

Development of Ethnoscience-Based Teaching Materials on Fluid Dynamics to Enhance Students' Creativity

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Abstract - This study aims to develop ethnoscience-based physics teaching materials on fluid dynamics to enhance students' creativity and learning outcomes. The research employed the 4-D development model (Define, Design, Develop, Disseminate) and was conducted up to the Develop stage, including needs analysis, design, expert validation, limited trials, and effectiveness testing. Validation results indicated that the materials were rated as very valid (88%) and valid (65%). A limited trial involving 34 students showed an improvement in conceptual understanding with a normalized gain (N-gain) of 0.61, categorized as moderate, while student responses were highly positive with an average score of 85.9 out of 100. The novelty of this research lies in the integration of local cultural knowledge, specifically the traditional sailboats of the Bima-Sape community, into physics instruction. This approach connects indigenous practices with scientific principles, producing culturally relevant and innovative learning materials that foster student engagement, contextual understanding, and creative thinking in physics education.

Keywords: Teaching Materials; Ethnoscience; Fluid Dynamics; Student Creativity

INTRODUCTION

Education is a conscious and systematic effort to create a learning environment that enables students to actively develop their potential. It covers spiritual, intellectual, moral, and practical aspects that are essential for personal and social life (Pristiwanti, 2020). Physics, as one of the core subjects in high school, explores natural phenomena based on facts, concepts, and laws that are tested through scientific methods.

In practice, however, physics is often perceived as a difficult subject. Many students feel less motivated and less engaged in the learning process (Idrus, 2022). This condition reflects a gap between the ideal goals of education and the real situation in classrooms. One approach that can bridge this gap is ethnoscience-based learning. This approach connects scientific concepts with local cultural knowledge, making learning more contextual and relevant. It helps students understand abstract concepts

through everyday experiences and encourages the development of critical and creative thinking skills.

Several previous studies have demonstrated the benefits of ethnoscience in physics learning. Amaliah (2022) developed an ethnoscience-based e-module on heat material. Yachod (2024) linked Archimedes' law to the traditional *gethek* game made from banana stems. Pangga (2023) applied an ethnoscience approach to solid-state physics to improve students' conceptual understanding. These studies show that integrating local culture can help students grasp scientific concepts more easily and enhance their engagement in learning. However, most of these studies focused on concrete and observable physics concepts, making the relationship between culture and scientific principles more direct and simple.

Unlike those studies, this research focuses on fluid dynamics, which involves more abstract and mathematically complex concepts. Students often struggle to

understand ideas such as Bernoulli's principle, fluid pressure, and flow rate because they lack relatable real-world examples. The novelty of this study lies in the development of teaching materials that integrate traditional sailboats of the Bima-Sape community as a cultural context for learning. These boats serve as local cultural models to explain various principles of fluid dynamics, such as buoyant force, wind propulsion on sails, and boat stability. This approach expands the application of ethnoscience from simple physics concepts to more abstract ones, which are rarely explored in teaching materials.

Therefore, the developed teaching materials aim not only to improve conceptual understanding but also to enhance students' creativity and engagement through the exploration of connections between traditional knowledge and modern science. This research provides an original contribution to the development of ethnoscience-based physics learning. It shows that local cultural values can serve as effective learning resources, even for complex physics topics such as fluid dynamics.

RESEARCH METHODS

This study employed a Research and Development (R&D) approach using the 4-D model, which consists of four stages: Define, Design, Develop, and Disseminate. The implementation in this study was limited to the Develop stage.

In the Define stage, a needs analysis was conducted through curriculum review, teacher interviews, and an assessment of students' characteristics. The analysis also included identifying local cultural potentials of the Bima-Sape community that are relevant to fluid dynamics, particularly the traditional sailboats. The results of this analysis served as the foundation for

formulating learning objectives and determining the content of the material.

The Design stage focused on developing a printed project-based module that integrates physics concepts with local cultural contexts. The module was equipped with illustrations, case studies, and problem-based learning activities. Supporting learning tools were also designed, including lesson plans (RPP), student worksheets (LKPD), validation instruments, pretest and posttest questions, and student response questionnaires.

The Develop stage involved product validation by two expert validators who assessed content feasibility, language clarity, presentation quality, and integration of ethnoscience elements. After revisions were made based on expert feedback, a limited trial was conducted with 34 students from grade XI at SMA Negeri 1 Sape. The trial aimed to measure the improvement in conceptual understanding through pretest and posttest results and to evaluate student responses to the teaching materials using a Likert-scale questionnaire.

The research instruments included teaching materials, lesson plans, validation questionnaires, student response questionnaires, and conceptual understanding tests. The data collected consisted of both quantitative and qualitative data. Quantitative data from pretest and posttest results were analyzed using normalized gain (N-Gain) calculations to determine students' conceptual improvement. Questionnaire data were analyzed using percentages to assess the validity and practicality levels of the teaching materials. Qualitative data from observations, interviews, and documentation were used to support the interpretation of the findings.

The results of the teaching material analysis were presented in tables using the

Likert scale. The percentage value (NP) was calculated using the following formula:

$$NP = \frac{R}{SM} \times 100\% \quad (1)$$

Description:

NP = Percentage value

R = Score

SM = Maximum score

Table 1. Product Validity Criteria

Range	Category
81% - 100%	Strongly Valid
61% - 80%	Valid
41% - 60%	Fairly Valid
0% - 40%	Not Valid

To analyze the practicality of the teaching materials, data from teacher and student response questionnaires were evaluated using a Likert scale. The percentage value (NP) was calculated using the same formula as in the validity analysis.

Table 2. Likert Scale for Practicality Assessment

Range	Category
4	Strongly Agree
3	Agree
2	Disagree
1	Strongly Disagree

The improvement of students' conceptual understanding was analyzed using the normalized gain (N-Gain) calculation. The formula used was:

$$N\text{-gain} = \frac{\text{Posttest} - \text{Pretest}}{\text{max score} - \text{Pretest}} \quad (2)$$

The N-Gain value was then interpreted based on the following criteria: high if $N\text{-Gain} > 0.7$, moderate if $0.3 \leq N\text{-Gain} \leq 0.7$, and low if $N\text{-Gain} < 0.3$.

This research was conducted at SMA Negeri 1 Sape and involved students as trial subjects to evaluate the developed teaching materials.

RESULTS AND DISCUSSION

Research Findings

This study aimed to develop ethnoscience-based physics teaching materials on the topic of fluid dynamics to enhance students' creativity and conceptual understanding. The development process followed the 4D model (Define, Design, Develop, Disseminate). However, in practice, only three stages were implemented, namely Define, Design, and Develop.

1. Define Stage

At this stage, the researcher identified and formulated learning problems found in the field, particularly in the teaching of physics on fluid dynamics. Preliminary observations indicated that students had difficulty understanding abstract concepts such as Bernoulli's law, fluid pressure, and flow rate because these topics were not sufficiently connected to everyday experiences. Therefore, a needs analysis was conducted through curriculum review, teacher interviews, and examination of students' characteristics. In addition, an analysis of local cultural potential was carried out, focusing on the traditional knowledge of the Bima-Sape community related to the use of sailboats. This information served as the basis for integrating ethnoscience values into the teaching materials.

2. Design Stage

At this stage, the initial draft of the ethnoscience-based teaching material was designed based on the results of the needs analysis and local potential. The design included determining the format (a project-based module), developing learning content linked to local practices such as boat shapes and fluid flow beneath the hull, and designing problem-based learning activities. The researcher also prepared research instruments including validation sheets,

pretest and posttest questions, and student response questionnaires. Illustrations, images, and case studies were taken from the students' surroundings to make the material more engaging and easier to understand. This stage produced the first draft of the ethnoscience-based physics teaching material for the topic of fluid dynamics for Grade XI students.

3. Develop Stage

After completing the initial design, this stage focused on validation, revision, and product testing. The product was validated by two experts who assessed aspects such as content feasibility, language use, presentation quality, and the integration of ethnoscience. Based on the validators' feedback, the researcher revised the product before conducting a limited trial. The trial was carried out with 34 Grade XI students at SMA Negeri 1 Sape. Students were given a pretest before and a posttest after the learning process to measure their conceptual improvement. They also completed a questionnaire to assess the attractiveness, clarity, and readability of the teaching material.

a. Product validation results

The validation results indicated that the teaching materials were categorized as "Valid." Based on the comments and suggestions provided by the validators (Table 3), minor revisions were made.

Table 3. Teaching Material Validation Results

No	Validator	Percentage Score	Criteria
1	Validator 1	88%	Strongly Valid
2	Validator 2	65%	Valid

Validator 1 suggested adding examples of ethnoscience applications related to fluid dynamics concepts in daily life, while Validator 2 recommended including additional materials and examples that

further reflect ethnoscientific aspects. According to Purwanto's (2017) interpretation of eligibility criteria, these scores fall within the "feasible" category, indicating that the teaching materials meet the standards of content quality, language accuracy, presentation, and integration of local cultural values.

b. Pretest and Posttest Results

The effectiveness of the teaching materials was evaluated through pretest and posttest assessments involving 34 students from Class XI at SMA Negeri 1 Sape. The average scores are presented in Table 4.

Table 4. Pretest and Posttest Results

No	Student	Pretest	Posttest	N-Gain
1	Student 1	30	85	0,78571
2	Student 2	15	70	0,64706
...	...	...	...	...
34	Student 34	12,5	60	0,54286
Average	23,3088	70,2206	46,9118	0,61004 2626

According to Hake's (1998) classification, the normalized gain value ($0.3 \leq g < 0.7$) falls within the "medium" category. This improvement indicates that the developed teaching materials effectively enhanced students' understanding of fluid dynamics concepts.

c. Students' Responses to the Teaching Materials

Students' responses were measured using a Likert scale questionnaire that assessed readability, attractiveness, ease of use, contextual relevance, and the influence of the materials on creativity. The average score obtained was 85.9 out of 100, indicating a highly positive response. Students reported feeling more motivated and interested in learning fluid dynamics through project-based activities grounded in local wisdom, such as designing miniature

traditional sailboats. The integration of local cultural contexts made the learning process more meaningful and engaging.

Discussion

The development of ethnoscience-based teaching materials on fluid dynamics in this study was guided by the 4D model (Define, Design, Develop, Disseminate) in a systematic manner. The use of this model was essential because it provides a structured sequence from needs identification to product validation, ensuring the quality and feasibility of the developed materials.

During the Define stage, the researcher identified the difficulties experienced by students at SMA Negeri 1 Sape in understanding the abstract nature of fluid dynamics and the lack of contextual learning resources. Observations and interviews with physics teachers revealed that students were often passive because they perceived the subject as difficult and disconnected from real life. The needs analysis was then combined with an exploration of local cultural knowledge in Sape, particularly the traditional use of sailboats, which are closely related to the principles of Bernoulli's law, fluid pressure, and buoyant force. This aligns with the concept of contextual learning, which emphasizes that lessons connected to students' daily experiences tend to be more effective. By linking physics phenomena to traditional Bima sailboats, such as the buoyant force on the hull (Archimedes' principle), the wind thrust on the sail (Newton's laws), the rotational stability of the keel, the drag reduction by the bow, and the momentum at the stern, students were able to see the relevance of fluid dynamics in real situations.

The Design stage produced a project-based printed module integrating ethnoscience elements. The teaching

material not only presented physics concepts but also included local illustrations, images of traditional boats, case studies, and simple experiments demonstrating fluid behavior in cultural contexts. This approach reflects the principle of contextual and relevant learning resources. The module was designed to be interactive and participatory, encouraging exploration and critical thinking. The design also included lesson plans, student worksheets, pretest and posttest items, and response questionnaires, all adapted to a Problem-Based Learning (PBL) approach to foster creativity and conceptual understanding. The constructivist perspective was also evident, as students built new knowledge from their cultural experiences.

At the Develop stage, expert validation showed that the teaching material was highly valid, receiving a score of 88 percent from the first validator and 65 percent from the second. The lesson plan and student worksheet also achieved high validity scores of 89 percent and 87 percent, respectively. These results indicate that the material met the required standards of content quality, language clarity, presentation, and integration of local cultural values. After revision, a limited trial with 34 students demonstrated a significant improvement in learning outcomes. The average pretest score of 23.30 increased to 70.22 in the posttest. The normalized gain score of 0.61 (medium category) indicated that the ethnoscience-based material was effective in improving students' conceptual understanding.

The effectiveness was also supported by very positive student responses, with an average score of 85.9 out of 100. Students expressed enjoyment, interest, and motivation when using materials that connected science with their own cultural background. This finding is consistent with

the concept of ethnoscience, which provides relevant and meaningful contexts that enhance student engagement and learning motivation. The results reinforce Amaliah (2022), who found that ethnoscience-based e-modules improve conceptual understanding and active participation. Similarly, Pangga (2023) emphasized that ethnoscience learning promotes collaboration and engagement among students. Yachod (2024) also reported that understanding of fluid concepts improves more rapidly when taught through familiar local contexts, such as the traditional “gethek” raft used to illustrate Archimedes’ principle. In this study, the use of traditional Sape sailboats as analogies for fluid dynamics yielded similar outcomes by improving students’ comprehension and creativity. Puspasari (2019) also stressed the importance of utilizing local potential in lesson planning to foster character and independence, which was reflected in students’ positive responses to the ethnoscience-based lesson plan and worksheet.

Beyond effectiveness and student responses, it is important to identify the strengths and limitations of the developed material and to compare them with related studies.

The development of ethnoscience-based teaching materials on fluid dynamics demonstrates several key strengths. First, it enhances relevance and motivation by linking abstract concepts such as Bernoulli’s principle, pressure, and flow rate to familiar local practices. This makes it easier for students to construct meaning and engage actively. Empirical evidence and pedagogical theory confirm that culturally relevant and contextual instruction increases learning engagement (Ladson, 1995). Second, learning effectiveness was measurable through the improvement in

average scores and the moderate normalized gain ($g \approx 0.61$), consistent with previous ethnoscience module studies that reported similar gains in learning outcomes and critical thinking. Third, the practicality and appeal of the product, as reflected in students’ positive perceptions, align with other studies that found ethnoscience-based learning materials easy to implement and motivating for students.

However, the development process also has several limitations. First, its scalability and generalizability are limited. Since the material is strongly rooted in local contexts such as Bima–Sape sailboats, it may require adaptation before being applied elsewhere. Consequently, the results may not be directly replicable in different regions. Prior literature on culturally responsive pedagogy emphasizes the need for teacher adaptation and professional training to maintain quality during broader implementation (Cobern et al., 1998; Hewson, 2012). Second, the study’s scope was limited to the Develop stage without broad dissemination or long-term evaluation of creativity or conceptual retention. Related studies have highlighted the need for follow-up assessments to measure long-term impact. Third, the dependence on local expert validation, as reflected in varying validator scores, suggests that further refinement and cross-institutional validation are needed to ensure wider academic consensus.

In relation to previous research, the findings are consistent with both national and international ethnoscience studies and with the internationalization of culturally responsive practices. Teaching materials that integrate local culture have been shown to facilitate conceptual understanding and higher-order thinking. Recent R&D studies and meta-analyses also highlight that culturally responsive approaches can be

combined with digital or augmented-reality media to enhance visualization of fluid dynamics concepts. Nevertheless, the literature emphasizes the importance of longitudinal research, multi-site trials, and teacher capacity-building to ensure sustainability and replicability of such innovations (Bang et al., 2007).

Overall, the application of the 4D model in this study not only produced valid, practical, and effective materials but also demonstrated that the ethnoscience approach can bridge the gap between scientific concepts and students' cultural experiences. The study confirms that ethnoscience-based teaching materials contribute significantly to improved learning outcomes and creativity while aligning with curriculum standards and successfully integrating local cultural values into scientific concepts. The Disseminate stage could not be fully implemented due to time and scope constraints, although limited dissemination was carried out among physics teachers at the school.

CONCLUSION

Based on the objectives of this research, which were to develop ethnoscience-based teaching materials relevant to local cultural and environmental contexts and to analyze their effectiveness in enhancing students' creativity, several conclusions can be drawn. The developed teaching materials align with the principles of high-quality instructional design, namely relevance, contextuality, interactivity, and participation. These characteristics support an active and creative learning process. The use of ethnoscience-based materials proved effective in improving students' creativity. Students were able to connect physics concepts with their cultural experiences, which enabled them to think critically and

innovatively in understanding the topic of fluid dynamics.

In addition to enhancing creativity, the materials also increased students' learning motivation and awareness of local cultural values, making the learning process more meaningful and enjoyable. Future researchers are encouraged to develop ethnoscience-based materials for other physics topics or for different subjects, as well as to conduct follow-up studies to assess the long-term impact of such materials on creativity and academic achievement. Regular evaluation and refinement of the materials should also be carried out based on feedback from teachers and students to ensure continued relevance, effectiveness, and alignment with evolving cultural and educational needs.

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