiple choice	2	The question involves analysis of distance, travel time, and safety level.

	traditional village.					
Students are able to apply the concept of uniformly accelerated rectilinear motion	Calculating the travel time of the *Rori Lako* (hunters) in the traditional event of the “Ngada” *Paruwitu* tribe (hunting).	The traditional event of the “Ngada” *Paruwitu* tribe as a real context.	C4 (Analysis)	Multiple choice	3	The students are given data on initial speed, acceleration, and distance between the prey and the animal.
Dynamics						
Students are able to understand Newton's laws	Analyzing the total force on the main *Sa'o* pillar due to the weight of the uniquely shaped traditional house roof.	The *Sa'o* structure which reflects the “Ngada” traditional style.	C4 (Analysis)	Multiple choice	3	A force diagram on the main pillar is shown to aid the analysis.
Students are able to understand the force on an inclined plane.	Calculating the total force required to push a stone to a traditional ritual site on sloping terrain.	The activity of carrying large stones for the “Ngada” traditional ceremony.	C4 (Analysis)	Multiple choice	4	The question involves friction force, the mass of the rock, and the slope of the plane.
	Evaluating the effect of friction on energy efficiency when lifting large stones for traditional ceremonies on different	The activity of carrying large stones in the “Ngada” geographical conditions.	C5 (Evaluation)	Multiple choice	2	The students compare fields with different friction levels to evaluate optimal energy.

	sloping terrain.					
Students are able to understand centripetal force.	Determining the centripetal force on the *Maka* (spinning top) used in the "Ngada" *Wela Maka* local game.	*Wela maka* which is a "Ngada" local game tradition.	C4 (Analysis)	Multiple choice	3	Real scenarios involve track radius and speed.
	Evaluating the top design (then) to improve stability when spinning in a longer circular path.	The game of *Wela Maka* as local wisdom.	C5 (Evaluation)	Multiple choice	2	The question involves analysis of optimal design and the effect of centripetal force on motion.

Table 5. Grid for students' problem-solving ability test

Data Analysis

The data collected in this study are analyzed quantitatively as follows:

Validation Result Data Analysis

The physics application that was developed was evaluated through the product validation process. 9 experts, including 3 physics material experts, 3 learning design experts, and 3 learning media experts, participated in the validation process. The evaluation was conducted by experts in the initial stage, using a 5-point Likert scale with a range of 5 assessments from 1 (not relevant) to 5 (very relevant). The application content was revised to enhance its quality in accordance with the advice of experts. The same instrument was used to conduct a second evaluation following the revision to verify the implementation of the improvements. The Content Validity Index (CVI) was employed to determine content validity, and it was assessed at two distinct levels:

1) I-CVI (Item-Level Content Validity Index): The proportion of experts who gave a score of 4 (relevant) or 5 (very relevant) for each item. The validity criteria are I-CVI $\geq$ 0.78: The item was considered Valid (Lynn, 1986). I-CVI < 0.78: The item needed to be revised or deleted.
2) S-CVI (Scale-Level Content Validity Index): Calculated using two approaches:
   (1). S-CVI/Ave: Average I-CVI value of all items.
   (2). S-CVI/UA: Proportion of items that have I-CVI = 1.

Validity criteria for S-CVI: S-CVI/Ave $\geq$ 0.80: The scale or instrument was considered Valid overall. S-CVI/UA $\geq$ 0.80: The scale/instrument was considered Valid universally.

Analysis of Practicality Test Result Data

The teacher and student response questionnaire data were also analyzed through score conversion using a Likert scale. The total percentage value of the product practicality assessment aspect was used to determine the product practicality criteria. The percentage of practicality is calculated using the following equation:

$$P = \frac{f}{N} X100\%$$

P= Percentage of practice; f= Total score of all respondents; N= Number of respondents

Score Interval	Practicality Criteria
$80 < P \leq 100$	Very Practical
$60 < P \leq 80$	Practical
$40 < P \leq 60$	Quite Practical
$20 < P \leq 40$	Less Practical
$0 < P \leq 20$	Not Practical

Table 6. Practicality criteria (Source: Cahyadi (2019))

Effectiveness Test

The data analysis process was carried out with the help of IBM SPSS Version 30 software. The main analysis was carried out using the t-test to test the difference in scores between before and after using the product and to determine the effect of the product on students' problem-solving abilities. Furthermore, the N-Gain calculation was carried out to evaluate the increase in students' abilities. The N-Gain score obtained was used as an indicator of the effectiveness of the development product based on the N-Gain interpretation criteria. The N-Gain score is calculated using the following equation:

$$N - Gain = \frac{S_{posttest} - S_{pretest}}{S_{Max} - S_{pretest}}$$

$$\frac{S_{posttest} - S_{pretest}}{S_{Max} - S_{pretest}}$$

N-Gain criteria: > 0.7 considered as high; 0.3 < g < 0.7 considered as medium; and N-Gain < 0.3 considered as Low (Hake, 1999)

Results

Physics SmartBoard Application Validity

In order to ensure the content validity of the Physics SmartBoard application, which was developed in accordance with the "Ngada" local culture, a validation process was carried out by 9 experts, including 3 material experts, 3 media experts, and 3 learning design experts. Using a 5-point Likert scale (1 = not relevant, 5 = very relevant), each group of experts evaluated only the aspects that were relevant to their field of expertise. Validity analysis was conducted using the Content Validity Index (CVI) method, which comprises two primary metrics: Scale-Level CVI (S-CVI) and Item-Level CVI (I-CVI). An item is considered valid if its I-CVI value is at least 0.78. A scale is considered to have good content validity if the S-CVI/Ave value is ≥ 0.80. Table 7 presents the content validity calculation Table (I-CVI and S-CVI) of physics application based on “Ngada” Local Culture

No	Expert Group	Assessment Aspect	Number of Item	Average I-CVI (per Aspect)	Interpretation per Aspect
1	**Material Expert**	Depth of Physics Materials	5	0,87	Valid, some points need narrative improvement
		Scientific Accuracy	5	0,93	Perfectly valid
		Relation of Physics Concepts to "Ngada" Local Culture	5	0,80	Valid, minor revision
		Clarity of Material Explanation	3	0,78	Quite valid, revision for language consistency
		Relevance of Material to the Independent Curriculum	3	0,89	Valid
		Conformity with "Ngada" Local Culture	4	0,83	Valid
		Total/Average	**25**	**0,867**	Valid overall
		S-CVI/UA		**0,60**	Revisions needed on some items
2	**Media Expert**	Cover	3	1.00	Perfectly valid
		Typography	3	0,89	Valid
		Appearance	3	0,78	Quite valid, minor revisions
		Visual Communication Components	3	0,89	Valid
		Software Engineering	4	0,88	Valid
		Presentation Supports	4	0,86	Valid, further technical review required
		Total/Average	**20**	**0,900**	Valid overall
		S-CVI/UA		**0,70**	A need for harmonization of perceptions between experts
3	**Learning Design Expert**	Alignment with Learning Objectives	3	0,89	Valid
		"Ngada" Local Culture Integration	4	0,92	Strong Valid
		Relation to Problem-Solving Steps	4	0,86	Valid, needs minor revision
		Interactivity and SmartBoard Technology	3	0,78	Quite valid

Feedback in Problem-Solving	3	0,89	Valid
Navigation Ease and Usability	3	0,86	Valid
Total/Average	**20**	**0,900**	Valid overall
S-CVI/UA		**0,70**	Some points which have not yet reached full consensus.

Table 7. Content validity calculation table (I-CVI and S-CVI) of physics application based on "Ngada" local culture

Validity by Material Experts

The material expert group evaluated 25 assessment items covering six aspects: depth of physics materials, scientific accuracy, relation of physics concepts to "Ngada" local culture, clarity of material explanation, relevance of material to the independent curriculum, conformity with "Ngada" local culture. The results of the analysis show that the highest average I-CVI value is in the scientific accuracy aspect (0.93), while the lowest value is in the clarity of material explanation (0.78). Overall, the S-CVI/Ave value of 0.867 indicates that the scale is considered valid. However, the S-CVI/UA value of 0.60 indicates that only 60% of the items are absolutely agreed upon by all experts, so some items still need to be revised, especially regarding the clarity and depth of the narrative.

Validity by Media Experts

A total of 20 items were assessed by media experts based on six aspects: cover typography, appearance, visual communication components, software engineering, presentation supports. The aspect with the highest validity is the cover (1.00), indicating full agreement from all validators. However, the appearance aspect shows a lower I-CVI value (0.78), so special attention is needed to the aesthetic and layout aspects. In general, the S-CVI/Ave score of 0.900 indicates that this scale is very valid, while the S-CVI/UA of 0.70 indicates a fairly high level of consensus between validators.

Validity by Learning Design Experts

In the learning design aspect, 20 items were analyzed covering six main aspects: alignment with learning objectives, "Ngada" local culture integration, relation to problem-solving steps, interactivity and SmartBoard technology, feedback in problem-solving, navigation ease and usability. The highest I-CVI average is in the "Ngada" local culture integration aspect (0.92), while the lowest value is in the interactivity and SmartBoard technology (0.78). It indicates the need to strengthen the integration of technology features with the design of learning activities. The S-CVI/Ave value of 0.900 confirms that the learning design is considered very valid, although the S-CVI/UA of 0.70 indicates that full understanding has not been achieved on all items.

The developed learning instrument has a high level of content validity, as determined by the evaluations of three expert groups, as indicated by the overall results. The scale's overall validity is indicated by the fact that all S-CVI/Ave values are greater than or equal to 0.80. Despite the fact that the S-CVI/UA value has not yet reached 0.80, this condition is still within acceptable limits. It is recommended that items with an I-CVI value of less than 0.78 are needed to be revised in order to enhance the quality and consistency of the content.

Practicality of Physics SmartBoard Application

The Physics SmartBoard application was then tested on the teachers and students. Tables 8 and 9 present the trial results by teachers and students.

No	Assessment Aspects	Number of Items	Average Score	Percentage (%)	Criteria
1	Access Ease and Navigations	2	4.5	90.0	Very Practical
2	Compliance with Curriculum and Problem-Solving Objectives	3	4.2	84.0	Very Practical
3	"Ngada" Local Culture Integration	3	3.6	72.0	Practical
4	Substance Quality of Physics Materials	3	3.8	76.0	Practical
5	Problem-Solving-based Learning Design	3	3.6	72.0	Practical
6	Interactivity and SmartBoard Technology	2	4.0	80.0	Practical
7	Presentation of Information and Media Supporting Problem-Solving	2	3.7	74.0	Practical
8	Providing Feedbacks	2	3.9	78.0	Practical
9	Evaluation of Students' Problem-Solving Abilities	3	4.5	90.0	Very Practical
10	Practicality and Reliability of Application	2	4.3	86.0	Very Practical
	Overall Practicality Percentage			80.20	Very Practical

Table 8. Trial results by the teacher

The analysis of the trial results by the teachers shows that all aspects have an average score in the practical to very practical range, with the aspects of Access Ease and Navigations and Evaluation of Evaluation of Students' Problem-Solving Abilities obtaining the highest average score (4.5) and categorized as very practical. Table 8 shows that overall, the product obtains a practicality percentage of 80.20%, which is includes in the very practical category. This result means that the product is suitable for use in implementing classroom learning.

No	Assessment Aspects	Number of Items	Average Score	Percentage (%)	Criteria
1	Access Ease and Application Use	2	4.2	84.0	Very Practical
2	Information Clarity and Material Presentation	2	4.5	90.0	Very Practical
3	Relevance of Material to Problem-Solving	2	3.8	76.0	Practical
4	"Ngada" Local Culture Integration	2	4.0	80.0	Practical
5	Student Engagement in Problem-Solving Activities	2	4.5	90.0	Very Practical
6	Application Interactivity	2	4.0	80.0	Practical
7	Providing Feedbacks	2	3.6	72.0	Practical

8	Easy Access to Offline Materials	2	3.9	78.0	Practical
9	Media Comfort and Design	2	4.3	86.0	Very Practical
10	Impacts on Physics Understanding and Problem-Solving	2	3.9	78.0	Practical
	Overall Practicality Percentage			81.40	Very Practical

Table 9. Trial results by the students

The analysis of the trial results by the students shows that most aspects are in the practical category, with several aspects reaching the very practical category, namely Information Clarity and Material Presentation (average score of 4.5), Student Engagement in Problem-Solving Activities (4.5), and Media Comfort and Design (4.3). Other aspects, such as Access Ease and Application Use (4.2) and Application Interactivity (4.0), also show values approaching the very practical category. Table 9 shows that overall, the product obtained a practicality percentage of 81.40%, which is categorized as very practical. This result means that the product is feasible to be used in supporting technology-based problem-solving learning, with features that suit students' needs.

Effectiveness Test

The data analysis in this study is conducted with the help of IBM SPSS Version 30 software. The test used is the Paired Sample t-Test to determine the differences in students' problem-solving abilities before and after using the product in both groups (control and experiment). In addition, N-Gain calculations are carried out to evaluate the level of improvement in students' abilities, with the interpretation of N-Gain, namely: High (N-Gain> 0.7), Medium (0.3 <N-Gain ≤ 0.7), and Low (N-Gain ≤ 0.3). Table 10 presents the results of the t-test and N-Gain of students' problem-solving abilities

Statistics	Control Group	Experiment Group
Number of Respondents (N)	60	60
Pretest Mean (Mean Pre)	52.78	51.23
Posttest Average (Mean Post)	58.4	73.43
Pretest Standard Deviation (SD Pre)	4.54	2.64
Posttest Standard Deviation (SD Post)	4.76	4.39
Mean Diff	5.62	22.2
t count (t)	-78.37	-37.64
df (degrees of freedom)	59	59
Sig. (2-tailed)	0.0	0.0
Interpretation	Significant	Significant
Average N-Gain	0.12	0.455

Table 10. Results of the t-test and N-Gain of students' problem-solving abilities

The results of the analysis in the control group show an average pretest score of 52.78 with a standard deviation of 4.54, while the average posttest increase to 58.40 with a standard deviation of 4.76. The difference in the average pretest and posttest scores is 5.62. The t-test produced a t-value of -78.37 with a degree of freedom (df) of 59 and a significance value (Sig.

2-tailed) of 0.00000, which means that there is a significant difference between the pretest and posttest scores in this group. The average N-Gain of the control group is 0.300, which is included in the Moderate category.

Meanwhile, in the experimental group, the average pretest score is 51.23 with a standard deviation of 2.64, and the posttest score increase significantly to 73.43 with a standard deviation of 4.39. The difference in the average pretest and posttest scores is 22.20. The t-value in this group is -37.64 with df 59 and a Sig. (2-tailed) value of 0.00000, which also shows a statistically significant difference. The average N-Gain of the experimental group is 0.705, which was categorized as High according to Hake's interpretation. Based on these results, it can be concluded that the development product in this study significantly influences the improvement of students' problem-solving abilities, with a greater increase occurring in the experimental group than in the control group.

Discussion and Recommendations

An innovative approach to addressing learning challenges is the integration of technology and cultural context in education. The Physics SmartBoard, which incorporates “Ngada” local cultural elements, is a prime example of how technology can be customized to meet the specific needs of a community in order to improve the problem-solving abilities of students in the field of physics.

Physics SmartBoard's cultural constructivism is one of its most significant contributions. Incorporating local culture into the study of physics for Vector, Kinematics, and Dynamics materials, such as *Sagi* (traditional boxing), *Rori Witu* (hunting), *Wela Maka* (whirligig game), and *Maki Jara* (horse racing), and making *Ngadhu dan Bhaga* (sacred places of the “Ngada” people) makes physics more relevant to students and fosters a deeper appreciation for their heritage. The contextualized learning has been demonstrated to significantly enhance student engagement and comprehension in a prior research (Centillas et al., 2024). This is consistent with constructivism theory, which promotes learning through meaningful contexts (Vijayakumar Bharathi & Pande, 2025). This method not only improves cognitive comprehension but also fosters a sense of pride in local identity, a dual benefit that is consistent with global trends in culturally responsive pedagogy (Almulla, 2023; Lindqvist & Forsberg, 2023).

Physics, often considered abstract, is greatly aided by tools that offer visualization and interactivity. Based on the results of this research investigation, the use of animations, simulations, and interactive whiteboards on the Physics SmartBoard allows students to better understand complex concepts such as vectors, kinematics, and dynamics. Prior research supports that interactive whiteboards and virtual simulations improve students’ conceptual understanding and learning outcomes (Jammeh et al., 2022; Yalman & Basaran, 2021). Additionally, the ability to simulate real-world scenarios, as demonstrated by these applications, improves students’ critical thinking and analytical skills, which are essential for problem solving in physics (Ma et al., 2023; Mahir & Martawijaya, 2025; Marcinauskas et al., 2024; Satriawan et al., 2022).

According to the prior investigation in the introduction and the results of this research, the problem-solving skills play a vital role in physics learning because they help students 1) learn to apply theoretical concepts to real-world situations, such as the use of Newton’s laws in traditional constructions which this results are in line with Diyana's and Sutopo's (2024) study; 2) analyze situations, recognize patterns, and generate solutions based on logical evidence which this results are in line with Musengimana et al.'s (2025) study; 3) develop adaptive skills relevant to various real-life scenarios which this results are in line with Heldalia's, Kuswanto's, and Salim's (2025) study; and 4) improve long-term retention and understanding of physics concepts which this results are in line with Prayogis's and Verawati's (2024) study.

Physics SmartBoard is a tool that integrates step-by-step problem-solving features and feedback mechanisms to help students develop reasoning and decision-making skills. It aligns with the findings of Jammeh et al. (2022) as well as Yalman and Basaran (2021), emphasizing the importance of scaffolding in fostering problem-solving skills (Sengul, 2024; Ucar-Longford, Hosein, & Heron, 2024). Meanwhile, this research demonstrates that the application activities, such as quizzes and simulations, are designed to enhance cognitive engagement in the “Ngada” cultural context. The Physics SmartBoard is flexible, accessible, and suitable for teachers in low-resource areas like Ngada. It offers offline access and supports multiple devices, addressing digital inequality in remote areas. Its alignment with the Independent Curriculum demonstrates its adaptability to the national education framework (Afandi & Sajidan, 2019; Herlinawati et al., 2024; Sukarno et al., 2024).

According to the results of this research investigation, the Physics SmartBoard helps improve teachers’ teaching efficiency by providing feature-rich tools, such as interactive simulations, culture-based modules, and adaptive quizzes. These features make it easier for teachers to deliver complex materials in a more engaging and understandable way for students. With an intuitive user interface and user-friendly navigation features, teachers can reduce the time spent preparing materials and focus more on the learning process in the classroom. This is in line with the needs of teachers in remote areas who often face resource constraints, such as limited access to laboratories and other learning support devices (Adigun, 2022; Manca & Delfino, 2021).

In addition, Physics SmartBoard supports collaboration between teachers and students through discussion forum features and direct feedback. This collaboration allows teachers to better understand the difficulties faced by students in learning physics so they can provide more timely and effective interventions. In the context of the Independent Curriculum, this tool also offers the flexibility to adjust learning content according to local and individual needs of students, ultimately improving their learning outcomes.

With this integrative approach, Physics SmartBoard is not only a learning tool but also an innovative solution that empowers teachers to address the challenges of education in the digital age, especially in areas with limited access to modern technology. Although the validity and practicality of the application are highly rated, some areas still require attention. For example, typography and interface design issues, as highlighted by media experts, need to be refined to improve usability. Similarly, the integration of advanced analytics to provide real-time feedback and adaptive learning can further personalize the learning experience, as recommended by three previous studies (Agustina et al., 2022; Dolo & Kua, 2023; Kua, Dolo, & Suparmi, 2022). Physics SmartBoard can be equipped with artificial intelligence (AI)-based learning analytics to provide more adaptive and personalized feedback to students based on their performance. Furthermore, ensuring cultural sensitivity when designing content is essential to maintain authenticity and respect for local traditions.

Conclusion and Implications

The Physics SmartBoard app significantly enhances the accessibility, engagement, and cultural relevance of physics education. This method addresses a pressing educational challenge and contributes to the global discourse on culturally responsive teaching by integrating local wisdom with technological innovation. To evaluate the long-term effects of this application on student learning outcomes and its potential for broader application, future research should concentrate on longitudinal studies.

Implication

The results of this investigation have various theoretical and practical implications. In practical terms, the Physics SmartBoard can be implemented as a technology-based learning model that is integrated with local culture and adapted to a variety of other regions with distinct cultural contexts. Additionally, this product offers educational software developers assistance in the development of applications that are pertinent to local requirements. Theoretically, this study emphasizes the value of a culturally responsive and contextual approach to science education while simultaneously making new contributions to the literature on technology-based learning in local cultural contexts. In addition, the necessity for government and related institution support to promote and fund similar innovations to enhance the quality of education in regions with limited resources is also indicated by the implications for educational policy.

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