



Development of Water Filtration Teaching Aids Based on Local Materials on Dynamic Fluid Materials to Improve Science Process Skills of SMA Negeri 1 Ternate City Students

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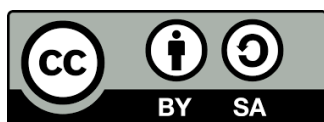
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Dynamic Fluid; Local Materials; Science Process Skills; Teaching Aids; Water Filtration.

Abstract

The limited use of contextual learning media in physics instruction may hinder students' understanding of dynamic fluid concepts and the development of science process skills. This study aimed to develop and evaluate a water filtration teaching aid based on local materials for learning dynamic fluid concepts at SMA Negeri 1 Ternate City. The study employed a Research and Development (R&D) approach using the ADDIE model, which consists of analysis, design, development, implementation, and evaluation stages. The teaching aid utilized locally available materials, particularly coconut fiber and activated carbon derived from coconut shells. Product feasibility was assessed by material, media, and language experts, while practicality was evaluated through teacher and student responses involving 20 students. The results showed that the teaching aid obtained an average expert validation score of 93.3%, indicating a highly feasible category. Teacher and student responses reached 92.5% and 88.5%, respectively, demonstrating highly positive acceptance. Students' average science process skills scores increased from 48.5 on the pretest to 85.6 on the posttest, with an N-gain score of 0.72, categorized as high. These findings indicate that locally based water filtration teaching aids are feasible, practical, and potentially effective in improving students' science process skills in dynamic fluid learning.



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INTRODUCTION

Education is a conscious and planned effort to create a learning environment and learning process that enables students to actively develop their potential. Based on this principle, learning is not merely the delivery of information but also involves empowering students to construct their own knowledge so that they are able to think critically and solve problems (Totalia et al., 2015:3).

However, based on the results of initial observations at SMA Negeri 1 Ternate City, physics learning on dynamic fluid materials was still dominated by lecture-based methods with limited use of learning media. As a result, students' science process skills, such as observing, classifying, and drawing conclusions, had not developed optimally. Among the interviewed students, 80% stated that they experienced difficulties in understanding fluid concepts. One effort to address this issue was the development of water filtration

teaching aids based on local materials as learning media to improve the science process skills of students at SMA Negeri 1 Ternate City (Fajarianingtyas et al., 2025; Firdaus et al., 2025; Hafiz et al., 2025; Marlina et al., 2025; Prayogo et al., 2024).

Learning physics requires a systematic scientific investigation process. Physics is both a process and a product. A process refers to procedures used to discover physical products in the form of facts, concepts, theories, and laws through scientific steps (Indrawati, 2011:5). Along with developments in science and technology, scientific investigation processes have been systematically structured. Therefore, individuals conducting scientific investigations need to possess skills related to the scientific process, known as science process skills (Akben, 2015; Dolapcioglu & Subasi, 2022; Ekici & Erdem, 2020; Gizaw & Sota, 2023).

Science process skills are fundamental, experimental, and systematic skills that form the foundation of science (Limatahu, 2019). These skills are important for both teachers and students to understand and develop (Limatahu et al., 2018; Yunita et al., 2017; Limatahu, 2019). Therefore, students learning physics should not only memorize and understand concepts discovered by scientists but also develop the ability to think and act like scientists in discovering concepts independently (Limatahu & Rahman, 2020:17). Students use science process skills as basic abilities to master physics concepts (Prayitno et al., 2017; Penis & Baykara, 2014). These skills can be developed through learning activities based on scientific approaches (Ramli, 2017; Penis & Baykara, 2014).

Science process skills are among the essential characteristics of physics learning because they support students in solving problems through scientific investigations. In this study, students' science process skills in dynamic fluid topics were trained through the use of water filtration teaching aids based on local materials as learning media. These activities enabled students to conduct experiments, construct concepts, and identify scientific facts in physics learning (Banda & Nzabahimana, 2021; Chiu et al., 2015; Hamed & Aljanazrah, 2020; Husnaini & Chen, 2019; Wang et al., 2015).

To develop these skills, students require learning media that are realistic and concrete. One appropriate teaching aid to address this problem is a simple water filtration device. This teaching aid can clarify the water filtration process, particularly in the learning of dynamic fluid concepts. Through the development and use of this filtration teaching aid, students have opportunities to directly observe the filtration process, identify concepts, and understand scientific principles based on their own observations. For example, students can recognize the function of each material used in water filtration and observe the characteristics of the resulting filtered water. Therefore, the water filtration teaching aid can serve as supporting media in physics learning and potentially improve students' science process skills.

Based on this background, the researcher proposed an alternative solution entitled "Development of Water Filtration Teaching Aids Based on Local Materials on Dynamic Fluid Materials to Improve Science Process Skills of SMA Negeri 1 Ternate City Students." This teaching aid was developed to support the achievement of learning objectives related to environmental pollution solutions, in accordance with Basic

Competency (KD) 4.8, which involves developing written ideas for solving environmental pollution problems based on observation results.

Based on the background described above, the research problems were formulated as follows: (1) What is the validity level of simple water filtration teaching aids for dynamic fluid materials at SMA Negeri 1 Ternate City? (2) How practical are the simple water filtration teaching aids for dynamic fluid materials? (3) How do students respond to the use of simple water filtration teaching aids for dynamic fluid materials?

Based on the research problems, the objectives of this research and development study were as follows: (1) to describe the validity of simple water filtration teaching aids for dynamic fluid materials at SMA Negeri 1 Ternate City; (2) to describe the practicality of carbon-based water filtration teaching aids for dynamic fluid materials; and (3) to describe students' responses to simple carbon-based water filtration teaching aids for dynamic fluid materials.

The product specifications developed in the form of simple water filtration teaching aids were as follows: (1) a simple water filtration teaching aid designed for senior high school students; (2) a teaching aid that supports learning of dynamic fluid materials; and (3) a teaching aid developed using simple designs and locally available or recycled materials from the surrounding environment.

Based on this research, it is hoped that it can be useful theoretically and practically, namely as follows:

1. Theoretical Benefits

Theoretically, the researcher developed teaching aids in the form of carbon water filtration devices in order to increase the insight of SMA Negeri 1 Ternate City students and can be useful in learning to improve students' science skills process.

2. Practical Benefits

The benefits obtained in developing carbon water filtration props include the following:

a. For Students

The development of water filtration teaching aids is expected to help students in improving student learning outcomes and psychomotor skills so that students understand the material better. In addition, it trains students in utilizing used items to be used as learning media.

b. For Teachers

The benefits for teachers in research on the development of water filtration teaching aids are expected to be an alternative medium for science teachers, especially to help in the learning process. This water filtration is expected to help motivate teachers in developing media from used materials, so that they are not only fixated on the media in the school laboratory.

c. For Schools

The development of water filtration props is expected to be able to become a medium from used materials that support school laboratory equipment. In addition, it can help to help improve the science learning process so that it is expected to improve

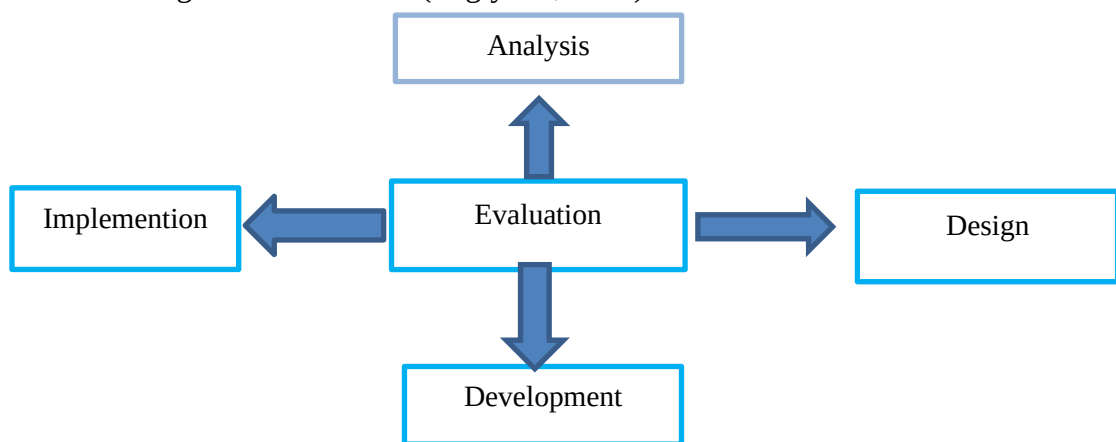
d. For Researchers and Other Researchers

Research on the development of simple water filtration can be a learning experience so as to increase the knowledge and experience of researchers. In addition, in the future, it is hoped that it can be a reference and comparison for researchers in developing simple water filtration teaching aids

METHOD

Development Methods

This study employed a Research and Development (R&D) approach to develop and evaluate a product. The developed product was a water filtration teaching aid based on local materials for dynamic fluid learning, designed to improve the science process skills of senior high school students (Sugiyono, 2019).



Development Procedure

This study uses the development of a water filtration tool based on local materials on dynamic fluid materials in this study using the *ADDIE model (analysis, design, development, implementation and evaluation)*

Tahap *analysis*

Analyzing the need for learning media and the potential utilization of local coconut waste in Ternate.

Needs Analysis

The analysis carried out includes the curriculum and characteristics of physics learning and the analysis of student characteristics.

Design stage

Designed a prototype of a water filtration KIT that uses a combination of fiber and activated carbon of coconut shells.

Implementation Stage

Testing the physical characteristics (porosity and discharge) of carbon materials and coconut fibers.

Produce KIT products that have been validated by experts (materials and media).

Evaluation Stage

Testing the effectiveness of the use of the filtration KIT in improving the Science

Process Skills of grade XI students at SMA Negeri 1 Ternate City.

Product Trials

Test design

Product trials are very important to obtain data so that they can be used. Therefore, it is necessary to conduct targeted trials of the developed products, before being tested, dynamic fluid material products are validated first by material experts, media experts, and language experts. Product feasibility tests as well as comments and suggestions so that they can be used as a better picture

Data subjects

In this development research, it consists of several test subjects including lecturers who are media experts, material experts, linguists and teachers of physics subjects at SMA Negeri 1 Kota Ternate as early users of water filtration tools and representatives of 20 students at SMA Negeri 1 Kota Ternate to be tested.

Data Type

The data used in this development research is

Qualitative data

Qualitative data that can be obtained by entering validators, media experts, material experts and language experts. In the form of suggestions and comments for the resulting products

Quantitative data

Quantitative data is data in the form of numbers, quantitative data in this development research is in the form of assessment scores of validators of material experts, media experts and linguists for the products produced, digital literacy data and student learning outcomes.

Data Collection Techniques

The data collection techniques in this study are in the form of questionnaires and learning outcome tests. Validation sheets are submitted to media experts, material experts and linguists to assess the teaching aids which aim to test the feasibility of water filtration teaching aids based on local materials, both in terms of graphic, local materials, language feasibility, content feasibility, and feasibility of questions on dynamic fluid materials in high school students. Testing the level of validation of water filtration teaching aids is carried out by selecting expert validators who master competencies in accordance with the instrument, in this case three media expert lecturers, three lecturers who are subject matter experts, and three language expert lecturers. Meanwhile, the response questionnaire of students and teachers is carried out by giving a set of questions or written statements to respondents which aim to see the response of water filtration teaching aids in terms of aspect and presentation.

Table 1. Validity Criteria

Data Type	Data Collection Techniques	Instrument Type
Water filtration props product validation data	Not your	Validation sheet
Digital literacy data	Tests	Quiz
Student learning outcome data	Tests	Test questions
Teacher's response	Not your	Questionnaire
Student responses	Not your	Questionnaire

Trial questions

Validation is a concept to the extent to which the test has measured what should be measured. To test the validity of the measuring tool using the *biserial formula*, the biserial point is chosen on the grounds that the variable question item in the aspect of knowledge is dichotomous, namely the form of multiple-choice questions where the correct question is given a number (1) and the wrong one is given a number (0). Biserial correlation is determined using an equation formula

$$Ppbi = \left(\frac{Mp - Mq}{St} \sqrt{pq} \right)$$

With biserial point correlation decision-making, that is, if the validity coefficient ≥ 0.30 , then the question item is valid. Meanwhile, if the coefficient < 0.30 , then the question item is invalid (Surapratnata, 2005). Based on the trial question with 15 trial participants, the following data was obtained,

Technical Data Analysis

The technical data used to determine the quality of the products produced by the data is used in the form of responses given to experts, science teachers and also students who will be analyzed using descriptive and quantitative methods.

Analysis of validation data

The analysis of the validator is quantitative descriptive, which is obtained from filling out a questionnaire by a team of validators or experts is analytical data using the Likert scale, and for qualitative in the form of input suggestions and comments, from the validator for the perfection of the *e-book* of quantitative calculation data results using the Likert scale as follows.

This questionnaire data is obtained based on the calculation of the likert scale as shown in the following table:

Table 2. Practicality Criteria

Rating	Score
Very good/ strongly agree	5
Okay / agree	4
Pretty good	3
Unfavorable/disagree	2
Very unkind/very disagree	1

Presentation of validation results using calculations to obtain the following percentages

$$p = \frac{x}{\sum x} \times 100\%$$

Description :

p = number of presentations

x = the average number of skorts of validators

$\sum x$ = total number of ideal scores (Tiara, 2020:24)

Then after the calculation results are known, they are identified into categories according to table 3.

Table 3. Student & Teacher Response Criteria

Assessment stub	Skort range	Category
4	$91 \leq \text{score} < 100$	Highly feasible
3	$76 \leq \text{score} < 90$	Worthy
2	$60 \leq \text{score} < 75$	Quite feasible
1	≤ 60	Not eligible

(Yunita, 2019:174)

Student digital literacy data

Student digital literacy data is disseminated using *the google form link format* with the aim of seeing the improvement of students' digital literacy

This student's digital literacy data was obtained based on a quiz on *a google form* as in the table below

Table 4. KPS Assessment Criteria

Skort Range	Rating categories
0-20	Very Low
21-40	Low
41-60	Enough
61-80	Height
81-100	Very high

The presentation of students' digital literacy results can be calculated using the following equation

$$\frac{\text{skort perolehan}}{\text{skort maksimum}} \times 100$$

Student learning outcome data

Student learning outcomes are determined using *normalized gain* (fokaaya, quoted in Hake: 1998). By using the following formula.

$$<g> = \frac{\% < St > - \% < St >}{100 - \% < St >}$$

Where: Sf = War of War Skort Pretest

Si = war posttest

<g>= average amount

Table 5. Intrusion <g>

<g>	Category
(<g>)≥0.70	Height
0.70>(<g>)≥0.30	Medium
(<g>)<0.30	Low

Feedback from students and teachers

The data of the student and teacher response questionnaire was distributed to students and teachers with the aim of seeing the response of students and teachers to water filtration teaching aids in students of SMA Negeri 1 Ternate. With the assessment score used, namely:

Table 6. Assessment of Student and Teacher Responses

Assessment stub	Skort range	Category
1	Disagree	TS
2	Disagree	KS
3	Agree	S
4	Strongly agree	SS

The presentation of the results of the responses of students and teachers can be calculated using the following equations:

$$p = \frac{f}{N} \times 100\%$$

With p is the percentage number sought, f is the score acquisition and N is the maximum score. (Azmanita, 2019:13)

The calculated percentage assessment table obtained from the students' and teachers' responses to the questionnaire using the likert scale of the assessment category can be seen in the following table.

Table 7 Assessment of the Percentage of Student and Teacher Responses

Yes	Category	Value %
	Disagree	>60
	Pretty good	60-69
	Agree	70-79
	Strongly agree	80-100

(Putri, 2019:142)

RESULTS AND DISCUSSION

Development of Water Filtration Teaching Aids Based on Local Materials

The product developed in this study was a simple water filtration teaching aid designed to support learning on dynamic fluid concepts. The development process followed the ADDIE model, consisting of analysis, design, development, implementation, and evaluation. The analysis stage focused on identifying learning problems, student characteristics, curriculum requirements, and the potential use of locally available materials in Ternate.

The initial observation indicated that physics learning was still predominantly delivered through lecture-based instruction with limited use of concrete instructional media. In addition, approximately 80% of the interviewed students reported difficulties in understanding fluid concepts. These conditions indicated the need for instructional media that could help students observe physical phenomena directly and participate actively in the learning process.

At the design and development stages, the researchers produced a water filtration prototype using coconut fiber and activated carbon derived from coconut shells. These materials were selected because they are readily available in the local environment and can be integrated into learning activities related to fluid flow and filtration. The teaching aid was designed to allow students to observe water movement, identify the function of each filtration layer, conduct experiments, record observations, and draw conclusions based on the experimental results. This approach is consistent with the product development procedure described in the study.

The developed teaching aid therefore served not only as a visual learning medium but also as an experimental tool that enabled students to practice science process skills. Through direct interaction with the filtration system, students were expected to connect theoretical concepts of dynamic fluids with real-world environmental phenomena.

Expert Validation Results

Before implementation, the developed teaching aid was evaluated by material, media, and language experts. The validation process involved three validators for each area, in accordance with the research procedure.

Table 8. Expert Validation Results

Validation Aspect	Percentage	Category
Material Expert	94.0%	Highly Feasible
Media Expert	92.7%	Highly Feasible
Language Expert	93.3%	Highly Feasible
Average	93.3%	Highly Feasible

The results showed that the material expert assessment reached 94.0%, the media expert assessment reached 92.7%, and the language expert assessment reached 93.3%. The overall average validation score was 93.3%, placing the developed teaching aid in the highly feasible category.

The high score obtained from material experts indicates that the content and learning activities contained in the teaching aid were relevant to dynamic fluid concepts and consistent with the intended learning objectives. The media validation result also demonstrated that the physical design, presentation, usability, and integration of local materials were appropriate for classroom use. Meanwhile, the language validation score indicated that the instructions and supporting information were sufficiently clear and understandable for senior high school students.

According to the criteria applied in this study, scores ranging from 91 to 100 are classified as highly feasible. Therefore, the developed product met the required feasibility criteria and could proceed to the implementation stage.

These findings also suggest that the use of simple and locally available materials does not necessarily reduce the quality of instructional media. Instead, locally based learning materials can provide an additional contextual dimension because students are familiar with the resources used in the teaching aid.

Teacher and Student Responses

The practicality of the water filtration teaching aid was evaluated through teacher and student response questionnaires. The product trial involved a physics teacher and 20 students of SMA Negeri 1 Ternate City, consistent with the research design described in the methods section.

Table 9. Teacher and Student Responses

Respondent	Percentage	Category
Teacher	92.5%	Strongly Agree
Students	88.5%	Strongly Agree
Average	90.5%	Strongly Agree

The teacher response reached 92.5%, while the student response reached 88.5%. Both scores were within the strongly agree category based on the response assessment criteria used in the study.

The highly positive teacher response indicates that the developed teaching aid was considered easy to use, relevant to the learning material, and potentially applicable in classroom activities. The student response also demonstrated positive perceptions regarding the attractiveness, clarity, and usefulness of the teaching aid.

The high student response may be related to the concrete nature of the learning experience. Instead of only receiving explanations about fluid concepts, students could directly observe the movement and filtration of water through different materials. This type of activity can make abstract physics concepts easier to understand while encouraging greater student participation.

Furthermore, the utilization of coconut fiber and coconut shells provides practical advantages because these materials are inexpensive and relatively easy to obtain in the surrounding environment. This characteristic is consistent with the initial product specification, which emphasizes the use of simple, used, and locally available materials.

Improvement of Students' Science Process Skills

The effectiveness of the developed teaching aid was examined by comparing students' science process skill scores before and after learning. Students completed a pretest before implementation and a posttest after participating in learning activities using the water filtration teaching aid.

Table 10. Students' Science Process Skill Scores

Assessment	Mean Score
Pretest	48.5
Posttest	85.6
N-gain	0.72
N-gain Category	High

The average pretest score was 48.5, which was categorized as sufficient according to the science process skill assessment criteria. After the learning intervention, the average score increased to 85.6, which was categorized as very high. The N-gain score was 0.72, indicating a high level of improvement.

The study employed science process skill categories ranging from very low to very high, with scores of 81–100 classified as very high. In addition, an N-gain value of 0.70 or higher was categorized as high.

The increase from 48.5 to 85.6 indicates that students demonstrated substantial improvement after participating in learning activities supported by the water filtration teaching aid. This result suggests that direct experimentation can provide opportunities for students to actively engage in scientific processes rather than merely memorize physics concepts.

During the learning process, students were required to observe the filtration process, identify the function of the filtration materials, compare water conditions, collect information, interpret experimental results, and formulate conclusions. These activities are closely related to the development of science process skills.

The findings are consistent with the conceptual framework presented in the manuscript, which emphasizes that physics learning should involve systematic scientific investigation. Science process skills enable students to behave like scientists by observing, investigating, analyzing, and constructing concepts based on empirical evidence.

The relatively high N-gain may also be associated with the contextual nature of the teaching aid. Students interacted with materials that were familiar and readily available in their environment. Consequently, the learning process connected physics concepts with everyday phenomena, making the learning experience more meaningful

Overall Effectiveness of the Developed Product

Based on the three main evaluation components, the developed water filtration teaching aid demonstrated positive results. Expert validation produced an average score of 93.3%, indicating that the product was highly feasible. Teacher and student responses reached 92.5% and 88.5%, respectively, demonstrating high practicality and acceptance. Furthermore, students' science process skills increased substantially, with an N-gain score of 0.72.

Taken together, these findings indicate that the water filtration teaching aid based on local materials has the potential to support dynamic fluid learning in senior high schools. The product combines conceptual physics learning, scientific experimentation, utilization of local environmental resources, and practical learning activities in a single instructional medium.

The use of local materials also adds an environmental education dimension to the learning process. Students not only study the principles of dynamic fluids but also learn that materials found in their surroundings can be utilized for educational and environmental purposes. Thus, the developed teaching aid may contribute to more contextual and environmentally relevant physics learning.

Nevertheless, the implementation involved only 20 students at SMA Negeri 1 Ternate City. Therefore, the results should be interpreted within the scope of this development trial. Future studies should involve larger samples, different schools, and experimental or quasi-experimental designs to determine the effectiveness of the product more comprehensively.

CONCLUSION

This study successfully developed a water filtration teaching aid based on local materials for dynamic fluid learning using the ADDIE model. The teaching aid utilized coconut fiber and activated carbon derived from coconut shells to provide students with a concrete, contextual, and environmentally relevant learning experience. The product obtained an average expert validation score of 93.3%, consisting of material validation of 94.0%, media validation of 92.7%, and language validation of 93.3%, indicating that the teaching aid was highly feasible for use in physics learning. Teacher and student responses reached 92.5% and 88.5%, respectively, demonstrating high levels of acceptance and practicality. Furthermore, students' average science process skills scores increased from 48.5 on the pretest to 85.6 on the posttest, with an N-gain score of 0.72, categorized as high. These results indicate that the developed water filtration teaching aid had the potential to improve students' science process skills while supporting contextual understanding of dynamic fluid concepts. Therefore, the teaching aid could be used as an alternative instructional medium in physics learning, although further testing involving larger and more diverse samples is recommended.

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