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Integrating Ethnoscience in Physics Teaching Materials and its Impact on Student's Science Process Skills and Mastery Concept

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Abstract: This research aims to integrate ethnoscience in Enggros and Tobati tribal communities into physics teaching materials and see how it influences students' science process skills and mastery of concepts. The type of research is research and development (R&D) on the 4D model which was modified into 3D without a dissemination stage. The research sample was class XI students at public high schools in Jayapura City. Five validators validated the physics teaching materials developed. To see the effect of using teaching materials, a quasi-experiment was used using a randomized pretest-posttest control group design. The research results showed that the developed teaching materials had a positive impact, and it was found that there were significant differences in science process skills and concept mastery between students who studied with the developed teaching materials and those who studied with conventional teaching materials. The teaching materials developed can mediate student learning transitions and support science process skills and students' mastery of concepts in learning science.

Keywords: Ethnoscience; Mastery concept; Physics teaching material; Science process skills

Introduction

Education is a learning activity, one of which occurs in the classroom, which aims to develop students' potential as much as possible. Furthermore, education developed in Indonesia has special characteristics, namely education that refers to Pancasila and the 1945 Constitution which is rooted in religious values, and Indonesian national culture, and is responsive to changing times. Education is a real action to achieve quality humans and plays a very strategic role because the process and success of development in every sector always require education. The Indonesian government is realizing this action to educate the nation by implementing a formal education system which is implemented in school institutions (Partini et al., 2024; Sibarani et al., 2020).

As is known, educational activities in schools are teaching and learning processes that focus on changes in cognitive aspects (knowledge), affective aspects (attitudes), and psychomotor aspects (skills) (Abbasi et al., 2023; Borgerding et al., 2018; Kuo et al., 2024). Specifically referring to the cognitive aspect, learning outcomes are a reference to students' academic mastery, where the better the students' academic mastery, the better the learning outcomes will be, and vice versa. However, facts related to education in the field show that the results are far from expectations.

Papua, which currently has 6 new autonomous regions (DOB), is a province at the eastern tip of the archipelago, a province that is rich in natural resources but unfortunately does not contribute to the world of education. Papua Province's Human Development Index (HDI) data in 2022 is 61.39, lower than the national average of 72.91, far behind other provinces (BPS Papua, 2022). This data is reinforced by the findings of learning outcomes in schools which show that students' mastery of concepts in Jayapura is still low, almost 70% of students do not have a good mastery of physics concepts.

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Initial research conducted on high school level students in Jayapura City showed that students' mastery of physics concepts and science process skills was still low. The results of observations of learning activities carried out in the classroom during the learning process found that students did not show enthusiasm when interacting with the teacher in the classroom learning process. It was found that students did not interact positively in the learning process, they were passive when the teacher asked questions, and it was even found that there were students who did not pay attention to the teacher's explanation during the lesson. Furthermore, student learning outcomes are still low, far below the Minimum Completeness Criteria (KKM) value. Researchers further found that students studied using general (conventional) teaching materials, which were not under their local wisdom, and this had an impact on low physics learning outcomes. The existence of appropriate teaching materials is very useful for helping students understand the subject matter (Khairani et al., 2024; Sotero et al., 2020).

Naturally, Papua has a lot of ethnoscientific wealth in the form of various local wisdom that can be developed and used to support the Physics learning process. Examples of the diversity of Papuan flora which is endemic and different from other regions in Indonesia, such as red fruit (Pandanus Conoideus Lamk), the potential of the Sago tree (Metroxylon Sago), working together (Bhulau), and the Open/Barapen cooking method (traditional cooking method using burning rocks first to get heat which functions like a stove) turns out to contain various physics concepts and can be used to support the process of physics students in the classroom (Kujović et al., 2022).

The researchers' observations show that physics learning in schools is more oriented towards modern or contemporary physics concepts, where teaching places more emphasis on theories that are too advanced (complicated) and do not accommodate (Dwivedi et al., 2022; Siregar et al., 2022). Papuan ethnoscience makes it difficult for students who still live in their cultural context to understand every day. This condition is exacerbated by the absence of contextual examples to make it easier for students to digest the physics theories, concepts, and material taught by the teacher. This situation causes students to think that Physics is a science that is difficult to understand, is in the clouds is not applicable, and is far from its cultural context (Xu et al., 2021). This situation has an impact on low motivation to learn about Physics lessons. Physics or other exact sciences are contextual, simple sciences, which can be explained and applied in everyday life using examples in the surrounding environment (Zidny et al., 2020). One example of Papuan ethnoscience that contains the concept of physics is the Apen/Barapen activity found in the Biak tribe and the Enggros and Tobati tribes in Jayapura. The Open/Barapen activity is one of the local wisdom that contains the concept of thermodynamics. Papuan people burn stones until they are red and use them to cook food until cooked. This activity shows the transfer of heat in the form of conduction, convection, and radiation from hot stones that cook food. The use of ethnoscience, in this case, a form of local wisdom, in physics learning helps connect students' scientific knowledge with local science obtained from their daily life experiences. However, it is unfortunate that the use of ethnoscience in Indonesia or Papua is still minimally accommodated in Physics learning in the classroom (Dian et al., 2018; Ilhami et al., 2019; Ramdiah et al., 2020).

Based on the explanation of the problems above, this research aims to accommodate the integration of ethnoscience of tribal communities in Jayapura in the development of Physics teaching materials and determine the impact on the mastery of science process skills and mastery of concepts of high school level students in Jayapura City. It is hoped that the results of this research will help mediate students who still live in strong customs and culture when they study science at school.

Method

This research used research and development (R&D), development research aims to produce a product and test the effectiveness of the resulting product. This development research refers to the 4-D development model (Ula et al., 2021) which consists of 4 (four) stages, namely, Define, Design (planning), Develop (development), and Disseminate (distribution), in this research the researcher only carried out three stages, namely define, design, and develop only. The results of the development of teaching materials were tested on class XI high school students in Jayapura City in the experimental class and control class in the 2022/2023 Academic Year. To obtain an assessment regarding the teaching materials developed, a questionnaire instrument was used which was then assessed by 5 expert validators consisting of two Physics Education lecturers at FKIP Cenderawasih University and three senior and certified Physics teachers from high schools in Jayapura City. The data obtained is quantitative data obtained based on the validator's assessment of the questionnaire. In the validation sheet for teaching materials, several aspects are assessed, namely cover, illustrations, format, content of teaching materials, and the language used. The results of this research were processed using a Likert scale with a scale of 1 to 4.

Data on the validation of the developed teaching materials and the implementation of the learning tools were created in a questionnaire instrument and analyzed using descriptive statistical analysis techniques by calculating percentages using the following formula.

$$P = \frac{\sum x}{\sum xi} \times 100\% \quad (1)$$

Information:
P =percentage
$\sum x$ =total number of respondents answers
$\sum xi$ =total number of ideal scores in one item

The guidelines used to provide meaning and decision-making regarding product validity and implementation (product feasibility) are presented in Table 1.

Table 1. Five Absolute Scale Feasibility Conversion Guidelines

Score range (%)	Qualification
90– 100	Highly valid
75 – 89	Valid
65 – 74	Enough
55 – 64	Less
0 – 54	Very less

The criteria for success in the product feasibility test (product validity and suitability) is if it reaches a minimum score of 75% (valid) with minimum qualifications. If it is below the minimum score, it needs to be revised again. Next, validation and reimplementation are carried out. This is done continuously until the minimum good criteria are met. To determine whether there is an effect of using teaching materials containing Jayapura ethnoscience on the science process skills of students in the experimental class and control class, a difference test (t-test) was used. The t-test calculation is assisted using the SPSS 23 program. Furthermore, to find out the impact of the developed teaching materials on students' mastery of concepts, N-gain analysis was used between the experimental class and the control class:

$$g = \frac{S_{Post} - S_{Pre}}{S_{Maks} - S_{Pre}} \quad (2)$$

Information:
g =normalized gain
S_{maks} =maximum score of tests
S_{Post} = posttest scoree
S_{Pre} = pretest scoree

The high and low normalized gain values can be classified in Table 2 below.

Table 2. Normalized N-gain Category Values

N-gain Value	Categories
g > 0.70	High
0.30 ≤ g ≤ 0.70	Medium
g < 0.30	Low

Result and Discussion

The product of this development research is the production of Physics teaching materials for XI class high school which is an integration of ethnoscience in physics learning using the local wisdom of Enggros and Tobati tribes in Jayapura on Temperature and Heat topic by conduction, convection, and radiation. The activities carried out at each stage are as follows: The define stage is the stage for establishing and defining learning conditions under this research and development (operational definition). From the various analyses carried out at the Define stage, the result obtained is a guide to the preparation and guidance of teaching materials that will be developed. The design stage aims to design learning tools and the result of this design stage is the production of a blueprint or initial draft of the product (learning tools with the integration of ethnoscience in physics teaching materials). The design of the teaching materials developed contains competency standards (KI), basic competencies, indicators, learning objectives, material descriptions, learning summaries, practice questions, answer keys, and a bibliography.

The development stage is the stage to produce a development product which is carried out through two steps, namely expert appraisal followed by revision and development trials (developmental testing). The final aim of this development stage is to produce a final form of learning device that is feasible after going through revisions based on input from experts and data from trial results. Regarding the science process skills evaluation instrument, the validator practitioner provided notes that the images were selected according to the conditions and life of the Enggros and Tobati Tribe Community as well as selecting images of Apen/Barapen activities which showed the presence of conduction, convection, and radiation events in Bajar Batu activities. Apart from that, revisions were made to the enlarged image size so that it is visible and makes it easier for students to learn. Apart from that, notes from validator practitioners contain suggestions to pay attention to the typing in the manuscript layout, because there are still several typing errors found.

Next, the research results section presents several results related to the development of teaching materials, which include validation based on feasibility instruments for media and content aspects as well as expert and practitioner responses to the products developed. Below is shown the cover and parts of the pages of the teaching materials resulting from the development research carried out.

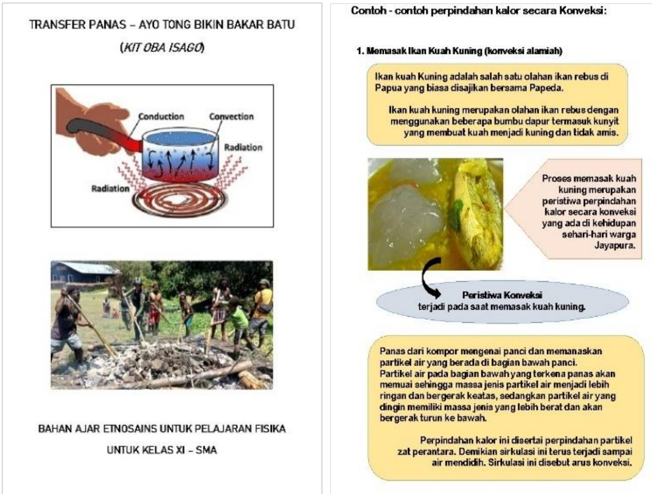

Figure 1. Display of developed teaching material

The validation results of teaching materials found that content experts responded positively to the teaching materials developed in this research. Content assessment is carried out by content and material experts on 5 (five) components, namely: cover, illustrations, format, content, and language. Assessment is carried out by giving a score of one to four which represents the response, namely a score of 1-4. The results of the analysis show that content and material experts responded in the very good category (90.67%), this indicates that the quality of teaching materials according to content and material experts is very good, as shown in Table 3.

Table 3. Validation Result by Expert Judgment

Component	Mark Val. I	Mean Val. II	Qualification (%)	Mark
Cover	91.67	91.67	91.67	Highly valid
Illustration	83.33	91.67	87.50	Valid
Format	90	90	90	Highly valid
Content	95	90	92.50	Highly valid
Language	91.67	91.67	91.67	Highly valid
Mean			90.67	Highly valid

Furthermore, the results of validation by practitioners of teaching materials developed are presented in Table 4. From the analysis results of teaching materials validated by practitioners, it was found that the average score was 92.11% (in the highly valid category). The validation value shows that practitioners assess the teaching materials developed as suitable for use. The revision notes provided by five validators have been corrected so that this learning material can be used in class XI high school physics lessons on temperature and heat material.

Table 4. Validation Results by Practitioners

Component	Prac. I	Prac. II	Prac. III	Mean (%)	Qualifications
Cover	91.67	100	100	97.22	Highly valid
Illustration	91.67	91.67	91.67	91.67	Highly valid
Format	95	91.66	90	92.22	Highly valid
Content	90	91.67	90	90.56	Highly valid
Langguagge	91.67	91.67	83.33	88.89	Valid
Mean				92.11	Highly valid

Next, the researchers used a difference test (t-test) to see whether the teaching materials developed had a different impact on students' science process skills in the experimental group and the control group. The difference test (t-test) can be carried out provided that the data is normally distributed and homogeneous. Researchers used SPSS 23 to carry out normality tests and homogeneity tests. The t-test results are attached in Table 5.

Table 5. Recapitulation of t-Test Results for Both Class

Class data	t-test t	t-test Sig.	Conclusion
Pre-test control and experiment class	0.16	0.87	There were no significant differences between the two class
Post-test control and experiment class	5.47	0.00	There are significant differences between the two class

The results of the t-test in Table 5 show that there is a significant difference in the science process skills of students in both classes with the use of teaching materials resulting from the use of ethnoscience in physics teaching materials. It can be concluded that the integration of ethnoscience in physics teaching materials is better compared to learning with conventional teaching materials in Temperature and Heat material in class XI.

To get a percentage increase in students' concept mastery using normalized gain (N-gain). Data on the percentage increase in N-gain in students' concept mastery is presented in Table 6.

Table 6. Percentage Increase in N-gain Concept Mastery

Class Data	N-gain (%)	Category
Experiment Class	75	High
Control Class	46	Medium

Based on the data results presented in Table 6, it can be concluded that the percentage increase in concept mastery N-gain is higher in the experimental class which learns using teaching materials that integrate Jayapura ethnoscience compared to the control class which learns with conventional teaching materials sourced from textbooks. The validation test results of developed teaching materials show that the teaching materials containing Jayapura ethnoscience which has been developed are in the very good category, expert validators gave an average rating (M) of 90.67, and practitioner validators gave an average rating (M) of 92.11, where both assessment results are in the very good category. The validation results show that the teaching materials developed can be used easily by students. The validators gave a very good assessment which shows that the teaching materials are easy for students to use, this is because the teaching materials use ethnoscience potential in the form of local wisdom and local potential that is known, understood, known, and encountered in students' daily lives (Febrian et al., 2024; Fuadi et al., 2024; Kristanto et al., 2019; Misbah et al., 2024).

Theoretically, efforts to develop and validate learning products based on Jayapura ethnoscience are based on two propositions (Hanum et al., 2023). The first argument is that the ethnoscience-based learning model is a very important part of the effectiveness of learning practice. This statement implies that ethnoscience, which contains local wisdom, should be used as a basis for efforts to increase the effectiveness of educational outcomes. Second, meaningful learning is the most important element in learning. This implies that the learning process should link the content and context in the area itself, thus, learning will become more meaningful and attract students' interest in learning (Pieter et al., 2023; Toharudin et al., 2021; Wibawa et al., 2023).

The results of the differences test (t-test) on the use of teaching materials that integrate ethnoscience from Enggros and Tobati tribes in Jayapura on students' mastery of science process skills show that there are differences in the experimental group and the control group, a significant value of 0.000 was obtained (Table 5). These results show that there is a difference in mastery of science process skills between students who use teaching materials that integrate Jayapura ethnoscience and students who study with conventional teaching materials.

The difference in mastery of science process skills is because students who study using teaching materials developed from the ethnoscience of the Engross and Tobati tribes find it easier to understand physics lessons using the developed teaching materials, thus having an impact on students' mastery of science process skills better than students who study with conventional teaching materials. These differences in mastery of science process skills ultimately have an impact on students' mastery of concepts.

At the end of the research, it was found that mastery of concepts in the experimental group and the control group gave significantly different results. Based on the data in Table 6, in the control class, the N-gain value was found to be 75 in the high category and it was 46 in the medium category, so the mastery of the concepts of students who studied using ethnoscience teaching materials increased more than the group who studied with conventional learning.

The local wisdom in the community, especially ethnoscience, can be used as a medium for science learning. Ethnoscience can be a contextual learning resource or science learning object. Integrating ethnoscience into learning becomes a means of learning science that is contextual and meaningful for students. Ethnoscience-based learning will strengthen literacy (science, data, and technology) because students will learn to study original science and uncover the potential of scientific knowledge contained within it. Knowledge of science and technology learned by exploring native science will give rise to a feeling of love for the culture. Therefore, it is considered important to elevate local Indonesian wisdom which contains original science into science learning, namely by exploring and identifying original science and then reconstructing it into ethnoscience, namely original science that has a scientific explanation (Sudarmin et al., 2018).

Activities carried out in science process skills include observing, comparing, classifying, measuring, and communicating. The process skills approach is an approach to learning physics that assumes that physics is formed and develops through a scientific process which must also be developed in students as a meaningful experience that can be used as a provision for further personal development (Fajri et al., 2024; Parker et al., 2022; Verhoeven et al., 2019). The process skills approach emphasizes how students learn and manage their acquisition so that they are easy to understand and use in life in society. In the learning process, students can gain their own experience and knowledge, scientific investigation, and train their intellectual abilities.

Developing skills with an emphasis on science process skills supports children to be able to discover and develop their facts and concepts as well as grow and develop the attitudes and values required (Mumtaza et al., 2023). In this way, these skills become the driving force for the discovery and development of facts and concepts, as well as the growth and development of attitudes and values (Wijaya et al., 2024). Furthermore, the increase in students' science process skills is due to the teaching materials that integrate Jayapura's ethnoscience produced having the advantage that the teaching materials developed integrate ethnoscience potential that exists in society so that students are very interested and easy to understand because they fit the context of their daily lives (Haleem et al., 2022). The integration of ethnoscience in the development of Physics teaching materials makes learning appropriate to everyday life and the real world (Azhar, 2022; Nurcahyani et al., 2021; Sudarmin et al., 2023) making learning meaningful because it fits the socio-cultural context of the Enggros and Tobati tribal communities in Jayapura.

The results of this research are in line with the research findings Risamasu et al. (2023) which shows that the application of a learning model based on local wisdom with an ethnoscience context in learning is very popular with students and science teachers. The students stated that they became more familiar with learning science using teaching materials based on their local wisdom. This statement is by the results of research by Abdillah et al. (2022) which states that students and science teachers in Bali can accept well the development of learning models based on local Balinese culture. Research by Hartini et al. (2018) and Suastra et al. (2021) stated that the use of Canva and e-modules based on local wisdom in a learning process has been proven to attract students' attention, this is because learning is appropriate to the context of their daily lives.

Furthermore, the results of this research prove that every local wisdom and every local potential that exists in communities in the archipelago is a learning resource that can be used to support Physics learning activities in schools (Bada, 2022; Kumar et al., 2021). This teaching material that integrates the ethnoscience of Enggros and Tobati tribes in Jayapura helps mediate students who are just starting to study physics, which is a scientific science, where students who are transitioning from an environment steeped in local culture often experience a cultural gap. The existence of physics teaching materials that integrate ethnoscience links traditional science originating from their local world with modern science lessons, thereby minimizing the occurrence of culture shock, and making it easier for students to learn modern science at school.

Conclusion

Based on the results of the data analysis and discussions that have been carried out, the following conclusions can be drawn: physics teaching materials that integrate the ethnoscience of Enggros and Tobati tribes that have been developed are very suitable for implementation in learning activities in schools. The results of expert validation show an average value of 90.67%, while the results of validation by practitioners show an average of 92.11%, both of which are in the very good category; There is a significant difference regarding students' mastery of science process skills by using physics teaching materials that integrate the ethnoscience of Enggros and Tobati tribes in Jayapura City compared to students who study using conventional teaching materials in class XI Physics lessons on Temperature and Heat; 3) The percentage increase in N-gain in students' mastery of concepts using physics teaching materials that integrate Enggros and Tobati ethnic ethnos in Jayapura was 75% in the high category, while the percentage increase in N-gain when using conventional teaching materials was 46% in the medium category.

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Author Contributions

Conceptualization; J. P., P. V., M. R.: methodology; J. P., validation; P. V.: formal analysis.; M. R.: investigation.; J. P.; resources; P. V: data curation: M. R.: writing—original; J. P.: draft preparation; P. V.: writing—review and editing: M. R.; visualization: J. P. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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