

Development of a Water Filter STEM Kit with the Addition of Cassava Peel as a Support Medium for the P5 Program Theme of Sustainable Lifestyles

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Abstract

Environmental problems and low awareness of water quality management have become important issues in daily life. On the other hand, 21st-century education requires students to possess 6C skills (critical thinking, creativity, collaboration, communication, character, and citizenship), making contextual learning based on real environmental problems essential. The STEM (Science, Technology, Engineering, and Mathematics) approach is considered relevant in addressing these demands by integrating multiple disciplines through applied learning activities. This study aimed to develop a learning support medium in the form of a STEM Water Filter Kit utilizing cassava peel waste as one of the filtration media. The research employed a Research and Development (R&D) method adapted from the Borg and Gall development model, consisting of seven stages: identification of potential and problems, data collection, product design, design validation, design revision, product testing, and product revision. Expert validation involved STEM education experts consisting of lecturers and teachers, resulting in an overall percentage score of 98.37%, categorized as very feasible. User response testing involved teachers, who obtained a percentage score of 94.56% categorized as very feasible, and students, who obtained a percentage score of 85.00% categorized as feasible. The results indicate that the STEM Water Filter Kit can be used as a STEM-based learning support media to help students understand water filtration concepts contextually.

Keywords: STEM Learning, Learning Media, Water Quality, Water Filtration, Waste Utilization

INTRODUCTION

Water is a vital substance for living things and is essential for survival. Humans use water for many activities, including bathing, drinking, washing, cooking, and other purposes (Elystia et al., 2023). Water quality standards must meet the raw water standards stipulated in Government Regulation of the Republic of Indonesia Number 20 of 1990 concerning Water Quality Classification (Novia et al., 2019). According to Yasin et al. (2024), various infectious diseases, such as typhus, cholera, and diarrhea, can potentially arise due to water quality that does not meet health standards.

This can occur due to the difficulty of obtaining clean water and the low level of public understanding regarding water treatment, forcing people to use available water for their daily needs (Elystia et al., 2023). The water treatment process aims to eliminate toxic substances, particles, and microorganisms and can utilize a simple water filter method with the use of certain selected media (Hoerunnisa et al., 2021). According to Purnaini et al. (2022) simple technology is considered low cost, environmentally friendly, and easy to use.

The water filter developed in this study uses charcoal as activated carbon made from cassava peel waste. According to Kosim et al. (2022), cassava peel waste was chosen due to its abundance in Indonesia, but its underutilization. Cassava is one of Indonesia's largest food commodities, possessing activated carbon for adsorption processes with high adsorption capacity. However, activated carbon prices are quite high, necessitating an economical alternative.

According to data from the Serang Regency Central Statistics Agency (BPS) (2024) found that Pontang District is one of the districts located within Serang Regency. Furthermore, Lebak Wangi District is also part of Serang Regency (BPS Serang Regency, 2021). A needs analysis conducted at a high school in Pontang and Lebak Wangi Districts revealed that the water quality in the school environment was experiencing problems, such as poor clarity, cloudy to brownish color, a brackish taste, and a metallic odor. Awareness of the importance of water treatment for students is also still relatively low and there is no use of STEM media in learning that can be implemented in P5 on the theme of Sustainable Lifestyle.

The STEM approach presents itself as a relevant learning alternative in the 21st century (Al Idrus, 2022) and its implementation supports the Independent Curriculum policy (Farwati et al., 2021). The Pancasila Profile Strengthening Project (P5) is a project-based co-curricular activity to shape the competencies and character of Pancasila student profiles (Maulida & Tampati, 2023), one of which is through the theme of Sustainable Lifestyle (Nursalam & Suardi, 2022). Therefore, the development of a STEM KIT water filter with the addition of cassava peels can be a supporting medium for the P5 program with the theme of Sustainable Lifestyle and provide innovation through the integration of STEM concepts with practical media in the form of Integrated Instrument Components (KIT) in learning.

METHOD

This study employed a Research and Development (R&D) approach using an adaptation of the Borg and Gall development model described by Gustina et al. (2024). The development process comprised seven stages: (1) identification of potential and problems, (2) data collection, (3) product design, (4) design validation, (5) design revision, (6) product testing, and (7) final product revision. These stages were selected to develop and evaluate the STEM Water Filter Kit as a supporting instructional medium for the Pancasila Student Profile Strengthening Project (P5), particularly within the sustainable lifestyle theme.

The initial stages focused on identifying instructional needs and collecting information to inform product design. The proposed design was then evaluated by experts and revised

based on their feedback. Subsequently, product testing was conducted to obtain teacher and student responses to the developed medium. These responses informed the final product revision. Thus, the study extended beyond design revision to include product testing and final revision, whereas broader implementation trials and mass production were outside its scope.

RESULTS AND DISCUSSION

Results of Potential and Problem Exploration

The development of a STEM water filter kit with the addition of cassava peel charcoal is based on the potential and real problems in schools and the surrounding environment. The water quality conditions in several areas of Serang Regency, particularly in Pontang and Lebak Wangi Districts, pose challenges for the local community, with water characteristics that are brownish, brackish, and have an iron smell based on observation and needs analysis. This problem is exacerbated by low public awareness of the importance of water quality for health, leading to a tendency to use available water without first undergoing a purification process (Elystia et al., 2023). These conditions do not meet the government's raw water standards as stipulated in Government Regulation No. 20 of 1990, which covers physical, chemical, and biological aspects, including that water must be clear, odorless, and tasteless, have a TDS level below 1,000 mg/L, normal water temperature, and neutral acidity (pH 7) (Novia et al., 2019). Therefore, water treatment through filtration is considered a relevant method to reduce contaminants and harmful microorganisms (Hoerunisa et al., 2021).

The use of commercial filtration media is often constrained by relatively high prices, while Indonesia has abundant agro-industrial waste potential that has not been optimally utilized, one of which is cassava peel waste (Kosim et al., 2022). Pontang District in Serang Regency is an area with fairly high cassava production, which, based on data from the Serang Regency BPS, experienced an increase in production in 2021–2023 (Arianto et al., 2025). Cassava peel, which accounts for about 16% of the weight of the tuber (Suprabawati et al., 2018) and has a high carbon content of about 59.31% (Ariyani et al., 2017), has great potential to be used as economical and environmentally friendly activated carbon in the water filtration process.

Data Collection Stages

The issue of clean water needs and the potential that has been described shows that meeting clean water needs can be pursued through education. This is according to Novia et al. (2019), who state that water treatment technology can be adapted to the socio-cultural, economic, and human resource capacity of the local community. According to Suwardi (2021),

developing high-quality human resources can be achieved by improving the quality of education. In line with current conditions in the context of 21st-century education, experts have put forward the concept of 6C skills, which include critical thinking, collaboration, communication, creativity, citizenship/culture, and character education/connectivity (Anugerahwati, 2019).

STEM learning is one of the most relevant types of learning today (Al Idrus, 2022), and it has been reinforced by positive responses from students because it is considered to help them develop effective problem-solving skills (Triwulandari et al., 2023). The education system in Indonesia has developed in line with the demands of the times through the implementation of the Merdeka Curriculum, which is designed to face the 5.0 era (Manalu et al., 2022). According to Barlian et al. (2022), this curriculum has the characteristics of project-based learning that is oriented towards strengthening soft skills and character building in accordance with the Pancasila Student Profile.

The Pancasila Student Profile Strengthening Project (P5) is a project-based co-curricular activity that aims to achieve the competencies and character of the Pancasila Student Profile in accordance with the Graduate Competency Standards (Maulida & Tampati, 2023). In the Merdeka Curriculum, there are seven project themes, one of which is the theme of sustainable lifestyles (Nursalam & Suardi, 2022), which is relevant to the problem of clean water quality that is still faced today (Yasin et al., 2024). The needs analysis conducted shows that there is no specific program in schools related to water quality issues and that STEM-based learning media integrated into the P5 theme of Sustainable Lifestyle has not been implemented.

The curriculum analysis results show that P5 activities are included in the E phase of grade X with the theme of Sustainable Lifestyle, specifically in the sub-theme of Sustainable Water Resource Management. STEM-based learning is a relevant alternative in facing the demands of the 21st century, and in the learning process, students need teaching aids in the form of Integrated Instrument Components (KIT) that not only present theory but also practical application (Nugroho & Suiyanah, 2018). Thus, this study combines the STEM concept in the P5 program through the development of learning media in the form of a simple water filter tool packaged in the form of a KIT as a supporting medium for the P5 program on the theme of Sustainable Lifestyle.

Product Design Stage

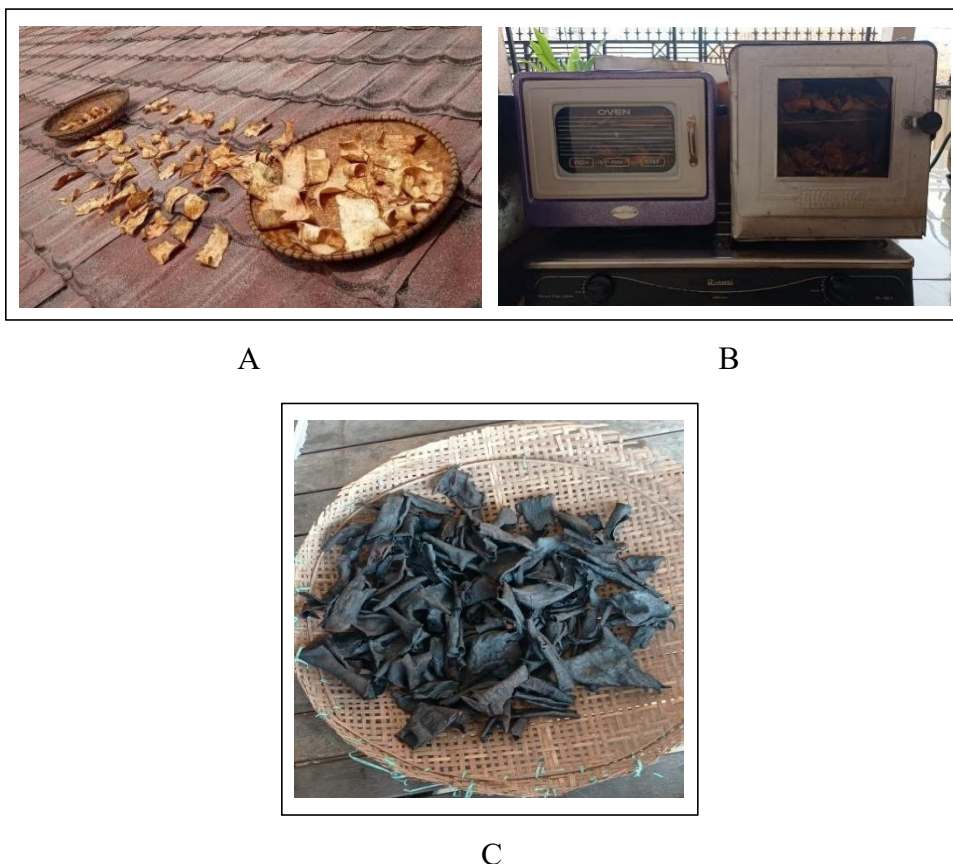


Figure 1. Making Cassava Peel Charcoal

Figure 1 shows the main process of making cassava peel charcoal, which consists of three main processes, namely drying (A), heating/carbonization (B), and cooling (C). The process of making cassava peel charcoal begins with preparing the necessary tools and materials, such as cassava peel waste, an oven, a gas stove, a tray/container, a knife, and a thick cloth.

The first step in making cassava peel charcoal is to peel the cassava from the tuber and outer skin, so that only the white skin in the second layer of the cassava is taken, which can be used to make the most effective charcoal. Cassava peel has a carbon content of 59.31% and contains protein, non-reducing cellulose, and crude fiber, with functional groups $-OH$, $-NH_2$, $-SH$, and $-CN$ that play a role in binding metal ions, making it potentially useful as an adsorbent in water filtration systems (Chitra et al., 2023). In water treatment practices, activated carbon is the most commonly used adsorbent because it has high absorptive capacity through the adsorption process between the adsorbent and adsorbate (Kosim et al., 2022).

Entering the drying stage, the cassava peel is then washed clean and dried in the sun for 2–3 days to 5 days until completely dry (Lutfia & Nurhayati, 2022). After the drying stage is

complete, the process continues with carbonization through combustion to produce activated carbon, which is a porous solid material containing approximately 85–95% carbon and formed through heating with a very limited supply of oxygen (Monarita et al., 2022). Burning is carried out by placing the cassava peel in an oven over a stove with medium to high heat for 45–60 minutes until it turns into dark black charcoal.

Carbon will have more optimal absorption capabilities after undergoing the activation process and is characterized by its black color, odorlessness, and tastelessness (Ariyani et al., 2017). The cassava peel charcoal is then removed from the oven, transferred to a heat-resistant container, cooled naturally, and stored in an airtight container to prevent moisture and mold growth. After the entire process is complete, the cassava peel charcoal is used as one of the filter media in the STEM KIT Water Filter, as shown in Figure 2.



Figure 2. Realization of the STEM KIT Water Filter Design (Left: Water Filter; Right: Water Filter Media)

The water filter components consist of a funnel, a four-layer filter tube, filtration media, and a container to collect the filtered water. The first layer uses zeolite to absorb chemical pollutants and reduce water pollution levels (Elianti et al., 2022), the second layer consists of cassava peel charcoal as activated carbon which functions to remove odors, tastes, colors, and pollutants (Purwanti et al., 2021), the third layer uses beach sand to bind Fe, Mn, and sulfide (Firmansyah & Sihombing, 2022), and the fourth layer consists of silica sand to filter sludge and sediment (Nur et al., 2020). Each layer is equipped with an aquadine sponge to capture fine particles (Ferdi et al., 2022), while the container lid serves as a connector between the filter tube and the filtration container. Once completed, the STEM KIT Water Filter is

packaged in a transparent KIT box (Figure 3). The KIT box serves to keep the components intact and is made transparent to support more meaningful visual learning (Nurfadillah et al., 2021).



Figure 3. STEM KIT Water Filter Box (Front and Top Views of the Water Filter STEM Kit)

As a complement to the product, the development of the STEM KIT Water Filter also includes a user manual to facilitate users and provide instructions for using the STEM KIT Water Filter, with examples of the manual contents as shown in Figure 4.

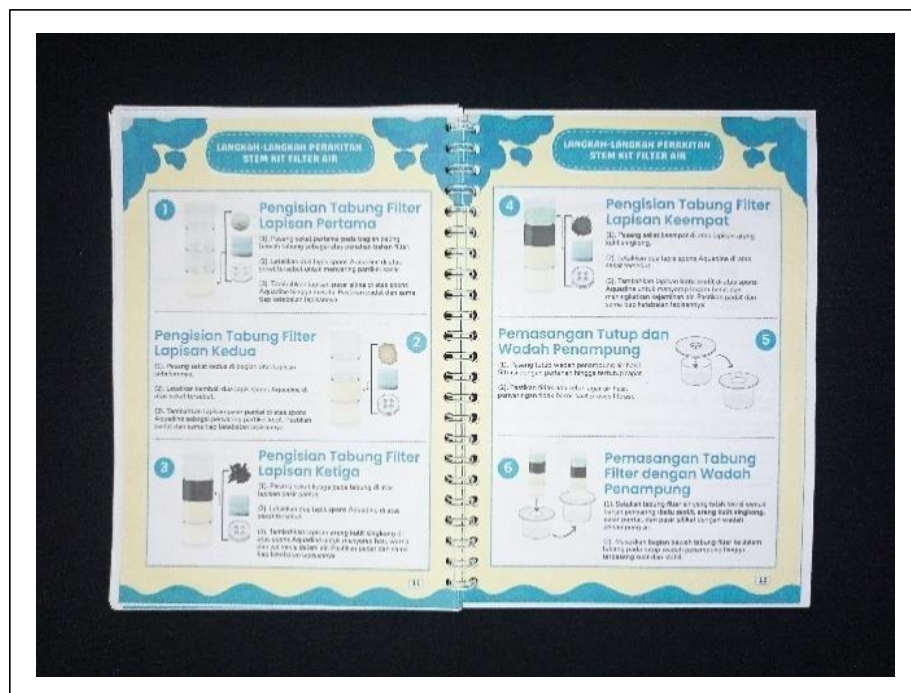


Figure 4. Contents of the User Manual: “Steps for Assembling the STEM Water Filter KIT”

The STEM KIT Water Filter User Guide contains an introduction that explains the background of product development, including water quality issues, the use of cassava peel waste, and solutions through the STEM KIT Water Filter as a supporting medium for the P5 Program on Sustainable Lifestyle. This guidebook also contains the objectives and benefits of using the STEM KIT Water Filter to provide an understanding of water filtration concepts,

environmental pollution issues, and integrated STEM-based learning experiences. Additionally, the guidebook includes the concept of the STEM KIT Water Filter, a list of tools and materials, steps for making cassava peel charcoal, assembly and use of the tool, use of a TDS meter, tool maintenance, experimental activities, case studies and reflections, conclusions, and a bibliography.

Analysis of Data Processing for STEM Learning Expert Tests and User Response Tests

The validation stage in the development of water filter media was conducted to obtain assessment scores from STEM learning experts. The criteria for scoring can be seen in Table 1.

Table 1. Criteria for Feasibility Test Scoring by STEM Learning Experts

Criteria	Score
Exactly without notes	3
Exactly with notes	2
Inappropriate	1

Modified from Sugiyono (2017)

User Response Test Data Analysis

Analysis of user response test data using the Likert scale. The Likert scale was chosen with the criteria “Strongly Agree”, “Agree”, “Disagree”, and “Strongly Disagree” with scoring criteria as shown in Table 2.

Table 2. Criteria for User Response Test Scoring

Criteria	Score
Strongly Agree	4
Agree	3
Dissagree	2
Strongly Agree	1

After the data is scored on each aspect of the criteria that has been assessed, the data results are calculated as a percentage using the following formula to calculate the percentage value obtained.

$$NP = \frac{R}{SM} \times 100\%$$

(Karnia et al., 2022)

The percentage data obtained was then categorized into assessment criteria for testing the feasibility of developing the media. The assessment criteria for testing feasibility can be seen in Table 3 (Rahmatullah et al., 2020).

Table 3. Criteria for Interpreting Expert Assessment and User Response Assessment

Score (%)	Description
86 - 100	Very Feasible
76 – 85	Feasible
60 – 75	Fairly Feasible
55 – 59	Less Feasible
0 – 54	Unfeasible

Design Validation Stage

Based on the assessment results from the three experts who tested and evaluated the feasibility of the STEM KIT Water Filter development product, the product feasibility percentage score was 98.37% with a category of highly feasible, which was obtained from the accumulation of the scores for all aspects assessed by the STEM learning experts.

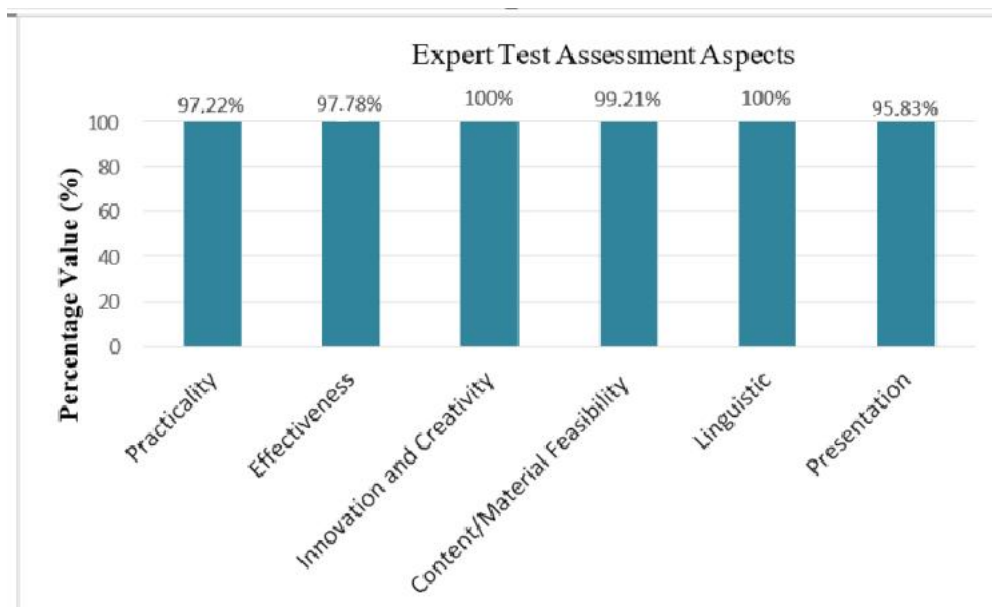


Figure 5. Assessment Aspects of the STEM KIT Water Filter Expert Test

a. Practicality

The practicality aspect assesses the ease of use of the product (Abdollah et al., 2022), and the STEM Water Filter KIT scored 97.22% with a very feasible criterion, indicating a very high ease of use in school learning. The product was assessed as meeting practicality indicators, including ease of use, safety, feasibility of implementation, and availability of materials, so that it can be used by teachers and students without special skills or complex equipment. Although there are notes for improvement in the illustrations and assembly instructions, this does not hinder the main function of the product and it is still considered safe and feasible to be applied in learning, in line with Abdollah et al. (2022) and Jannah et al. (2022) who stated that practicality is fulfilled if the product is easy to use and can be applied in real learning.

b. Aspect of Effectiveness

The effectiveness aspect of the STEM KIT Water Filter received a score of 97.78% with a rating of highly feasible, indicating the integration of product design with the objectives of Biology and P5 learning themes on Sustainable Lifestyles as well as time and process efficiency. The product was assessed as being able to facilitate understanding of the concept of water filtration and foster environmental awareness, with experts assessing that the user manual is very important to support the smooth and targeted use of the tool. These results are in line with Bakara (2023) that good learning media must be effective, objective, and efficient, so that the STEM KIT Water Filter is declared very feasible in terms of effectiveness.

c. Aspects of Innovation and Creativity

The innovation and creativity aspects received a score of 100% with the criteria of highly feasible, which shows the high level of novelty of the STEM Water Filter KIT as a learning medium. Innovation is evident in the use of cassava peel waste as a filtration medium in the STEM-based KIT, while creativity is reflected in the design that encourages active student participation. All indicators were assessed as fulfilled without any notes for improvement, so the STEM Water Filter KIT was declared highly feasible in terms of innovation and creativity.

d. Content/Material Feasibility Aspects

The content/material feasibility aspect received a score of 99.21% with a very feasible criterion, because the material is in line with the theme of Sustainable Lifestyle, contextual, easy to understand, and supports the development of collaboration, creativity, independence, and critical thinking through experiment-based STEM learning. This result is in line with the opinion of Widiastika et al. (2021), who emphasized that learning media must be in harmony with learning objectives and supported by clear concepts. However, experts provided input on the integration of mathematics elements, which was not yet optimal, so improvements were made during the design revision stage.

e. Linguistic aspect

The linguistic aspect received a score of 100% with a very feasible criterion, indicating that the use of language in the guidebook and supporting components was in accordance with Indonesian language rules, clear, consistent, and easy to understand without any notes for improvement. This finding is in line with Amini et al. (2021), who stated that good and appropriate language in learning media plays an important role in supporting understanding and the smoothness of the learning process.

f. Presentation aspect

The presentation aspect received a score of 95.83% with a very good rating, indicating that the structure, material flow, and appearance of the Water Filter STEM KIT have been arranged systematically and attractively. However, experts provided input regarding the clarity of the illustrations of the work steps and the strengthening of visuals to make them more effective. This is in line with the opinion of Agustina et al. (2020), who stated that learning media needs to be designed in a sequential and visual manner so that it can be used optimally in supporting the learning process.

Design Revision Stage

Based on the results of design validation by STEM learning experts involving two lecturers from a Public University and one teacher from a Public Senior High School in Serang, Indonesia, several inputs were obtained for the improvement of the STEM Water Filter KIT, including clarity of visual illustrations for assembly, instructions for use, strengthening of mathematics elements in the usage process, and the addition of tools to facilitate the adjustment and removal of tube partitions. These improvements aim to increase the ease of understanding and use of the product. This is in line with Okpatrioka's (2023) opinion that product revisions are necessary to produce a more optimal final product.

Before Revision	After Revision
 Pengisian Tabung Filter Lapisan Ketiga (1). Pasang sekat ketiga pada tabung di atas lapisan pasir pantai. (2). Letakkan dua lapis spons Aquadine di atas sekat tersebut. (3). Tambahkan lapisan arang kulit singkong di atas spons Aquadine untuk menyerap bau, warna, dan zat kimia dalam air. Pastikan padat dan sama tiap ukuran lapisannya.	 Pengisian Tabung Filter Lapisan Ketiga (1). Pasang sekat ketiga pada tabung di atas lapisan pasir pantai. (2). Letakkan dua lapis spons Aquadine di atas sekat tersebut. (3). Tambahkan lapisan arang kulit singkong di atas spons Aquadine untuk menyerap bau, warna, dan zat kimia dalam air. Pastikan padat dan sama tiap ketebalan lapisannya.
 Pemasangan Tabung Filter dengan Wadah Penampung (1). Satukan tabung filter air yang telah berisi semua bahan penyaring (batu zeolit, arang kulit singkong, pasir pantai, dan pasir silika) dengan wadah penampung air. (2). Masukkan bagian bawah tabung filter ke dalam lubang pada tutup wadah penampung hingga terpasang kuat dan stabil.	 Pemasangan Tabung Filter dengan Wadah Penampung (1). Satukan tabung filter air yang telah berisi semua bahan penyaring (batu zeolit, arang kulit singkong, pasir pantai, dan pasir silika) dengan wadah penampung air. (2). Masukkan bagian bawah tabung filter ke dalam lubang pada tutup wadah penampung hingga terpasang kuat dan stabil.
The illustration is not clear enough on the part of the tube that needs to be filled with water filter media.	Illustration that has been corrected on the part of the tube that has been filled with water filter media
The assembly instructions illustration is still not clear enough.	Improved illustration with added instructions on assembly steps.

Figure 6. Revised Illustration of STEM KIT Water Filter Assembly

Revisions to Figure 6 were made to clarify the illustration of the STEM KIT Water Filter

assembly based on expert input, through adjustments to the sequence of steps, visual emphasis on components, and the addition of arrows as instructions. This is in line with Gustina et al. (2024), who stated that expert feedback is used to improve design weaknesses. This revision aims to make it easier for users to understand the assembly systematically.

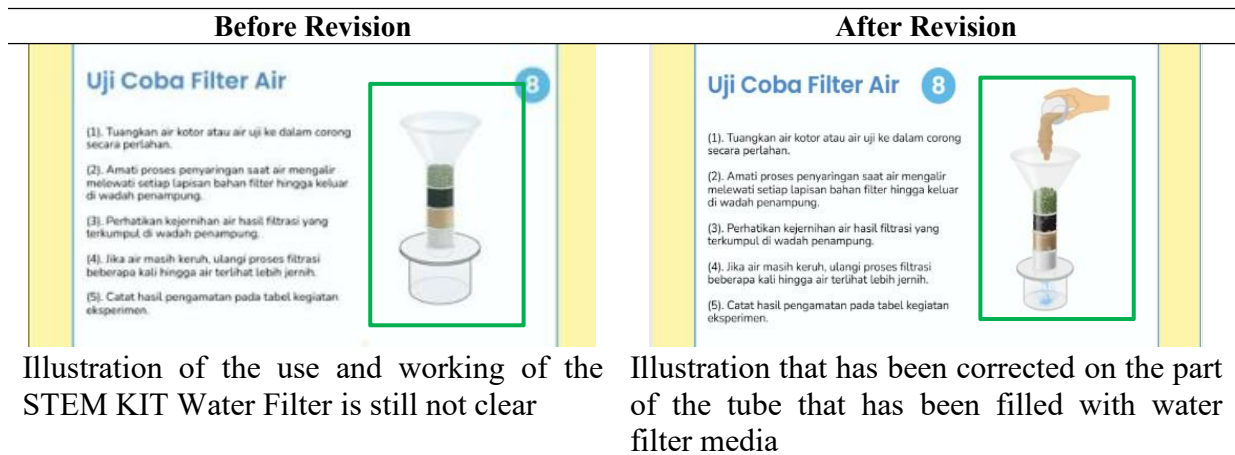


Figure 7. Revised Instructions for Using the STEM Water Filter KIT

Based on the results of design validation by STEM Education experts, the instructions for using the STEM Water Filter KIT were deemed unclear due to a lack of visual support. Therefore, in the revised design in Figure 7, visual illustrations were added showing the process of pouring dirty water and the flow of filtered water into a container. The addition of these illustrations aims to clarify the usage activities and minimize errors in operating the STEM Water Filter KIT.

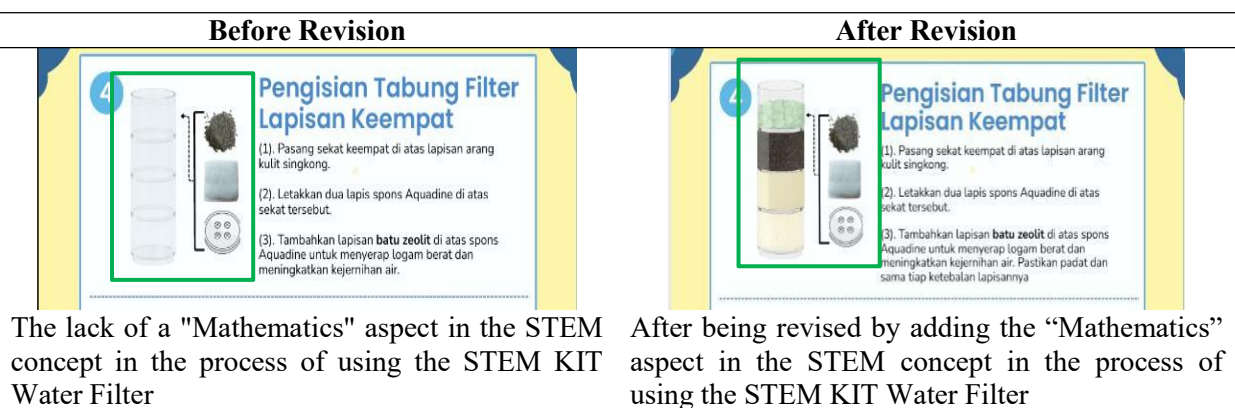


Figure 8. Revision of the "Mathematics" aspect in the STEM Concept in the Section on the Use of the STEM Water Filter KIT

Further input from experts on the Mathematics aspect shows that the integration of this element in the Water Filter STEM KIT still needs to be strengthened. In the initial design, the Mathematics aspect was not explicitly apparent in the learning activities. Therefore, the design was revised (Figure 8) by adding instructions for students to measure and ensure that the

thickness of each filter medium was the same as the capacity of the tube. This revision aimed to clarify the relationship between the use of the STEM Water Filter KIT and the application of STEM concepts, particularly Mathematics. The final form can be seen Figure 9.



Figure 9. Addition of STEM KIT Water Filter Tools

Based on expert validation results, there were obstacles in adjusting the position of the filter media partition because it was difficult to adjust by hand without tools. Therefore, a thin, curved tool was added to facilitate adjustment and maintain the position of the filter in the tube. The addition of this tool aims to make the assembly process more practical, neat, and stable as a form of design improvement so that the STEM KIT Water Filter can be used optimally.

Product Testing Stage

Based on the results of the user response test, two pieces of research data were obtained and presented in diagram form. The results of the user response test from teachers obtained a percentage score of 94.56%, which falls within the criteria of very feasible in general from all aspects of assessment.

1. Testing Teachers' Responses to the STEM Water Filter KIT Product

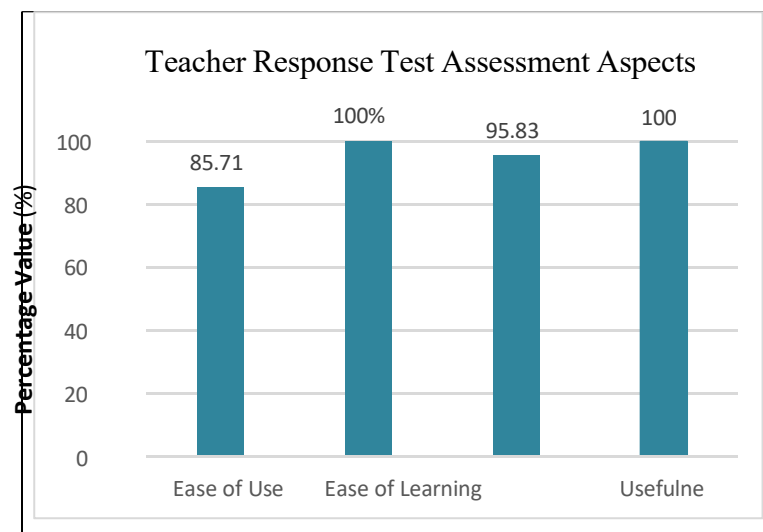


Figure 10. Teacher Response Test Assessment Aspects

a. Ease of use aspect

The results of the teacher response test to the Water Filter STEM KIT show that the ease of use aspect scored 85.71% with acceptable criteria. although there are still obstacles in installing and removing the tube partition that need to be improved in the product revision stage, in line with Wibisono et al. (2025) view that ease of use describes the level of comfort and ease of use of a product, as well as the feasibility criteria according to Rahmatullah (2020).

b. Ease of learning aspect

The ease of learning aspect scored 100% with a very feasible criterion, indicating that the STEM KIT Water Filter is easy to learn and effectively supports P5 learning on the theme of Sustainable Lifestyle through the integration of tools, guidebooks, and learning activities, in line with the opinion of Novita & Amelia (2019).

c. Satisfaction aspect

The satisfaction aspect scored 95.83% with a very feasible criterion, indicating a high level of teacher satisfaction with the media's functions, experiment results, and guidebook content, although there was feedback on the need to add water quality indicators as a reference for experiments, in line with the concept of user satisfaction proposed by Novita & Amelia (2019).

d. Usefulness aspect

The usefulness aspect received a maximum score of 100% with a very feasible criterion, confirming that the Water Filter STEM KIT is very useful as a contextual, applicable, and relevant learning medium for sustainable water management issues, as emphasized by Novita

& Amelia (2019) that product usefulness is the main indicator of suitability for user needs.

2. Testing Students' Responses to the STEM Water Filter KIT Product

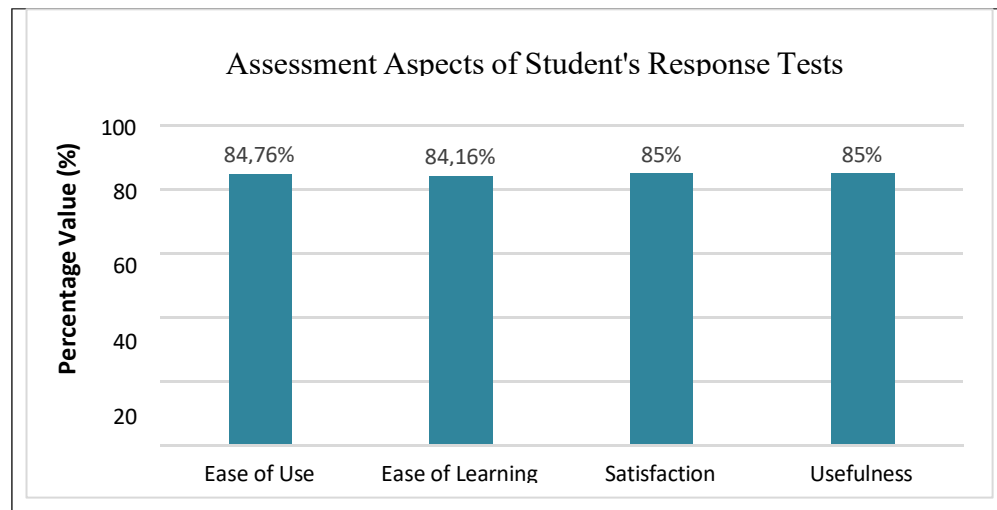


Figure 10. Testing Students' Responses to the STEM Water Filter Kit Product

a. Ease of use aspect

The results of the students' response test to the STEM Water Filter KIT show that the ease of use aspect scored 84.76% with a passable criterion, indicating that students found it relatively easy to understand the instructions and assemble and operate the tool, although there was feedback regarding the need for additional explanations on the use of the TDS meter, which should be emphasized more during the implementation stage, in line with the opinions of Wibisono et al. (2025) and Rahmatullah et al. (2020) criteria.

b. Ease of learning aspect

The ease of learning aspect scored 84.16% with a feasible criterion, indicating that the STEM Water Filter KIT is capable of supporting P5 learning on the theme of Sustainable Lifestyle in a concrete and contextual manner. However, it is not yet optimal because students are still in the adaptation stage of project-based learning and are not yet fully accustomed to reading and following the guidelines independently, as explained by Novita & Amelia (2019).

c. Satisfaction aspect

The satisfaction aspect scored 85% with a feasible criterion, indicating a positive response from students to the results of the experiments, visuals, and content of the guidebook, although satisfaction was not evenly distributed across all indicators of usage experience, in line with the concept of user satisfaction according to Novita & Amelia (2019).

d. Usefulness aspect

The usefulness aspect scored 85% and was considered acceptable, confirming that the Water Filter STEM KIT is considered useful in helping students understand the concept of

water filtration and relate it to real environmental issues through project-based learning. however, the perception of usefulness still needs to be deepened through habituation and further exploration, in accordance with Novita & Amelia (2019) views and Rahmatullah et al. (2020) assessment criteria.

Product Revision Stage

Product improvements were made based on the results of initial trials and suggestions and feedback from teachers and students as users of the STEM Water Filter KIT. This feedback was used as the basis for improving the product to make it more practical and efficient as a learning support medium. One of the obstacles encountered was the difficulty students had in installing and removing the filter media partition inside the filter tube, resulting in a less than optimal assembly process. Therefore, improvements were made by adding a special tool to the STEM Water Filter KIT. This tool makes it easier to adjust and remove the filter without using your hands directly, thereby improving the practicality and convenience of assembling and using the water filter (see Figure 11).



Figure 11. Pry Tool

Teachers' suggestions regarding the practicality of using the tool point to the need to add indicators of good water quality to the discussion of experimental activities in the guidebook (see Figure 12). Improvements were made by adding information about the characteristics of good water quality, including clarity, no odor and taste, maximum Total Dissolved Solids (TDS) limits, temperature, and acidity (pH). This addition aims to ensure that students not only carry out the water filtration process, but are also able to assess the filtration results in a more measurable and targeted manner.

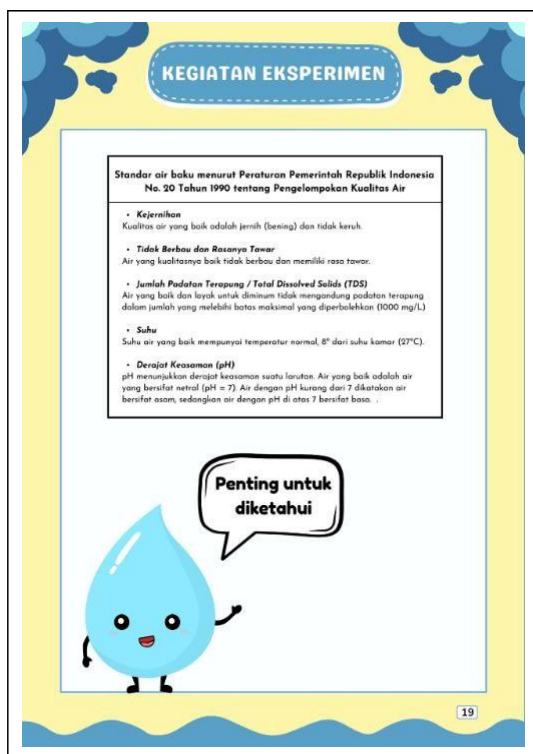


Figure 12. Teachers' Suggestions Regarding the practiAddition of Water Quality Indicators to the Water Filter STEM KIT User Manual

The STEM Water Filter Kit integrates science, technology, engineering, and mathematics through the use of cassava peel charcoal for water filtration and sustainable agricultural waste utilization. Science involves understanding particle retention and adsorption, including why improved water clarity does not necessarily indicate safe drinking water. Technology connects locally available materials with practical water treatment, while engineering provides opportunities to design, test, and refine filter configurations by considering material quantity, particle size, arrangement, and trade-offs between flow rate and filtration performance. Mathematics supports these decisions through measurements of water volume and filtration time, flow-rate calculations, and comparisons of results using tables or graphs. Together, these activities can support conceptual understanding by connecting observable outcomes with filtration mechanisms and provide opportunities to practice problem solving through prediction, evidence interpretation, and design revision. Expert validation (98.37%), teacher responses (94.56%), and student responses (85.00%) support the kit's suitability and user acceptance as a contextual STEM resource for the sustainable lifestyle theme; however, direct assessments are needed to establish improvements in conceptual understanding and problem-solving skills.

CONCLUSION

The STEM Water Filter Kit incorporating cassava peel charcoal received an expert

validation score of 98.37%, a teacher response score of 94.56%, and a student response score of 85.00%. These findings demonstrate favorable expert evaluations and positive responses from teachers and students, supporting its suitability as an instructional medium for the Pancasila Student Profile Strengthening Project (P5) under the sustainable lifestyle theme. The kit provides a practical learning resource that connects STEM concepts with water filtration and the utilization of agricultural waste. Through hands-on exploration, it offers opportunities for students to examine filtration mechanisms, consider sustainable uses of local materials, and practice problem solving in an environmental context. Further research is needed to establish its effectiveness in improving students' conceptual understanding and problem-solving skills.

SUGGESTIONS

This research was conducted up to the initial product trial stage, so that in subsequent research it can be continued to further development stages. The development of the Water Filter STEM KIT is intended as a supporting medium for the Independent Curriculum in the implementation of the P5 Program with the theme of Sustainable Lifestyle. Therefore, in subsequent research it is recommended to conduct a more in-depth curriculum analysis to determine the suitability of the learning materials with the applicable curriculum. In addition, the product being developed is still limited and testing only involved a limited number of teacher and student respondents, so that further research can optimize trials on a wider scale of respondents to obtain more comprehensive results.

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