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Development of a Recycled Materials Lab Kit for an Electrostatics Experiment

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Abstract

Lab kits play an essential role in supporting the learning process. This study aims to develop a feasible and practical physics experiment kit on static electricity from simple tools and materials. The static electricity lab kit was developed using the 4D model (define, design, develop, disseminate). The stages carried out in this study are only up to the third stage, namely development, because the output is in the form of lab kit products. The lab kit is made using simple tools and materials easily found in everyday life. The props can also be disassembled easily. Four physics teachers from different schools conducted validation of the lab kit. The validation results show that in terms of media, the lab kit has valid criteria, with a percentage of 98.08%. Regarding material, the lab kit also has valid criteria, with a percentage of 96%. Overall, the static electricity lab kit met valid criteria with an average percentage of 97.5%, showing that the lab kit could be disseminated directly to students. It is hoped that using this lab kit can help teachers explain the concept of static electricity and make it easier for students to understand it.

Keywords: 4D development; Home materials; Lab kit; Learning media; Static electricity

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INTRODUCTION

In substance, science is a body of knowledge, a way of thinking and investigating (Collette & Chiappetta, 1994; Haifaturrahmah, 2019; Vilmala & Mundilarto, 2019). According to Daryanto (2014) and Wahana (2016), science is the knowledge of the universe and all its contents and phenomena that occur in it. Physics is part of science that studies the properties and natural phenomena and their interactions, such as matter and energy, both microscopic and macroscopic (Rahayu, 2022).

Physics has several characteristics, namely (a) focusing on basic concepts, (b) applying theory to the real world, (c) understanding the interrelationships of concepts, (d) based on experiments, (e) using mathematical language, and (f) stimulating cognitive abilities. Based on these characteristics, the delivery of physics must be accompanied by appropriate supporting media. The most important thing in learning physics is using learning media to improve the delivery of material (Fitriah et al., 2020; Mulhayatiah et al., 2019).

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Lab kits are objects or media used to help convey information or concepts to others. In education, Lab Kits are often used as learning media to assist students in understanding a material or concept being taught (Pauji et al., 2021). The use of Lab Kits in the physics learning process has several objectives, namely (a) to make the learning situation more effective, (b) to accelerate the process of students' understanding of the material, (c) to provide stimulation to students to learn (Dachi, 2017).

Physics demonstration tools must be made following the established criteria to make the learning process more effective. According to Suprayitno (2011), the characteristics that need to be met in developing lab kit are (a) materials are easy to obtain, (b) easy to design and manufacture, (c) easy to use, (d) can demonstrate physics concepts well, (e) does not harm the user, (f) has good endurance, (g) is creative and innovative, (h) attracts and increases students' learning motivation, and (i) has educational value. The use of visual aids in learning physics has several advantages, namely (a) the learning process becomes more enjoyable, (b) students understand learning material more easily, and (c) it provides an attraction for students to learn (Murdiyanto & Yudi, 2011). The benefits of using visual aids in learning physics are (a) helping to visualize physics concepts, (b) making it easier for students to understand and remember concepts, (c) growing motivation to learn because learning becomes more interesting, (d) facilitating experiments, (e) reducing misconceptions physics material.

In the physics learning process, especially in several schools in Indonesia, teachers have yet to use learning media fully (Fartina et al., 2022; Fitriah et al., 2020; Kumalasari et al., 2022). This is because there are still limited facilities in schools and lab kits, which tend to be expensive (Fartina et al., 2022). The teacher only uses the school's lab kit; if there is none, then learning is carried out only by delivering material without props (Fajrin et al., 2021). This will affect students' understanding of the material (Darmaji et al., 2019). The teacher should create a physics lab kit with available materials (Malonzo et al., 2017; Malicoban & Castro, 2022). In addition to the low cost, a simple lab kit will make it easier for students to understand the material because it is directly related to materials or phenomena they often encounter daily (Joseph, 2015; Kaylene & Rosone, 2016). In addition to the low cost, a simple lab kit will make it easier for students to understand the material because it is directly related to materials or phenomena they often encounter daily. Through a simple lab kit, students can explore and find physics concepts independently without the teacher having to worry about equipment damage because the lab kit can be obtained easily (Sambite et al., 2019).

In physics learning, some material is abstract or cannot be seen directly. This kind of abstract material causes students to find it challenging to understand physics material. One of the abstract sub-materials of physics is static electricity because it discusses electrical charges that cannot be seen directly (Akmar et al., 2020). One solution to make static physics easier to understand is to provide an experiment kit to represent the possibility of static electricity.

Previous researchers have developed a lab kit for static electricity material. Cikanawati (2011) developed a static electricity prop to model the Rutherford atom using waste paper. Prelina (2015) developed teaching tools using environment-based atomic structure modeling in line with this. However, these two teaching aids only produce modeling of atomic shapes and cannot explain the phenomena of static

electricity. Ningrum (2022) also developed a static electricity demonstration tool as a simple electroscope. The tool developed can be used to determine the type of charge on an object but cannot show the phenomenon of static electricity in everyday life.

Based on several studies that have been carried out, teaching aids that can demonstrate static electricity phenomena are not yet available. To solve this problem, simple props must be developed to show the symptoms of static electricity. Therefore, researchers have developed static electricity props from simple materials.

METHOD

The electrostatic experimental kit was developed using Thiagarajan's 4D model research and development method. The 4D development model consists of four stages: Define, Design, Develop, and Disseminate (Thiagarajan, 1974). In this research, researchers only reached the development stage with outputs in the form of practical tools and have yet to reach the dissemination stage of the electrostatic experimental kit. The lab kit development flow diagram is shown in Figure 1.

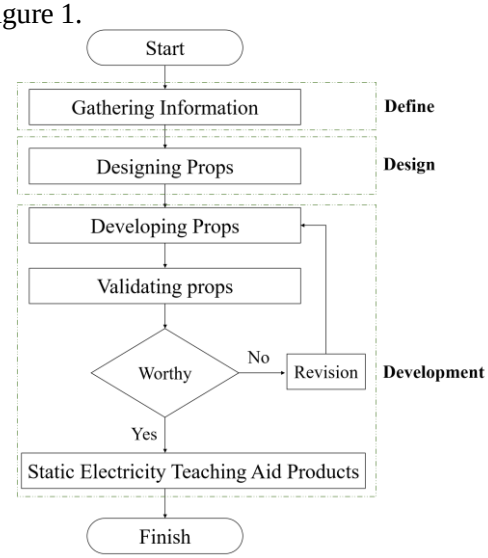

Figure 1 Lab kit development flowchart

The Define stage involves identifying problems or product needs that are the background to the need for developing a lab kit. This stage is carried out by studying literature and observation to analyze needs and review the material as a reference for developing a lab kit (Fajrin et al., 2021).

The Design phase involves designing the design along with the tools and materials needed to develop the product. The results of this stage are in the form of tool sketches and procedures for making a lab kit.

The development stage involves making tools based on the design stage. The results of this stage are in the form of a lab kit, which will later be validated. If the product results are not valid, improvements to the tool are made according to the suggestions from the validator so that the product can be validated.

The evaluation of this product is carried out by conducting validity tests by media experts and material experts. The validation technique is done by giving a questionnaire containing several statements and then being assessed based on a Likert scale. The Likert scale has five scales, each representing agreement with the statement given, as shown in Table 1 (Budiaji, 2013).

Table 1 Likert scale

Scale	Description
5	Strongly Agree
4	Agree
3	Undecided
2	Disagree
1	Strongly Disagree

The percentage of props assessment is determined by the equation:

$$P = \frac{\Sigma X}{N} \times 100\% \quad \ldots(1)$$

With:

P = Percentage of Product Value
ΣX = Total score
N = Maximum Score

(Suastika & Rahmawati, 2019; Sari et al., 2020)

Table 2 Lab kit validity criteria

No	Validity Value	Validity Level
1	$75\% \leq P \leq 100\%$	Valid
2	$P < 75\%$	Invalid

If the lab kit has a minimum validity level of 75%, then the lab kit is valid and can be used as a learning medium. However, if the lab kit does not meet the validity level (P<75%), it must go through the improvement stage to meet the minimum level and be used as a learning medium.

RESULT AND DISCUSSION

Define

Laboratory equipment supports learning (Jamian & Baharom, 2012; Ordu, 2021). According to Kumalasari's research (2022), teachers and students need lab kits in the physics learning process. Based on research conducted by Fitriah et al. (2020), lab kits can increase students' learning creativity; demonstrations can improve science process skills and students' understanding. In line with what was stated by Hidayah et al. (2018), lab kits can have a positive influence on students' learning abilities in the cognitive domain.

Besides that, according to Zaus (2018), static electricity physics material is included in abstract physics material, so it needs to be concretized with the help of media or an experiment kit. Therefore, it is necessary to have media or visual aids that can support the learning process of physics on static electricity material so that it is easier to understand.

Design

This developed electrostatic lab kit has a minimalist design, with the primary support using a lightweight PVC pipe. The supporting leg of the tool consists of three pieces of pipe connected by an L joint, which is 48 cm high and 14 cm wide. For the support to stand in balance, the bottom of the support is connected with a T-connector. On top of the T-connection, a piece of GRC board is placed in the shape of a rectangle with a size of 10 cm x 15 cm. Sketches of the props for front and side views are shown in Figures 2 and 3.

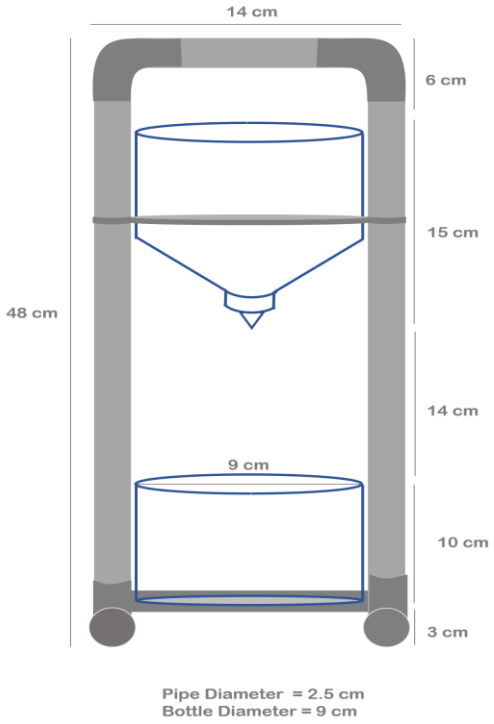

Figure 2 Front view of props sketch

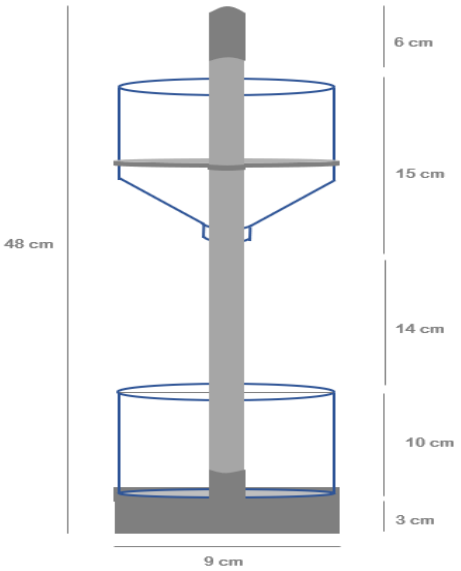

Figure 3 Side view of props sketch

A 1.5-liter plastic bottle was added as a water container and then cut in half. The bottom of the bottle is placed on the GRC board. Meanwhile, the top of the bottle is placed in the middle of the supporting leg with the help of a wire. The position of the top bottle is made upside down to accommodate water. The center of the bottle cap is perforated, and a ballpoint pen is attached so there is a hole. This hole is where water flows from the top bottle to the bottom bottle.

The tools and materials used to make static electricity props can be seen in Table 3.

Table 3 Lab kit validity criteria

No	Name of Tools/Materials	Specifications	Quantity
1	Paralon Pipe	d = 1 inch l = 86 cm	1 stick
2	Connection Pipe (T)	d = 1 inch	2 pcs
3	Connection Pipe (L)	d = 1 inch	2 pcs
4	Plastic Bottles	1,5 liters	1 pcs
5	Pen tip	-	1 pcs
6	GRC Board	5 cm x 10 cm	1 pcs
7	Wire	l = 50 cm	1 pcs
8	Fox Glue	20 gram	1 pcs
9	Scissors	-	1 pcs
10	Knives	-	1 pcs

Develop

The procedure for making static electricity props consists of three stages, namely the preparation stage, installation stage, and demolition stage. The preparation stage for making props is carried out by (1) preparing tools and materials; (2) cut the pipe to a length of 40 cm (2 parts) and 6 cm (1 piece); (3) Cut the GRC material into a square shape (5 cm x 10 cm), then cut the middle part of the width side to form a semicircle (r = 1.5 cm); (4) cut the wire 15 cm long, then shape it like 3/2 waves; (5) cut the bottle into two parts; and (6) hit a hole in the bottle lid and connect the end of the ballpoint to the perforated bottle hole.

The installation stage for making props is carried out by (1) forming a support pipe by connecting it using a pipe joint to shape it like the letter n; (2) Stick the top of the bottle up and down on the top support pipe using the wire; (3) place the pieces of the GRC board at the base of the support pipe; (4) place the bottom of the bottle at the base of the support pipe; and (5) props ready to use.

The demolition stage for making props is carried out by (1) removing the top and bottom bottles. (2) remove the base of the props. (3) remove the joint from the pipe, and (4) store the prop components in the provided space.

The static electricity props that have been designed can be seen in Figures 4 and 5.

Figure 4 Front view of props

Figure 5 Side view of props

Electrostatic experiment kits are made to show the phenomenon of static electricity to facilitate understanding of the types of electric charges and the interactions between electric charges, both of the same kind and different types. These lab kits are made of simple materials that are easy to use. Pipes were chosen as the primary material because they have a light mass and are easy to connect (Rucika, 2017). Each connection on this kit does not use adhesive. This situation allows the kit components to be installed and disassembled quickly. Even without adhesive, the connection between kit components remains strong. Complementary components are needed to use an experiment kit on static electricity, namely water and a ruler.

In the first step, water is poured into the top of the bottle so that a stream of water is poured out from the bottom of the bottle cap. Make sure water goes into the container below and nothing comes out of the container. After that, take a ruler and rub the ruler into dry hair. Then, the ruler is brought closer to the water flow so that there is a deflection of the water flow. When a ruler is rubbed against hair, electrons transfer from the hair to the ruler so that the ruler is negatively charged. When the negatively charged ruler is brought close to a neutrally charged stream of water, the negative charge of the ruler will attract the positive charge on the water so that the water turns closer to the ruler.

Besides rubbing it on the hair, the ruler can also be rubbed on other objects, such as woolen cloth. The water poured into the bottle is only one-third of its volume when using the kit; this avoids too much water pressure, resulting in an intense outpouring. When this occurs, the water will not appear to bend when approached by a ruler rubbed against the hair. The interaction between the charges will not occur because the charges in the water move too fast.

Figure 6 Use of experiment kit on static electricity

Teaching Aid Validity

Four physics teachers from several schools validated the electrostatic experiment's lab kit. Each validator is given a price to validate the tool regarding media and material (Wira, 2021). The media validation questionnaire consists of 4 assessment aspects, including form, quality, function, and practicality of the media, with 13 statement items. In comparison, the questionnaire validation material consists of 2 aspects of assessment, including engagement with learning and material concepts, with a total of 5 statement items. The media validation results can be seen in Table 4.

Table 4 Media expert validation results

No	Validity Aspect	Validator Score	Ideal Score	Percentage (%)	Category
1	Media Form	58	60	96.67	Valid
2	Media Quality	60	60	100	Valid
3	Media Function	57	60	95	Valid
4	Media Practicality	80	80	100	Valid
	Average	255	260	98.08	Valid

Based on the validation results of media experts, the experiment kit on static electricity has an excellent shape with a percentage of 96.67%. This result shows that the static electricity model has an attractive shape, simple appearance, and proportional size. Because it is made of pipes, this tool is also light, making it easy to carry.

In terms of quality, the experiment kit on static electricity has outstanding quality, with a percentage of 100%. This result shows that the props have good sturdiness and durability. In addition, the teaching aid is also equipped with an easy-to-understand guide so that it can make it easier for users to operate the tool.

Regarding its usefulness, the experiment kit on static electricity can function well with a percentage of 95%. This result shows that the visual aid can present symptoms well according to the concept of static electricity. This tool is flexible and can be used inside or outside the classroom.

From a practical aspect, the experiment kit on static electricity has an excellent practicality level with a percentage of 100%. Props are made of simple materials that are easy to find daily. The manufacturing process is also simple and does not require tools that are difficult to obtain. Besides being easy to get materials and tools, props are also easy to use. The tool can be installed and disassembled and is easy to carry to another place.

From the assessment results of the four aspects, the experiment kit on static electricity from the side of the media can be categorized as very good, with an average percentage of 98.07% (Arikunto & Jabar, 2009). Based on the results of material validation, the experiment kit on static electricity also has excellent validity. The results of material validation can be seen in Table 5.

Table 5 Material expert validation results

No	Validity Aspect	Validator Score	Ideal Score	Percentage (%)	Category
1	Relations with Learning	38	40	95	Valid
2	Relations with Material Concepts	58	60	96.67	Valid
	Average	96	100	96	Valid

Based on the results of the validation of material experts, electric visual aids have an excellent relationship with the learning process, with a percentage of 95%. This outcome shows that experiment kits on static electricity can be used in learning because they follow the essential competencies and learning objectives of static electricity material.

From its attachment to static electricity, the lab kit has an excellent attachment with a percentage of 96.67%. This outcome shows that the lab kit can

indicate static electricity following the theory being studied.

Regarding media and material, the experiment kit on static electricity has a rating percentage of 96%. This result shows that the static electricity lab kit is valid and can be disseminated to students for the physics learning process (Arikunto & Jabar, 2009; Wulandari et al., 2019).

Based on the assessment results, the static electricity trainer has a simple and practical form, is light to carry, and can be disassembled. The manufacturing process is easy, does not require expensive costs, and can be made independently by students. In contrast to previous teaching aids, which could not show static electricity phenomena, these props can show static electricity phenomena directly.

CONCLUSION

The development of a lab kit for an electrostatics experiment has been completed. In contrast to previous teaching aids, which could not show static electricity phenomena, these props can show static electricity phenomena directly. Static electricity trainers are made with recycled materials and simple tools. The results of media validation show that teaching aids have excellent quality, shape, function, and practicality, with a percentage of 98.08%. The results of the material validation show that the teaching aids follow the concept of the material and learning objectives with a percentage of 96%. Overall, the static electricity trainer has valid criteria with a percentage of 97.5%. The lab kit can then be disseminated to students for the physics learning process. It is hoped that the use of this lab kit can help teachers explain the concept and make it easier for students to understand it.

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