Multipurpose tube from waste to instructional media for physics education

IOP Conf. Series: Journal of Physics: Conf. Series **1185** (2019) 012104 doi:10.1088/1742-6596/1185/1/012104

Multipurpose tube from waste to instructional media for physics education

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Abstract. Waste is a substance that is not liked by the community. However, if managed and processed professionally can be useful. The most heavily processed waste is solid waste. This research is a recycle process of industrial solid waste and household in the form of wood, rubber, and glass. The recycle process has been carried out on garbage and produces physics learning media, named "Multipurpose Tubes". The application of scientific method in making the set of instructional media, proved able to hone the skills of science process of high school students through physics education.

1. Introduction

Garbage is the remainder of the processing of raw materials into semi-finished or finished materials. Garbage can be produced by both household and industry activities. Organic garbage can be processed either by the substance or sponging substances or professionals by humans. Processed organic waste is usually used as fertilizer and animal feed. Inorganic waste is relatively more difficult to process than organic waste. Wood, glass, rubber, plastic, metal, various types of liquids, and various types of gases are examples of inorganic waste. Some of the waste can be reused through the 3R or 4R (reuse, reduce, recycle) process (reuse, reduce, recycle, replace). Reduce means restricting or minimizing waste products, reusing activities or attempts to reuse waste directly, and recycling is recycling activities with efforts to reuse waste after going through the process, replace waste removed with more effective management and processing objectives.

In 2016, the Directorate General of Human Settlements of Indonesia has carried out infrastructure development in the field of garbage through the development of a regional the final dump in 2 districts/municipality, city-level landfill development in 46 districts/municipalities, Integrated Waste Treatment Site development in 193 districts/municipalities, and infrastructure development of temporary treatment facilities in 3 districts. In 2017, the Directorate General of Human Settlements is optimistic to support the 20-20 garbage-free Indonesia movement by preparing strategic activities in the form of Regional Final Disposal (TPA) in three cities, i.e. TPA Regional Banjar Bakula, Banjarmasin, TPA Regional Nambo, Bogor and TPA Regional Legok Nangka, Bandung. Efforts by the government will not solve the problem if all components of society do not participate. This research is one form of participation of the research team in the process of reducing, reuse, recycle, and replace garbage from household and industry.

The idea of exploiting this garbage came about because on one side the researchers saw the huge pile of garbage, the waste generated in the city of Padang, West Sumatra 450 tons per day and

increased by 10% during the holidays. Some of the waste is discharged into rivers and seas, causing hygiene and health problems in the community. "During October 2017, at least 50 tons of waste were transported from the coastal lane of Padang city" [1]. The problem of waste is not only happening in the city of Padang, a number of big cities in Indonesia are also experiencing the same thing as revealed by Director PSLB3, "In 2016 there are about 65 million tons of waste per day produced by the people of Indonesia. This amount is up one ton compared to 2015 production of about 64 million tons of waste per day, "[2].

On one side of the rubbish heap that some of it can be recycled is danger and threat, but on the other side recycle process can give added value even to overcome other problems such as increasing public income and overcoming the lack of learning media. Because the recycle results one of them in the form of learning media. There are a number of physics learning media that can be developed through the recycle process. Among other learning media for straight motion materials, Newton's law and its applications, circular motion, parabolic motion, impulses and momentum, static fluids, dynamic fluids, common waves, sound waves, and a host of other materials. When designed well, a set of instructional media can be used for two or more physics lessons. One of the physical learning media generated from the recycle process is the set of straight-motion experiments and parabolic motion. The application of scientific method in the recycle process produces physics learning media for motion on plane, incline, and parabolic motion [3].

Multiporpous cube is a physics learning medium designed for physics experiments of free fall motion, vertical motion, fluid versicity, and sound resonance. The raw materials for the manufacture of media are wood, glass tube, acrylic, spring, and other materials collected from household and industrial waste. Research is part of a series of research conducted related to the development of physics learning media through the process of recycle and utilization of local materials. In a follow-up study that will be done focus on improving the function of the tube with modification and addition components of the media. All research results are expected to produce instructional media in the form of experimental sets that can train and improve students' science process skills through physics learning at high school senior level.

To train students' science process skills through physics learning is a real effort to realize the mandate of physics learning part of science. Science learning aims to print a scientific community that affect the social life of society. The scientific community formed by science learning also contributes to the socio-economic development of a State. Learning science also aims to promote thinking and scientific work experience. Physical learning at the high school level also aims to prepare learners to learn science and technology at a higher level, as well as prepare them to be future scientists [4].

The work of a scientist is inseparable from the problems in society that must be solved, there are questions in the laboratory that need to be answered, or there is information or data with certain trends that need to be interpreted. So essentially the work of a scientist always culminate in a solution of the existing problems. The workings of a scientist always follow a certain pattern that can be accepted by a healthy mind or logic. Because in their work they always apply the scientific method, characterized by an integrated study of experience and empirical data with existing theories or knowledge.

Giving learning experience, like or similar to the work of scientists, is expected to hone students' ability to solve problems through the application of scientific steps. In short the learning experience is known as the science process skill. Habituation using a scientific approach is the goal of learning science [5].

The importance of a physics-centered learning process to learners has been recognized by policy makers in this country. It is regulated in Minister of National Education Regulation number 16/2007 on standard process, that the recommended learning model for physics learning is Problem-Based Learning, Discovery, Project-Based Learning, learning sircle, and cooperative learning. and other learner-centered learning; with a scientific, contextual, inductive-deductive approach.

Scientific process skills are skills needed to solve a problem such as measuring, comparing, classifying, observing, communicating, drawing conclusions, hypothesizing and finding variables

applied in science lessons [6]. Scientific process skills are also called investigation skills, because with science they seek to know about the world around us [7].

Abruscato [8] states that the science process skill consists of two parts, namely basic processes, including observation, number use, classification, measurement, communications, observation, and reference; and integrated processes, consisting of controlling variables, formulating hypotheses, operational definition, and conducting experiments.

High School physics learning is included in science learning groups. To sharpen the skill of science process through physics learning, has consequences of need of tools and materials to carry out investigation in the form of practicum and experiment activity. It takes a number of instructional media as supporting learning activities. The use of learning media can improve the quality of physics learning. Five reasons that the use of instructional media can improve the quality of learning, namely: (1) Teaching attracts more students, so the motivation to learn to grow; (2) Teaching materials more clearly meaning, so as to achieve the purpose of learning well; (3) The teaching methods will vary; (4) Students can do more learning activities, such as observing, performing, demonstrating and others; (5) In accordance with the level of thinking of students, starting from the stage of concrete thinking to the abstract, starting from the simple to the complex thinking.

The belief of why learning media can improve the quality of learning, can be seen from the benefits of media use in learning [9]: (1) Clarify the presentation of messages and information, 2) Improving and directing the students' attention so as to generate learning motivation and direct interaction, (3) Overcoming the limitations of the senses, space, and time, and (4) Giving similar learning experiences to the students. The learning media can enhance the learning process of students in teaching which in turn is expected to enhance the learning achievement.

Multipurpose cube with various functions is expected to be able to train and improve the skills of the process of learning the students to learn physics. So as to meet the needs of physics learning as part of the science such as messages and policy makers learning expert that has been delivered. This experimental set of development results has been tested against 60 High School Students. This article was written to convey the results of experiments on the use of experimental sets in Senior High School physics.

2. Methods

This article reports part of the results of development research, related to the purpose of seeing the effectiveness of multipurpose tubes to improve students' science process skills.

Implementation carried out 60 Senior High School students in three different schools. Level of effectiveness of use of Multipurpose tube, in improving the science process skills seen from the achievement of classical mastery. Where for the science process skills, set the value of MPL 70 or good category and 85% classical completeness.

Before being tested against students, the experimental set was validated and confirmed to three high school physics teachers. The teacher's assessment of the experimental set was collected using a questionnaire, covering five aspects; Student's science process skills are measured using two instruments, namely the observation format and the practice report. The observation format consists of ten points of assessment, while the report of practicum activity as many as fourteen points. Each item is assessed on a teacher questionnaire using a scale consisting of five categories; strongly disagree (STS, point 1), disagree (TS, point 2), do not know (TT, point 3), agree (S, point 4), and strongly agree (SS, point 5).

Scores obtained by students are converted into 1-100 scale. The value obtained is confirmed to the value of KKM, then determined mastery to the student concerned. Classical completeness is calculated by calculating the percentage of students who reach a value of 75.

3. Results

The results of this research are a tube that is equipped with various components, so that it can be used to carry out a number of physics experiments. Tubes and accessories are presented in the Figure 1.

Tubes made of acrylic with 5 cm of diameter and 100 cm of length, equipped with a scale of 0.1 cm accuracy. The stand is a square box with sized (30 × 30 × 15) cm^3 and a tube handle, made from 4 mm thick acrylic which serves as a barrier so that the tube can stand upright. There are three types bottom lid of the tube shown in the picture above is a lid that is equipped with a faucet to regulate the height of the liquid in the tube; the second lid is given a vertical hole in the middle of the lid in which a spring is installed, which is installed for the vertical upward motion experiment; while the third lid in the middle was installed with Parallon with a diameter of 1/2 inch and installed for sound resonance experiments. Tube arms can be unloaded used to hang objects through a rope in Archimedes' experiment and to adjust the position and speed of falling objects when the tube is used for experiments viscosity and free fall motion. The top lid of the tube is made of rectangular size (10 × 10) cm^2, given a circular hole in the center, functioning as a mini-generator generator. The infrared sensor is used as a detector for the movement of objects, which functions as a time counter, connected to the panel via a cable. The function sensor panel is the experimental data viewer with the output time taken on the segment distance between one sensor point and the next point. This panel can be connected directly to the laptop or computer.

This multipurpose can be used to carry out physical experiments as follows: (1) free fall motion, (2) vertical upward motion, (3) viscosities, (4) density. And (5) sound resonance. Different functions can be run by the tube, through the lower lid setting, sensor position, top cover, arm position and completeness, and supporting equipment outside the tube. Other supporting equipment needed to carry out all these functions are: (1) mini audio generator, (2) micrometer, (3) laptop, (4) plastic hose, (5) plastic ball and metal ball), (6) and plastic buckets.

The teacher's assessment of the quality and usefulness of multipurpose tube as a learning medium, as well as the prediction of whether the experimental set would be useful in improving students' science process skills, is conveyed in the teacher's assessment of the experimental set.

The teacher's assessment of the multipurpose tube experiment set includes 5 aspects, which are (1) functionality, (2) usability, (3) efficiency, (4) maintainability, and (5) portability. The lowest score given by teachers is 78.20 for usability aspect, the highest score is 88.80 for portability aspect; and an average of 85.06. In the form of bar charts, the teacher's assessment of the Multiporpous tube physics experiment set is presented in Figure 2.

Seen from the data, that physics teacher gives very good appreciation to 4 of five aspects of assessment. Namely for functionality, efficiency, main ability, and portability as well as a good assessment for usability. This assessment shows that the experimental set of the Multipurpose tube is feasible and used as a medium of physics learning medium.

Teacher's belief in the success of teachers that this learning media will be useful in improving the quality of learning can be proven through the data value of students' science process skills. Skill of science process of student either in the form of scientific skill to carry out experiment, or write scientific report is in very good category.

The data of science process skills assessed through the observation format, including 9 items of assessment consisting of (1) taking into account the readiness of the tool, (2) observing the condition at the time of measurement, (3) observing the change of magnitude, (4) equalizing the unit, (5) (6) performing measurements, (7) presenting the measurement results, (8) selecting the variable independently, and (9) performing the experiments according to the procedure. Distribution of science process skill values through observation format is as follows: The lowest score of 73 for item number 1, pay attention to the readiness of the tool and item number 2, observing the conditions at the time of measurement; the highest score of 100, for item 7, presenting the measurement result and item number 8, selecting the variable independently; and an average of 87.67. presented in Figure 3.

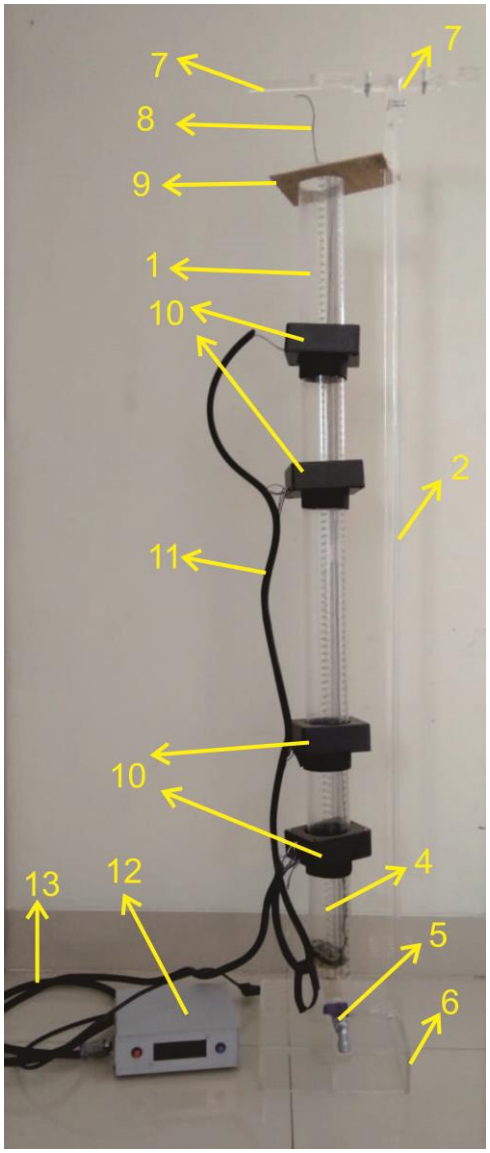

Figure 1. Mutipurpose tube. : 1. Tube with scale, 2. Retaining rod, 3. Tube holder, 4. Bottom lid, 5. Tap, 6. Mount the tube, 7. Tube sleeve, 8. Strap to dip objects, 9. Close up Tubes, 10. Infrared sensors, 11. Sensor connecting cables, 12. Sensor panels, 13. Cables Panel connection to Laptop.

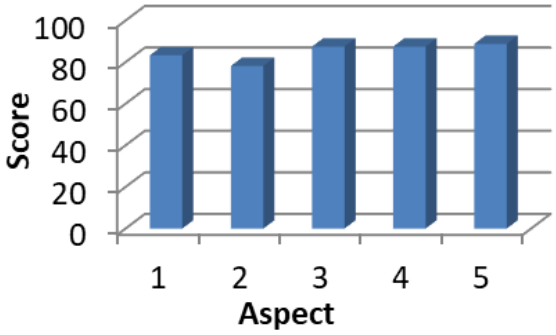

Figure 2. the teacher's assessment of the multipurpose tube physics experiment set

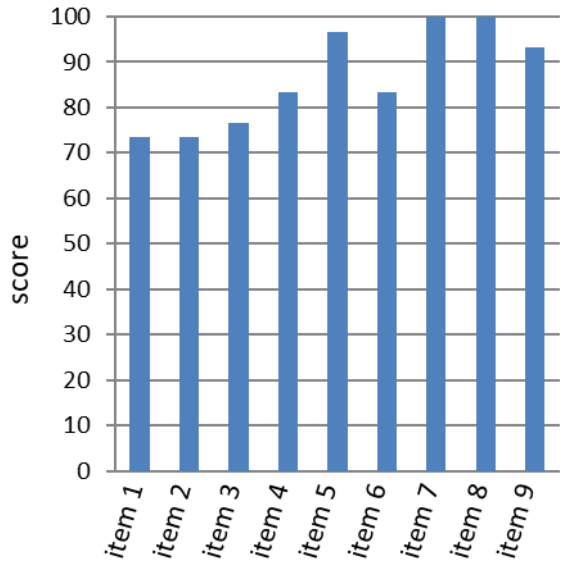

Figure 3. Science process skills

The result of the scoring of the students' science process using the experimental report consisted of 13 item, namely: (1) using the scale according to the needs of the experiment, (2) setting the research variable, (3) selecting the value of the scale according to the need of the experiment, (4) , (5) to present the experimental results according to the format, (6) to process the research data, (7) to present the experimental results, (8) to paint the relationship graph among the research variables, (9) to interpret the graph, (10) with previous experiments, (11) formulating relationships between experimental variables, (12) comparing research results with information in learning resources, (13) drawing conclusions. The lowest score is 75 for item 9, interpret the graph, the highest score of 100 for item 3, choosing the value of the scale according to the needs of the experiment; 4, record the measurement data; 6 process data research results; and 7, presented the experimental results; and an average rating of 87.50. Detailed information on the average scores for each of the assessment instrument items is presented in Figure 4.

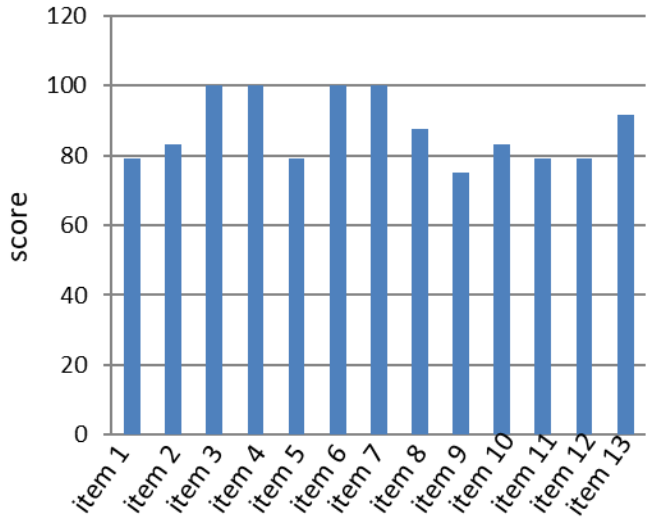

Figure 4. Students' science process using the experimental report

4. Discussion

Scores given by teachers to the multipurpose tube ranged from 78.20 to 88.80 indicates that the teacher has the belief that the experimental set is believed to be able to perform the function of the learning media very well. Four out of five assessment aspects score above 80. This means the teacher rated very well for the four aspects of the assessment. While one aspect, usability is given good value, almost closer to very good. This shows an excellent response by the teacher. In other words, according to his experience in teaching high school physics, the teacher is confident with the ability of the experimental set in running the learning media function.

Based on the aspects assessed by the teacher, the teacher's assessment results also show that learning will take place more effectively. Because the experimental set is easy to move, easy to install, and also easy to disassemble. So, the time required for the overall experimental activity is shorter. The time it takes to take the tool from its place, prepare the tool, enable the tool, to disassemble, and return the device to the storage, relatively shorter.

Storage set of this experiment does not require any specific space or specific conditions. Nor does it take a large space to store. Because this multipurpose tube experiment set can be stored in one of the corners of the preparation space. In short, the use of tools, is the advantage of the Four in One Cube experimental set. Another advantage of this experiment set is that it can be used to experiment with four different subject matter.

As presented in the methodology section, that the effective measure of whether or not this set of experiments of multipurpose tube as a learning medium is the achievement or not of classical mastery. The measurement of students' science process skills measured using the instrument of observation format indicates that the skills of the student science process observed during the learning activities ranged from 73 to 100. The lowest average score was in the good scoring category, obtained by the students for the skills to prepare the tool and observed whether the measurement is right to do. These two points concern the observing skills and associated with the attitude of prudence.

Physical experiments require readiness of the tool before use. Must be convinced first tool that will be used in ready condition or not. Because the tool is not ready to use will not give results in accordance with the provisions and expectations of users. While observing the tool carefully when measuring, is also important. Because there is a requirement that must be met in order for a measurement to give the most accurate results. For example, the value of constantly, the condition is balanced, the position is correct, and possibly other conditions. The lack of care of students in paying attention to the overall tool and measuring tool at the time of measurement is likely due to the lack of student experience working in the laboratory. This can be increased by multiplying the frequency of experimental activities.

Even if there is a grain with a good rating category, it is not very good, but when compared with the established minimum threshold, 70, all students totaling 60 people achieve complete mastery learning. In other words, classical mastery of 75% can be achieved.

Obtaining the value of science process skills similar to that obtained by students through observation, also obtained through reports of experimental activities. Of the thirteen items assessed in the report, 5 of them scored 80; i.e. for item number 1, using a scale; 5, processing data research results; 9, interpret the graph; 11, formulate the relationship between the experimental variables; and 12, comparing experimental results with information on learning resources. these skills are termed in advanced science skills, so it is only natural that the points have not achieved very good results. Because it takes experience experiments with more frequent experimental frequency. Given the previous students are still rarely using learning media that they can directly use independently in learning.

A total of 8 assessments on the report score above 80. There are even four items that get an average of 100; i.e. point number 3, selecting the value of the magnitude as needed, 4, recording the data of research results; 6, writing research results; and 7, presented the experimental results. This shows that all students have done what they have to do perfectly.

The high ability of students to write practical reports, is an indication that students already have a high motivation to learn. because the loran was made independently at home. They have time to search for additional information in their learning resources. Unable to be clothed, there is help from the third person in completing the report. But because there is a task to present the results of their work. Then students are required to understand what they write. So that directly or no impact on the work they write a report.

The mean value of science-process skills for all points of assessment recorded in both assessment instruments 86,67 for observation and 87.50 for the report of practicum activity showed that overall students' science process skills have been excellent. Conducting experiments for four physics materials proved to have honed their science process skills. Their ability, both in psychomotor aspect and in the form of making activity report has been very good. This shows that the experimental set of multipurpose tube is capable of performing the function of physics learning media very well.

The excellent assessment given by the teacher to this experimental set proved to be precisely the value of students' science-process skills that achieved a very good average. This information also shows that the experimental activity in the laboratory is an activity that cannot be eliminated from physics learning. Because without experience working in the laboratory, difficult to nurtured their science process skills. If the skills of the scientific process are not nurtured, then the objective of learning science that is saved by the curriculum is not achieved.

5. Conclusion

Based on the data and discussions that have been submitted, it is evident that the multipurpose tube experiment set is effective for improving the science process skills of high school students. Thus, it can be concluded that the experimental set is worthy of use as a medium of physics learning on Senior High School.

Acknowledgments

The author would thank to Prof. I Made Asra, M., Si, Prof. Dr. Agus Setio Budi, Dr. Anggara Budi Susilo, M. Si. and Dr. Ir. Vina Serevina, MM who has validated this media and also thanks to Ms. Esty Wikantini, M. Pd, Mr. Rustano, and Wahyu Hapsari who have provided the opportunity to conduct experiment.

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