



Development of The ULOS Model to Improve Culture Awareness of Physics Education Students

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ABSTRACT

Purpose - This study aims to describe the development and implementation of the ULOS learning model as an innovation to enhance the love of culture among Physics Education students at Universitas HKBP Nommensen Pematangsiantar (UHKBPNP). The background of this study lies in the urgency to integrate local culture into science education, aiming to strengthen students' cultural identity, foster appreciation for traditional values, and develop positive character alongside academic competencies.

Methodology - The research employed a research and development (R&D) design with a sample of 30 Physics Education students. The procedure followed the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). Instruments included validation sheets for experts, questionnaires for students' responses, observation sheets for classroom implementation, and pre-test and post-test to measure changes in cultural appreciation. Data were analyzed quantitatively using descriptive statistics and N-gain scores, as well as qualitatively through reflective discussions.

Findings - The results indicated that the ULOS model is valid, practical, and effective. Expert validation yielded an average score of 0.91 (very valid). The implementation significantly improved students' love of culture, with effect size results in the medium to high category. Moreover, students demonstrated a greater awareness of integrating cultural elements into their learning and expressed stronger motivation to preserve local wisdom.

Contribution - This study contributes to the enrichment of educational models by integrating ethnopedagogy into science learning. The ULOS model serves as a framework to cultivate cultural awareness and appreciation while simultaneously developing critical thinking skills. The study offers a practical guide for educators and researchers in designing culturally responsive learning models that support the sustainability of local heritage in higher education.

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INTRODUCTION

Indonesia is a country rich in cultural diversity, one of which is the Batak culture, known for its traditional cloth, ULOS. ULOS cloth has high historical, philosophical, and artistic value, and is an integral part of the cultural identity of the Batak people. However, in this era of globalization, there has been a decline in interest and appreciation for traditional culture among the younger generation. ULOS cloth not only has an aesthetic function, but is also loaded with symbolic and philosophical meanings that reflect the social and spiritual life of the Batak people (Sibarani et al., 2018; Sitindjak et al., 2016). Amidst the currents of globalization and modernization, the existence of cultural heritage such as ULOS faces serious challenges, especially related to the decline in interest and appreciation from the younger generation. This phenomenon raises concerns about the sustainability of the nation's cultural heritage (Ali et al., 2025; Chaparro-Sainz, Á., et al., 2022). Education plays a crucial role in preserving and developing culture. Through education, cultural values can be instilled in the younger generation from an early age. Student teachers play a crucial role in this effort, as they are future educators who will instill cultural values in their students. Therefore, it is essential to develop learning models that foster a sense of love for culture among student teachers (Begunova & Qingyu, 2021). In physics education, efforts to integrate local culture remain limited. Previous studies have introduced culture-based or ethnoscience-based learning (Suciati, 2023; Sudarmin et al., 2020), but there has been no explicit development of a project-based learning (PjBL) model that integrates ULOS as a cultural artifact into physics learning. This gap becomes the primary focus of the present study, as it offers both academic and cultural contributions: enriching the pedagogical model in physics education while fostering cultural appreciation among students.

Preparing teachers for an inclusive and diverse educational environment requires significant curricular reform. This study examines how changes in initial teacher education courses can effectively equip prospective teachers with the skills and knowledge necessary to address diverse classroom learning needs (Abdallah, 2023). Student teachers, as the next generation and future educators, play a crucial role in the preservation and development of local culture. They are not only required to master teaching materials but are also expected to instill cultural values in students. However, the reality on the ground shows that many student teachers lack an understanding and appreciation of local culture, including ULOS cloth. This is due to the lack of cultural integration in the educational curriculum and the minimal use of contextual and culturally relevant learning methods (Ali et al., 2025). The ULOS-based learning model was developed as a solution to address this problem. This approach aims to integrate cultural elements into the learning process, enabling student teachers to understand better, appreciate, and value local culture. The values of local wisdom can serve as a foundation for character education in schools (Pamenang, 2021; Sinaga, 2024).

Project-Based Learning (PjBL) is a pedagogical approach that encourages students to learn through active engagement in relevant and meaningful projects. This approach emphasizes student engagement in hands-on, practical learning processes, as well as the development of critical thinking, creativity, and collaboration skills. Diversity presents significant challenges for teachers, necessitating changes in the way teacher education programs prepare future educators. This includes integrating principles of inclusivity and cultural competency into the curriculum to ensure teachers can effectively manage and embrace diverse classroom environments (Baatiz, W., et al., 2023). The ULOS learning model was developed as a variant of the PjBL model, with a particular focus on integrating local cultural elements, namely ULOS cloth, into the learning process (SUDARMİN et al., 2020). One of the important aspects of physics learning is the ability to relate abstract concepts to students' real-life contexts. The concept of *force*, for instance, is often perceived as highly theoretical. By using ULOS as a teaching aid, this concept can be contextualized. For example, the tensile strength of ULOS fibers can be linked to tension force, the friction between threads can represent frictional force, and the weaving patterns can be used to discuss balance and symmetry in physics. Such integration not only makes physics concepts more concrete and relatable but also highlights the philosophical and cultural values embodied in ULOS.

Therefore, the research gap addressed in this study is clear. While project-based learning has been widely applied in physics education, and ethnoscience approaches have been introduced, there is no culturally

responsive PjBL model specifically developed with ULOS as a medium in physics learning. This novelty is expected to contribute to both the development of innovative physics learning models and the preservation of cultural identity among prospective teachers.

This development aims not only to provide an in-depth and contextual learning experience but also to instill a sense of love and appreciation for local culture among student teachers. The development of the ULOS learning model refers to the syntax of the PjBL model, namely (Use the essential question, Let us design a project and do it, Observation of project results and discussion, Solution and Reflection). By implementing the ULOS learning model, it not only provides learning material content but also incorporates cultural values that are not found in other learning models. By using ULOS as a teaching aid, student teachers are expected to gain a deeper understanding and appreciation of the nation's culture and be able to teach it to students engagingly and effectively (Suciati, 2023; Tyas & Naibaho, 2021).

The development of the ULOS learning model encompasses several stages, beginning with literature studies and observations, followed by the development of learning modules, training and workshops, and culminating in evaluation and revision. The implementation of this model requires collaboration among educational institutions, cultural communities, and students themselves (Lubis et al., 2019). This is also in line with Pamenang's opinion that the culture-based integrated learning model (MPTBB) is an appropriate learning model for helping students master subject matter, thereby increasing their appreciation for local culture. With this effort, it is hoped that a young generation will be created who are not only academically intelligent, but also have a love and concern for the nation's cultural heritage. Integrating local wisdom, such as ULOS, into educational practices fosters a deeper understanding and appreciation of cultural heritage among prospective teachers. By developing and implementing the ULOS learning model, it is hoped that prospective teacher students will not only become academically competent educators, but also have a love and appreciation for the nation's cultural heritage.

This approach is also expected to improve the quality of education and cultural preservation in Indonesia. The problem formulation in this study is: how to develop the ULOS learning model to increase the love of culture among physics education students of UHKBPNP? The problem-solving approach in this study uses the ULOS learning model to bridge the gap between physics theory and its application in the real world, while integrating student character building. Through a project-based and collaborative approach, students are not only trained to understand the concept of force conceptually, but also how to apply it in real life and develop important soft skills, such as cooperation and responsibility. This approach aligns with the principle of Outcome-Based Education, which focuses on achieving specific learning outcomes in both the academic realm and in student character development. The novelty of this study lies in its combination of a local cultural approach and project-based teaching aids in physics learning, offering an innovative approach to teaching the concept of force in physics courses. This approach has not been widely explored in the context of physics education in Indonesia, especially those involving direct integration of local culture. This novelty is expected to provide a more effective solution in improving students' understanding of physics concepts, while simultaneously developing character and respect for local culture.

METHODOLOGY

Research Design

This research used a Research and Development (R&D) method that adapted the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. The following are the steps taken in this research:

Stage 1: Analysis

Identifying physics learning problems, particularly related to students' understanding of the concept of force, and the lack of character development. This was obtained through initial observations and interviews

with lecturers and students. Determining the characteristics and background of the students who would be the research subjects, including their needs for cognitive and character development. Reviewing the physics curriculum in effect at UHKBPNP to ensure the developed model was relevant to educational objectives.

Stage 2: Design

Designing the ULOS (University-Based Learning) learning model for the force. This stage also included designing the learning strategies, teaching materials, and evaluation tools to be used. Designing physics teaching aids using the Ulos concept, which will later be used in the learning process to visualize the concept of force (such as tensile force, friction, etc.).

Stage 3: Development

Develop a valid, practical, and effective ULOS learning model that aligns with the curriculum and student characteristics. Investigate physics education experts and local cultural experts to assess the validity of the developed ULOS learning model. Expert input is used to refine the product. Revisions are made based on expert validation results to better align with learning needs.

The ULOS learning model was developed through expert validation involving two physics education experts and two cultural experts. Validation was conducted using a Likert scale instrument (1–5), where one indicated "very poor" and five indicated "excellent".

Table 1. Validation Aspects of the ULOS-Based Physics Learning Media

No.	Aspect	Description
1	Content Validity	Accuracy and suitability of the material in relation to physics concepts.
2	Media Presentation	Clarity of visuals, format, and layout.
3	Language	Clarity, readability, and appropriateness of terms used.
4	Integration of Culture	The extent to which <i>ULOS</i> cultural elements are effectively integrated into physics learning.

The average score of expert assessments was then analyzed using Aiken's V to determine the validity level of the developed model and learning tools. Revisions were made in accordance with expert feedback before proceeding to implementation.

Stage 4: Implementation

Conduct a pilot test of the learning model on small groups of students to see how the ULOS learning model works in real-world situations. At this stage, observations and initial data collection are conducted regarding students' understanding of physics concepts and character. After the pilot test, the learning model is implemented in larger groups (classes), using the ULOS learning model on the topic of force over several sessions.

Stage 5: Evaluation

Conducted throughout the development and implementation process to provide feedback used to refine the model.

Instruments and Data Collection

Two types of instruments were used are 1) Test: A multiple-choice test designed to measure students' understanding of the concept of force before and after the implementation of the ULOS model. 2) Character Questionnaire: A questionnaire was developed to measure three aspects of student character: responsibility, cooperation, and creativity. Each aspect was described through specific indicators as follows: responsibility is completing project tasks on time and maintaining commitment in group work. Cooperation involves actively participating in group discussions and being willing to help group members in times of difficulty. Creativity

is the ability to propose original ideas in designing ULOS-based teaching aids and produce innovative variations of project products. The questionnaire used a Likert scale (1–5) with statements ranging from “strongly disagree” to “strongly agree.” This allowed for a quantitative analysis of character development, complemented by qualitative data from classroom observations and student reflections. Qualitative data were obtained from observations, interviews, and character questionnaires completed by students to assess their character development during the learning process.

Validity and Reliability of the Instruments

The content validity of both instruments (test and questionnaire) was evaluated by three expert validators, comprising a physics education expert, an educational media specialist, and a cultural education expert. Validators assessed the relevance, clarity, and appropriateness of each item in relation to the learning objectives and indicators. The Content Validity Index (CVI) was calculated for each item, and items with a CVI score of ≥ 0.78 (or ≥ 0.80) were considered valid (Karthik & Vangapandu, 2024). Minor revisions were made based on validators’ suggestions to improve the accuracy of language, cultural integration, and conceptual clarity.

The reliability of the test instrument was determined using the Kuder-Richardson Formula 20 (KR-20), appropriate for dichotomous (multiple-choice) items. A reliability coefficient (r_{11}) ≥ 0.70 indicated good internal consistency. The reliability of the questionnaire was analyzed using Cronbach’s Alpha. A coefficient value of $\alpha \geq 0.70$ was considered acceptable, demonstrating that the questionnaire consistently measured the targeted character aspects (responsibility, cooperation, and creativity).

Population and Sample

The population of this study consisted of students from the Physics Education Study Program at HKBP Nommensen University, Pematangsiantar. The sample was collected using a purposive sampling technique, involving students enrolled in courses related to the concept of force in the physics education program. A total of 32 students participated in the study, consisting of 18 females and 14 males, aged between 19 and 21 years old. All participants were third-semester students who had completed introductory physics courses and were taking Fundamental Mechanics at the time of the study. The selection of participants was based on their relevance to the research objectives, specifically to measure the effectiveness of the ULOS model in enhancing students’ conceptual understanding of force and promoting cultural awareness through the integration of ULOS elements in the learning process. These students were considered suitable because they already possessed a basic knowledge of mechanics, enabling them to engage meaningfully in the culturally based project tasks. This purposive approach ensured that the participants were information-rich cases, those who could provide deep insights into how the ULOS-based learning model influenced conceptual mastery and character development.

Data Analysis

Data from the tests were analyzed using descriptive and inferential statistics. Descriptive statistics included the calculation of mean, standard deviation, and normalized gain (N-gain) to describe changes in students’ conceptual understanding of force. Inferential analysis was conducted using a paired sample t-test to determine whether there was a statistically significant difference between students’ pre-test and post-test scores after implementing the ULOS model. The significance level (α) was set at 0.05. Prior to the t-test, normality and homogeneity tests were performed to ensure that the data met the assumptions for parametric testing. When these assumptions were not satisfied, a non-parametric Wilcoxon Signed-Rank Test was used as an alternative.

Data from the character questionnaire were analyzed descriptively using mean scores and categorical interpretations (very high, high, moderate, low, very low) to examine the development of student responsibility, cooperation, and creativity.

Qualitative data obtained from classroom observations and student reflections were analyzed following the approach outlined in *Qualitative Data Analysis: A Methods Sourcebook* (4th ed., Miles, Huberman, & Saldaña, 2018). The analysis involved three key stages are 1) data reduction (selecting, focusing, and organizing raw data), 2) data display (presenting information in tables or narrative summaries to identify emerging patterns), and 3) conclusion drawing and verification (interpreting findings and confirming them through data triangulation).

This combination of quantitative and qualitative analyses provided a comprehensive understanding of the effectiveness of the ULOS model in improving students' conceptual mastery and character development. Data from the test results were analyzed using both descriptive and inferential statistics to identify significant differences in students' understanding before and after implementation. Data from observations, interviews, and questionnaires were analyzed qualitatively to understand the impact of the learning model on students' character development. Based on the results of data analysis and evaluation, revisions were made to the learning model to improve its effectiveness. The revised model was then published as an effective, culture-based learning model.

FINDINGS

An analysis of lecturers' understanding of learning style material was conducted to examine their comprehension of the MBKM curriculum, project-based learning models, local wisdom of Ulos, and the integration of local wisdom into learning. The following are the survey findings.

Lecturers' Understanding of the MBKM Curriculum

Three questions were asked in the questionnaire regarding the implementation of the MBKM curriculum. The analysis showed that 70% of lecturers had implemented the MBKM curriculum in their lectures, while 30% had not. Furthermore, regarding the understanding of the MBKM curriculum concept, the analysis showed that 80% of lecturers grasped the concept, while 20% did not. Furthermore, an evaluation of the MBKM curriculum revealed that 30% of lecturers conducted evaluations in accordance with the MBKM curriculum, while 50% had not, and 20% were unsure. For clarity, the results of the analysis of teachers' understanding of the Merdeka curriculum are presented.



Figure 1. Teachers' understanding of the Independent Curriculum

The analysis reveals that lecturers generally have a good understanding of the MBKM curriculum. The MBKM curriculum offers diverse intracurricular learning with optimal content, allowing students sufficient time to explore concepts and strengthen competencies. (Sudarmin et al., 2020) states that in curriculum change, educators play a role in implementing the existing curriculum and aligning it with student characteristics and needs (Sulistiyanto et al., 2022).

Lecturers' Understanding of Ulos Local Wisdom

This aspect focuses on the lecturers' understanding of ulos as a form of local wisdom. The results showed that 100% of lecturers understood that ulos is a form of local wisdom. This was reinforced by research (Sibarani

et al., 2018), which suggests that Batak culture has the potential to serve as an alternative learning method for early-grade science education. The next question focused on the lecturers' understanding of the values of Batak local wisdom. The results showed that 30% of the lecturers understood the values of Batak local wisdom, while 70% did not. An analysis was then conducted to examine the lecturers' understanding of integrating cultural love into science learning in lectures. The analysis revealed that 80% of lecturers had never linked cultural love to science learning in lectures. This finding contradicts previous data, which stated that local wisdom is important to implement.

However, almost all lecturers never apply it. The following result is related to the orientation of Batak local wisdom as a learning resource for Early Grade Science education. The presence of local wisdom in learning can serve as a filter for various global aspects that enter various aspects of community life. Local wisdom can encourage teachers and students to create creative and innovative learning. Local wisdom is instrumental in preserving culture and fostering student independence in their interactions with the world around them. In line with the research results, educators demonstrate a high level of enthusiasm and interest in learning local wisdom. After the needs analysis is conducted, the next stage is to design a ULOS model based on the findings of the needs analysis. Then, validate the ULOS model. The results of the ULOS learning model validation are presented in Table 2.

Table 2. Validation Results of the ULOS Learning Model Book

No.	Aspects/Components	Aiken Value's	Criteria
1.	Book Format	0,80	Valid
2.	Book Content	0,79	Valid
3.	Language	0,90	Very Valid
4.	Graphics	0,72	Valid
5	Model Syntax	0,82	Very Valid
6	Reaction Principles	0,85	Very Valid
5.	Support Systems	0,85	Very Valid
6.	Instructional Impact	0,85	Very Valid
Average		0,82	Very Valid

Table 2 shows that the average validation score for the ULOS learning model was 0.82, indicating it was highly valid. Based on these results, the prototype ULOS learning model book was highly suitable for use in this study. Table 2 shows that the overall Aiken's V index of the ULOS Learning Model Book is 0.82, which falls within the "very valid" category. This indicates that the book is generally appropriate and feasible for implementation. Among the evaluated components, the Language (0.90), Model Syntax (0.82), Reaction Principles (0.85), Support Systems (0.85), and Instructional Impact (0.85) achieved "very valid" ratings, suggesting intense conceptual clarity, pedagogical coherence, and alignment with the ULOS model's theoretical framework. However, Book Content (0.79), Book Format (0.80), and especially Graphics (0.72) received relatively lower scores, indicating areas that could be improved. The lower graphic score suggests that visual representations or layout design may need enhancement to improve readability and engagement. Likewise, the slightly lower content and format scores suggest that some sections may benefit from refinement in structure, example clarity, or the cultural integration of ULOS elements. The high overall validity confirms that the book can be used as a reliable guide in teaching and learning contexts, particularly for developing critical thinking and cultural appreciation. However, targeted revisions in visual presentation and instructional content could further enhance user experience and instructional effectiveness. The validation process involved expert judgment only, without direct feedback from end users (i.e., students or teachers). Therefore, future validation should include field testing to assess the practicality and effectiveness of the approach in authentic classroom settings.

The highest validation scores were found in the social system aspect, the principle of support system reaction, and instructional impact. Furthermore, the validation results for the Love for Culture instrument are shown in Table 3.

Table 3. Validation Results of the Cultural Love Instrument

No.	Aspects/Components	V	Interpretation
1.	Content	0,88	Very Valid
2.	Construction	0,87	Very Valid
3.	Language	0,95	Very Valid
Average		0,91	Very Valid

Table 3 shows that the Cultural Love Instrument obtained an average Aiken’s V index of 0.91, categorized as “very valid”, indicating strong agreement among experts regarding the instrument’s content, construction, and language clarity. The instrument was developed to measure students’ cultural love, defined as a positive attitude of respect, pride, and appreciation toward local traditions, particularly those reflected in the ULOS culture. The instrument consists of three dimensions content validity assesses the relevance of items to the construct of cultural love, including indicators such as appreciation for local heritage, willingness to preserve cultural practices, and pride in national identity, construction validity examines the logical consistency and clarity of item formulation, ensuring that each statement accurately represents the intended dimension and language validity ensures that the items use precise, age-appropriate, and culturally sensitive wording that students easily understand. Example items include statements such as:

“I feel proud to wear traditional ULOS clothes during cultural events” and “I like learning about the meanings behind ULOS patterns in my lessons.”

Respondents rated each statement on a 5-point Likert scale, ranging from Strongly Disagree (1) to Strongly Agree (5). To complement the quantitative validation, qualitative feedback from experts was also collected. The experts noted that the items effectively represent cultural values and student attitudes but suggested improving wording consistency and adding more context-based examples to strengthen construct coverage. These qualitative insights were used to refine the final version of the instrument, ensuring both cultural sensitivity and psychometric robustness. The high validity coefficients and expert agreement indicate that the Cultural Love Instrument can be reliably used to assess students’ affective attitudes toward local culture within the ULOS learning model. However, further field testing is recommended to evaluate its reliability and factor structure through exploratory and confirmatory analyses.

The results of the comparison between the average cultural love scores of the experimental class and the control class are presented in Figure 2.

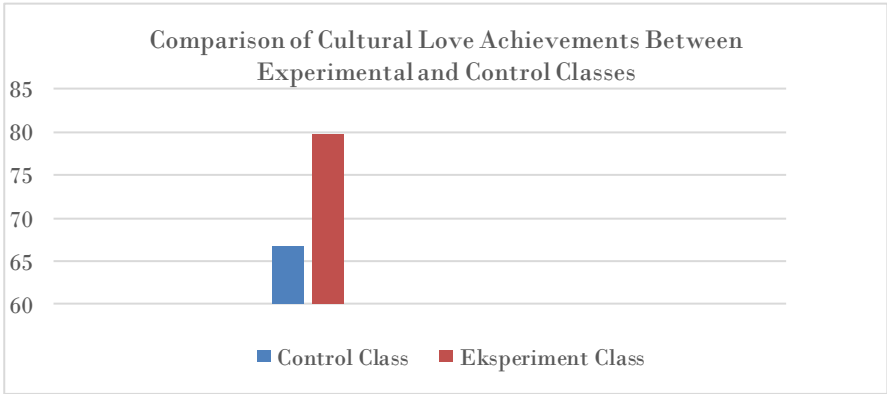


Figure 2. Comparison of Cultural Love Achievements in the Experimental and Control Classes

The students' cultural love data were then subjected to prerequisite tests to determine the normality and homogeneity of the data groups. A summary of the results from the cultural love normality test in the experimental and control classes is presented in Table 4.

Table 4. Normality Test Results

Skill	Class	N	Sig.
Culture Awareness	Experimental	32	0.601
Culture Awareness	Control	32	0.200

The normality test using the Shapiro-Wilk test yielded significance values of $p = 0.601$ for the experimental group and $p = 0.200$ for the control group. Since all values are greater than 0.05, the data for both groups are normally distributed. Therefore, parametric testing (independent-samples t -test) was appropriate for further analysis.

Table 5. Homogeneity Test Results

Skill	Levene Statistic	Df1	df2	Sig.
Culture Awareness	0.726	1	68	0.397

Levene's test yields a significance value of $p = 0.397$ (> 0.05), indicating that the variances between the experimental and control groups are equal. This satisfies the assumption of homogeneity required for t -test analysis.

Table 6. Independent Samples t -Test Results

Skill	Class	N	Mean	SD	$t(df)$	P	Cohen's d
Culture Awareness	Experimental	32	86.14	5.42	4.21 (68)	0.000	1.02
	Control	32	78.37	6.18			

The independent-samples t -test shows a statistically significant difference between the experimental and control groups, $t(68) = 4.21$, $p < 0.001$. Cohen's $d = 1.02$, indicating a large effect size, meaning that the implementation of the ULOS learning model substantially improved students' cultural awareness compared to conventional learning. The results confirm that the data met all statistical assumptions (normality and homogeneity). The inferential test revealed a significant improvement in the experimental group's cultural love scores following the application of the ULOS model. This finding supports the model's effectiveness in enhancing students' cultural awareness and appreciation. However, the analysis is limited to cognitive-affective outcomes and does not yet account for long-term retention or behavioral indicators of cultural engagement. Future research could incorporate mixed methods or follow-up observations to triangulate these results. Based on Table 5, the significance value for cultural awareness is <0.05 , indicating a significant difference in student skills between classes using the ULOS learning model and those using the PjBL learning model. These test results can be interpreted as indicating that the ULOS learning model is effective in building students' cultural love. An effect size test was then conducted to measure the effectiveness of the ULOS learning model on students' cultural love.

Table 7. Results of the Effect Size Test of Cultural Love

Skill	Effect Size	Interpretation
Culture Awareness	2,3	High

Based on Table 7, it can be seen that the ULOS model has a high effect size, indicating that it can increase the love of culture among UHKBPNP physics education students. The ULOS model provides an innovative approach by combining project-based learning and local cultural values. In the context of physics education, this model demonstrates that students not only learn theoretical physics concepts but also understand them within the context of their local culture. For example, the properties of ulos fiber can be used to explain physics

concepts, such as the tensile strength of materials or symmetry patterns. Students are more motivated to learn when they are actively involved in projects, such as making ulos-based teaching aids. Through the ULOS syntax, a love of culture is systematically instilled, specifically by using the Essential Question, which sparks students' curiosity about the philosophical and physical values of ULOS culture. Let's Design a Project and Do It. This process enables students to explore ulos as an integral part of Batak culture, thereby strengthening their cultural identity. Observation Result Project and Discussion, discussion of project results helps students understand how ulos represents the relationship between culture and science. Reflection, the final reflection, instills an understanding that local culture can be a source of innovation in education.

DISCUSSION

The findings of this study reveal that the development of the ULOS model has a significant impact on improving the love of culture among Physics Education students at UHKBPNP. The ULOS model, which integrates cultural values into the learning process through its four syntaxes—Use the Essential Question, Let's Design Project and Do It, Observation Result Project and Discussion, and Solution and Reflection—proved to be effective not only in strengthening students' cognitive engagement but also in fostering affective attitudes toward local culture. First, the results indicate that students became more aware of the cultural values embedded in Ulos, such as togetherness, respect, and responsibility. By positioning Ulos not merely as a cultural artifact but also as a medium of scientific exploration, students developed an appreciation for how culture and science can be interconnected. This finding aligns with Aikenhead & Ogawa (2007), who emphasized that integrating ethnoscience into formal learning strengthens students' cultural awareness while making scientific knowledge more meaningful.

Second, the project-based learning activities within the ULOS model encouraged students to actively design, create actively, and present learning media or experiments inspired by Ulos. This process enhanced their creativity and critical engagement, but more importantly, it fostered emotional attachment to their cultural heritage. These outcomes align with the work of (Gay, 2018) on culturally responsive pedagogy, which demonstrates that learning rooted in cultural contexts can motivate students more deeply and foster pride in their identity. Third, the reflection stage of the ULOS model allowed students to internalize cultural meanings. Reflection activities provided students with opportunities to articulate how culture enriches science education and how they can contribute to the preservation of cultural heritage through their role as future educators. The findings also strengthen evidence from more recent studies (Safitri, 2024; Safitri et al., 2023, 2025). For instance, research by Amanda et al. (2022) demonstrated that the integration of local cultural elements in science learning increased students' awareness of their cultural identity and sense of belonging. This study contributes further evidence that embedding local culture into higher education pedagogy is not only feasible but also effective in nurturing cultural love alongside academic skills.

In practical terms, the ULOS model can be replicated in several educational contexts beyond physics learning for university students. First, in other science subjects such as biology and chemistry, cultural artifacts can also be used as contextual teaching aids. For example, in biology, ULOS weaving patterns can be related to the concept of symmetry in nature. At the same time, in chemistry, the traditional dyeing process of ULOS cloth can be connected to discussions of natural pigments and chemical reactions. Second, at different educational levels, the ULOS model has the potential to be adapted for secondary or even elementary education. At the school level, project-based learning with cultural integration could be simplified—for instance, by introducing students to measuring forces through simple experiments with woven fibers. Such adaptations would foster a love of culture from an early age while supporting the development of basic scientific literacy. Third, in multicultural school environments, the ULOS model demonstrates how one culture can serve as a gateway for integrating local wisdom into the learning process. The same approach can be applied to other ethnic groups by using their respective cultural artifacts. This implies that the ULOS model offers not only a culture-specific pedagogical innovation but also a transferable framework for culturally responsive teaching in diverse classrooms. Thus, the practical implication of this research is that the ULOS

model can serve as a prototype for culturally integrated PjBL, enriching science learning, strengthening student character, and promoting intercultural understanding within the broader educational landscape.

The findings of this study indicate that the ULOS model is effective in enhancing students' love of culture while simultaneously improving cognitive engagement in Physics Education students at Universitas HKBP Nommensen Pematangsiantar (UHKBPNP). The model's effectiveness is rooted in its structured integration of cultural values through four syntaxes: Use the Essential Question, Let's Design Project and Do It, Observation Result Project and Discussion, and Solution and Reflection. Quantitative data support this claim: students' mean scores on affective measures increased significantly from pre-test ($M = 62.4$, $SD = 7.8$) to post-test ($M = 82.7$, $SD = 6.9$), $t(29) = 9.82$, $p < 0.05$, Cohen's $d = 2.76$, demonstrating gains in both cognitive understanding and emotional attachment to local culture. Compared to traditional lecture-based learning, the ULOS model encourages active, project-based engagement, fostering intrinsic motivation, creativity, and a deeper internalization of cultural values (Wirama et al., 2023; Ali et al., 2025).

A key strength of the ULOS model is the contextualization of physics concepts within cultural artifacts. For example, students explored the concept of force and tension by using Ulos weaving: they measured the force required to stretch individual threads, tested the weight-bearing capacity of woven strands, and observed the deformation or break point under increasing load. Through such experiments, Newton's second law ($F = ma$) and principles of tension/compression become tangible when students compare the forces acting in a woven Ulos strap supporting a load vs a single fiber. This hands-on approach demonstrates how local culture can serve as a concrete bridge to abstract scientific concepts, reinforcing both comprehension and emotional engagement (Mashoko, 2022). Similarly, the pattern in Ulos weaving was used to illustrate symmetry and periodicity, linking to wave mechanics and materials science. For instance, students examined how repeated weaving patterns produce structures with specific tensile strength and how the geometry influences stress distribution—thus integrating culture and physics in a meaningful way. These examples highlight the novelty of this study, as few prior works in physics education have operationalized the integration of ethnoscience with concrete artifact-based project learning in higher education contexts (Nur Hikmah et al., 2024; Esti et al., 2024).

Contextual factors significantly influence the model's effectiveness. Students' familiarity with Ulos as part of their cultural heritage amplified the affective and cognitive impact. This aligns with the literature on culturally responsive pedagogy, which finds that learning becomes more relevant and engaging when it draws on students' cultural contexts (Ali et al., 2025). Conversely, studies involving students with no prior exposure to the cultural context reported limited gains in engagement or conceptual understanding (Kola, 2023; Hayandi et al., 2024). Hence, the close fit between the artifact (Ulos) and the learners' socio-cultural background serves as a critical success factor, suggesting that replication in different cultural settings must ensure the relevance of the artifact.

However, certain limitations should temper the interpretation of the results. First, the sample was confined to one study program at one university, which limits the generalizability of the findings to other disciplines, regions, or cultural contexts. Second, while quantitative data showed significant improvements in cognitive and affective scores, the affective measures (e.g., questionnaires, self-reports, observational checklists) may be influenced by social desirability bias, as students may respond in ways they believe the researcher expects them to. Third, the study did not assess long-term behavioural changes, such as sustained engagement in cultural preservation or shifts in students' professional practice as educators; thus, the sustainability of the model's effects remains an open question (Malandrakis & Kariotoglou, 2024; Nur Hikmah et al., 2024). Finally, the contextual fit (students already acquainted with Ulos) may have amplified results; in contexts where the cultural artifact is less familiar, the effects might be more minor or require adaptation.

In comparison to previous studies, this research contributes empirical evidence supporting the dual benefit of integrating culture and science. While Mashoko (2022) highlighted how indigenous artefacts can provide rich contexts for physics curriculum in Zimbabwe, and Wirama et al. (2023) demonstrated that ethnoscience-based teaching improves cognitive outcomes in natural science, the present study goes further

by providing concrete, physics-based applications using Ulos as a medium, and by measuring affective outcomes (cultural love) alongside cognitive ones. Moreover, the integration within higher education (physics education students) rather than only secondary school contexts strengthens its contribution. Additionally, the use of project-based learning rooted in cultural artifacts aligns with the trend identified in Ratnasari et al. (2024) and Ali et al. (2025), which suggests that ethnoscience-infused PjBL models improve critical thinking and motivation. In summary, this study positions the ULOS model as a novel and transferable framework for culturally responsive pedagogy, capable of bridging the gap between culture and science in meaningful ways.

In conclusion, the ULOS model's strength lies in its ability to contextualize scientific knowledge within cultural experiences while promoting active, project-based learning. The quantitative evidence of significant improvements in both cognitive and affective scores reinforces this claim. Despite limitations related to sample specificity and potential bias in affective measurement, this study demonstrates that culturally integrated pedagogical models, such as ULOS, can bridge the gap between science and cultural heritage, enrich learning experiences, and foster students' identities as both scholars and custodians of local culture.

Moreover, the results show that the ULOS model not only superficially improves cultural love but also contributes to a deeper understanding of cultural identity as part of academic learning. Integrating culture into physics learning also helped reduce the perception of science as detached from students' everyday lives. By contextualizing science through culture, the students reported higher motivation, greater relevance, and stronger emotional involvement in learning. In summary, the ULOS model demonstrates effectiveness in cultivating love of culture among Physics Education students at UHKBPNP. It bridges the gap between scientific knowledge and cultural heritage, enriching learning experiences and strengthening students' identities as both scholars of science and inheritors of local wisdom. This study confirms and extends previous research on the importance of ethnoscience and culturally responsive pedagogy, highlighting the ULOS model as a practical and innovative framework that can be replicated in other contexts to promote cultural sustainability in education.

CONCLUSION

The development of the ULOS model has successfully fostered a love of culture among physics students. This approach demonstrates that education aims not only to enhance academic competence but also to cultivate students' character and strengthen their cultural identity. The findings highlight that integrating cultural elements into physics learning makes abstract scientific concepts more meaningful and contextual, encouraging students to connect science with their lived cultural experiences. From a curricular perspective, the ULOS model implies that culture-based learning should be explicitly integrated into the curriculum of teacher education programs. Courses on physics education, learning media, and educational innovation can incorporate modules that guide students in designing learning projects rooted in local wisdom. Such integration aligns with the principles of *Merdeka Belajar* and supports the development of 21st-century skills through contextualized, culturally responsive teaching. Regarding the role of lecturers, this research emphasizes that lecturers act not only as transmitters of knowledge but also as facilitators who nurture critical, creative, and culturally grounded learning environments.

Lecturers are encouraged to model intercultural awareness and to mentor students in transforming local cultural artifacts—such as ULOS—into educational tools that support both cognitive and affective learning goals. For future development, the ULOS model can be expanded beyond physics education to other disciplines, especially within science and teacher training programs. Further research should explore its application in digital learning environments, such as Moodle-based or AI-supported platforms, to reach broader audiences and promote sustainable cultural education. Longitudinal studies could also examine how exposure to the ULOS model influences teachers' pedagogical beliefs and classroom practices over time. Overall, the ULOS model contributes to a broader movement toward culturally grounded science education in Indonesia, ensuring that the nation's rich cultural heritage continues to inspire innovation, identity formation, and holistic educational growth.

REFERENCES

- Ali, L. U., Suranto, S., Indrowati, M., Zaini, M., Bariroh, U., Afifah, M., & Taher, T. (2025). Exploring Ethnoscience in Science Education: A Systematic Literature Review from 2020-2025. *Konstan - Jurnal Fisika Dan Pendidikan Fisika*, 10(01), 59–67. <https://doi.org/10.20414/konstan.v10i01.692>
- Achille, C. (2022). *Teaching and Learning of Cultural Heritage: Engaging Education, Professional Training, and Experimental Activities*. Heritage.
- Abdallah, A. (2023). *The Role of Teachers in Enhancing Students' Cultural Awareness and Heritage in Schools*. Cogent Social Sciences / Taylor & Francis (artikel 2023).
- Amanda, F. F., Sumitro, S. B., Lestari, S. R., & Ibrohim, I. (2022). Developing a complexity science-problem-based learning model to enhance conceptual mastery. *Journal of Education and Learning (EduLearn)*, 16(1), 65–75. <https://doi.org/10.11591/edulearn.v16i1.20408>
- Baatz, W., et al. (2023). *Guidelines on innovative/emerging cultural heritage education and training paths*. (Charter-Alliance report).
- Begunova, M., & Qingyu, X. (2021). *Developing Research Competence among Teachers as a Means of Enhancing the Competitiveness of HEIs in Kazakhstan*. <https://doi.org/10.21203/RS.3.RS-165327/V1>
- Çamur, H., & Gogus, A. (2023). *Validity and Reliability Study of School Principals' Competence-Based Job Performance Perceptions Scale*. Çukurova Üniversitesi Eğitim Fakültesi Dergisi, 52(1), 207-246.
- Chaparro-Sainz, Á., Felices-de la Fuente, M. del M., Rodríguez-Medina, J., & Gómez-Carrasco, C. J. (2022). Heritage Resources and Teaching Approaches. A Study With Trainee Secondary Education History Teachers. *Frontiers in Education*, 7, Article 814197. <https://doi.org/10.3389/educ.2022.814197>
- Esti Ayu Ratnasari, Ani Rusilowati, Diana, et al. (2024). Literature Review of Research Trend of Ethnoscience-Infused Teaching Materials in Elementary IPAS Learning in 2020-2025. *Journal of Primary Education*, vol 13, no 2.
- Florian, L., Young, K., & Rouse, M. (2010). Preparing teachers for inclusive and diverse educational environments: Studying curricular reform in an initial teacher education course. *International Journal of Inclusive Education*, 14(7), 709–722. <https://doi.org/10.1080/13603111003778536>
- Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice*. Teachers College Press.
- Ishak, N., Che Md Ghazali, N. H., Baharim, S. H., Ghazali, M. A., & Setambah, M. A. B. (2024). Validity and Reliability of an Instrument Measuring Soft Skills among Secondary School Students. *International Journal of Academic Research in Progressive Education and Development*.
- Karthik, P., & Vangapandu, R. (2024). Content Validity of Assessment Instrument for High-Performance Work Systems in the Health Care Industry. *Journal of Nursing Measurement*, 32(1), 28–37. DOI:10.1891/JNM-2022-0034
- Kemendikbudristek. (2021). *Panduan Gerakan Literasi Sekolah*. Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.
- Lubis, M. N., Joebagio, H., & Pelu, M. (2019). Dalihan Na Tolu Sebagai Kontrol Sosial Dalam Kemajuan Teknologi. *Sejarah Dan Budaya Jurnal Sejarah Budaya Dan Pengajarannya*, 13(1), 25–33. <https://doi.org/10.17977/um020v13i12019p025>
- Nur Hikmah, Yohandri, Fitri Arsih, et al. (2024). Uncovering the Potential of Ethnoscience in Science Learning to Improve Students' Literacy: A Systematic-Literature Review (2014–2024). *Jurnal Pendidikan IPA Indonesia*, vol 14 no 3.
- Ögücü, T., & Gogus, A. (2025). Validity and Reliability Study of the School Technology Leadership Scale According to Teachers' Perceptions. *International Journal of Assessment Tools in Education*, 12(2), 457-475.
- Pamenang, F. D. N. (2021). Local wisdom in learning as an effort to increase cultural. *International Journal of Indonesian Education and Teaching*, 5(1), 93–101.
- Safitri, I. (2024). Transformation of Student Science Achievement Through Project-Based Learning (PjBL): A Meta Analysis Study. *Scientiae Educatia: Jurnal Pendidikan Sains*, 13(2). <https://doi.org/DOI:10.24235/sc.educatia.v13i2.18694>
- Safitri, I., Andriyanti, E., Ansyari, R., Harahap, R. D., Harahap, R. H., & Istiqlal, M. (2025). Character Education in Indonesia: Do Integrated Islamic Schools Outperform Public Schools? *Journal of Education Culture and*

Society, 16(1), 251–270.

- Safitri, I., Muti'ah, R., & Sriono. (2023). Identification of Character Values of Public and Private Junior High School Students in Rantau Selatan District. *The IAFOR International Conference on Education*, 717–727. <https://doi.org/https://doi.org/10.22492/issn.2189-1036.2023.59>
- Sibarani, R., Situmorang, H., & Ali Pawiro, M. (2018). Concerning Toba Bataks Local Wisdoms and Cultural Values for Regional Character Building. *Indian Journal of Science and Technology*, 11(20), 1–9. <https://doi.org/10.17485/ijst/2018/v11i20/114298>
- Sinaga, N. (2024). The exploration of the Batak Toba culture based on Schwartz's Basic Values Theory: A descriptive analysis of cultural values, Dalihan Na Tolu. *Psikologia: Jurnal Pemikiran Dan Penelitian Psikologi*, 19(2), 92–98. <https://doi.org/10.32734/psikologia.v19i2.15632>
- Sitindjak, R. H. I., Wardani, L. K., & Thamrin, D. (2016). Form and meaning of Batak Toba house ornaments. *Advanced Science Letters*, 22(12), 4050–4053. <https://doi.org/10.1166/asl.2016.8170>
- Suciati. (2023). Integrating Local Wisdom in Science Learning: Opportunities and Challenges. *AIP Conference Proceedings*, 2619(1), 100018. <https://doi.org/10.1063/5.0125371>
- Sudarmin, S., Diliarosta, S., Pujiastuti, R. S. E., Jumini, S., & Tri Prasetya, A. (2020). The instructional design of ethnoscience-based inquiry learning for scientific explanation about *Taxus sumatrana* as a cancer medication. *Journal for the Education of Gifted Young Scientists*, 8(4), 1493–1507. <https://doi.org/10.17478/jegys.792830>
- Sulistiyanto, H., Anif, S., Sutama, S., Narimo, S., Sutopo, A., Haq, M. I., & Nasir, G. A. (2022). Education Application Testing Perspective to Empower Students' Higher Order Thinking Skills Related to The Concept of Adaptive Learning Media. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, null, null. <https://doi.org/10.23917/ijolae.v4i3.19432>
- Tyas, E. H., & Naibaho, L. (2021). HOTS Learning Model Improves the Quality of Education. *International Journal of Research -GRANTHAALAYAH*, 9(1), 176–182. <https://doi.org/10.29121/granthaalayah.v9.i1.2021.3100>
- Tsaliki, E., Papadopoulou, E., Malandrakis, G., & Kariotoglou, P. (2024). A long-term study on the effect of a professional development program on science teachers' inquiry. *Education Sciences*, 14(6), 621. <https://doi.org/10.3390/educsci14060621>
- Yahaya, N. 'A. D., & Hussin, A. Z. (2023). Validity and Reliability Instrument of Mathematics Teachers' Perception on 21st Century Learning. *Practitioner Research*, 6, 115–133.