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Analysis of the student responses on the developing Toricelli tube experiment based on the waste materials

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Abstract. Toricelli tubes made of waste materials have been developed to help students carry out basic Physics experiments. The process of developing the tube is designed with simple techniques and using basic materials of household goods. The purpose of this study was to reduce the effect of turbulent fluid flow on the tube when students conducted the Toricelli experiment. There is still a shortage during the empirical test of the Toricelli tube, ie the deficiency of the device in measuring the distance of the water jets and the speed of water coming out of the hole. In this study also comes with a student worksheet that was prepared based on Scaffolding theory. There are several question guides in the student worksheet that encourages students to become self-learner and able to construct concepts derived from the experiment coherently. The results of the feasibility test on Toricelli tube that has been developed is 89.06% with very high category. Furthermore, the result of student response data analysis is 78.86 which shows positive criteria.

1. Introduction

The development of science and technology which is accompanied by changes in various aspects of social life, demands the creation of a society with high intellectual capacity [1]. To transform a qualified Human Resources quality is necessary to improve the quality of education. It can't be separated from the objectives of science learning (IPA), especially in Senior High School (SMA).

One of the study material in science subjects in senior high school is the science of physics. Physical science aims to provide knowledge to students in understanding the concepts of physics and scientific methods. In addition, physics has a very important position among other sciences because physics can explain micro (molecular) to macro phenomena. Physical science also makes an important and meaningful contribution to the development of applied sciences. Physics as one part of science is a combination of the results of human activities in the form of ideas, knowledge, and as an organized concept of the natural surroundings derived from experience through a series of natural processes.

Less precisely the selection of learning methods for physics material, causing less learning process involving students. In the learning process with lectures, students only accept the concept given by the teacher without ever proving the concept. And to study physics not only by giving facts and concepts, but students need to be trained to find the facts and concepts. Mestre [2] states that the knowledge taught to solve problems must be explicitly taught and students should practice and apply the knowledge directly during the problem-solving process. Students not only know the facts, concepts or principles, but also skilled to apply their knowledge in everyday life.



Many factor that causing dynamic fluid material to be difficult to understand. This difficulty arises because students only memorize the term and do not understand the purpose of the term that is often used in teaching physics. Most of the concepts in physics and physics learning materials as a whole is a concept or material that is abstract and complex, whereas students are required to understand the concept correctly and deeply. In the dynamic fluid material, particularly about the theory Toricelli must understand the concept of how to calculate the velocity in the water flow that is affected by the height on the Toricelli tube.

Efforts to provide hands-on experience to students are not only done by teachers through appropriate learning methods but also supported by the government through curriculum change. In the 2013 curriculum, it is designed to strengthen students' competence in terms of knowledge, skills, and attitudes intact. This is in accordance with innovative learning techniques that involve students in full in the learning process. Familiarize students more actively solve problems in laboratory activities through observation activities, formulate problems, plan investigations, conduct experiments, use tools to collect data, analyze data, find answers, and make predictions and communicate results obtained. These activities are carried out by students through practicum activities.

The function of the practicum activities is to support the learning process activities to find a certain principle or explain the principles developed. Implementation of practicum can work well if supported by facilities and infrastructure in learning physics. With practicum activities, students become subject of learning directed to be more creative and active in learning, while teacher role as facilitator and motivator for student.

In the practicum activities, the physics practicum tool can clarify the presentation of messages and information about the physics lessons conveyed by the teacher. Physical practicum tools are tools made specifically for specific physics learning. The use of physics practicum tool makes it easier for students to understand and improve their ability in physics learning materials. Ahmad [3] stated that there is a significant difference to the students' learning outcomes in physics learning after learning media using practicum tool. With the increasing understanding and ability of students on physics learning materials, the students' physics learning outcomes also increased.

This is supported by [4], that the development of practical guidance of microwave devices on electromagnetic wave materials is effective in improving learning outcomes. A similar study was conducted by Dewi [5] who stated that the development of simple props is important to cultivate student skills.

Practicum activities in high school (SMA) are always constrained by laboratories that are not available or not ready to use. Inadequate tools and materials, causing practicum activities in high school is not developed. As a result, students' understanding of a material taught is less durable because it does not experience directly.

Development is the process or way that is done to develop something to be good or perfect. Development of practicum tool becomes necessary to produce a product that is able to support the lab activities in school. The statement was supported by Agustianti [6] stating that the development of practicum tools is very important as a medium of physics learning in high school. A simple practice with easy-to-find tools and materials in the neighborhood needs to be done. Furthermore, the practicum tool can be developed from used materials. Based on the above, conducted research on the development of an existing practicum tool into a practical tool more interesting and easy to use [7].

2. Materials and Methods

This research is a research and development of Toricelli tube physics practice tool on dynamic fluid material. This research uses Research and Development (R & D) approach which is the result of modification of research model of Borg and Gall according to Sugiyono [8] mentions there are ten steps of research and development that is, 1) research and information gathering, 2) data collection, 3) product design; 4) design validation; 5) preliminary product refinement; 6) improved product trial; 7) improved product refinement; 8) improved product testing; 9) enhanced product field testing; and 10) dissemination, implementation, and institutionalization. In developing the practical tool of physics

theory Toricelli is reduced only to field operational tests. Thus, the research steps to be undertaken in this study are 1) potential and problems, 2) data collection, 3) product design, 4) design validation, 5) design revisions, 6) initial design trials, 7) product revisions, and 8) operational field tests.

This research was conducted in SMA Negeri 1 Juwana, Pati, Indonesia. The subject of this research is practicum and practice manual of Toricelli tube. Meanwhile, the object of this study is the characteristic and feasibility of the tool of development result. The feasibility test of the practicum tool uses a validation sheet. The feasibility test is calculated using the equation,

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

where P is the percentage of the score, $\sum X$ is the number of answers per respondent from each item, and N is the total score of all respondents.

3. Result and Discussion

The design of the practicum development tool as a learning medium is made in accordance with the Toricelli theorem concept on dynamic fluid material. It shows that the practicum tool can be used as a learning media of the practicum intact completely and correctly without causing misconceptions among students.

The developed Toricelli tube practicum tool is made by considering the shortcomings of the typical Toricelli tube practicum. The developed Toricelli tube practicum tool is intended to reduce the flow of turbulence to the liquid in the tube during the practicum process. The difference of the Toricelli tube practicum tool developed with the existing Toricelli tube practicum is the modification of the addition of a small tube (Tube II) to tube I as shown in Figure 1.

From the schematic drawing of the developed Toricelli tube tool (Figure 1), there is a vertical opening in the tube II and tube I junction. The purpose of the hole or incision is to place the water from tube II to tube I. In other words, tube I is so small that it can be considered to have zero speed. Another advantage of the vertical incision also reduces turbulence when the addition of water, wherein water entering from tube II to tube I does not interfere with the flow direction of the water particles in tube I. Thus, the movements of the water particles of a particular direction or laminar so that the conditions Toricelli tube fulfilled. Another advantage of the Toricelli tube assembly tool developed as it is equipped with a ruler mounted on the tube and the base of the tube. It is intended that students are easy to see and measure the scale of the height of the leakage holes and the distance of the water jets from the leak hole.

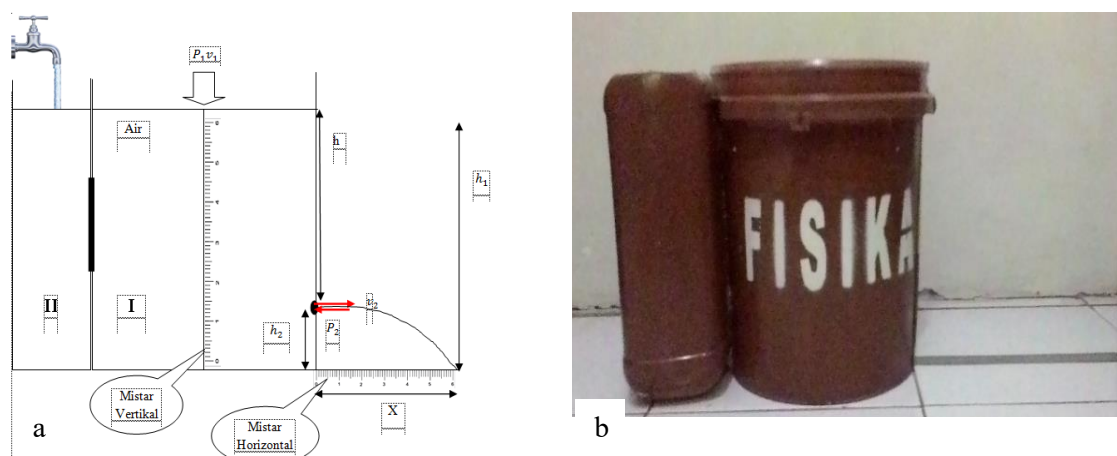


Figure 1. The Torricelli tube was Development a) schematic and b) photo

Furthermore, Toricelli tube experiments that have been developed are tested first before being used for research data collection (comisioning process). It is intended to determine the feasibility of the practicum tool developed as a supporting medium of practicum activities. The feasibility of the practicum tool developed is seen from the presence or absence of leakage and turbulence flow that occurs during the process of practicum, as well as the accuracy of the tool.

The small-scale trial in question is to identify leakage at the tube junction and the presence or absence of turbulence in the liquid. The leak identification is done on the two tubes of Toricelli by observing any seepage or wetting around the joint or not. This can be done by placing a cloth around the connection. When the cloth gets wet, it means there is a liquid coming out of the joint.

To identify the presence or absence of turbulence in liquids in a Toricelli tube, observe by observing whether or not there is a change in the rotation of the fluid during the lab or not. The identification of the magnitude of turbulence in the liquid is done by giving color to the liquid in tube I. It aims to know more clearly the magnitude of turbulence in the liquid. In the event of turbulence, there is a change in the rotation of the direction of water. The change can be known by observing whether or not the color of the liquid in the tube I when the water tap is opened and begin to fill the tube II. The results of trials to identify the presence of turbulence flow during the practicum process are shown in Figure 2.



Figure 2. The Test Result Turbulence Flow with Colored Liquid

The next small-scale trial is to find out whether the leak hole in the Toricelli tube is aligned or not. It can be observed by looking at the jets of water coming out of the leak hole simultaneously. If the liquid jets coincide, then the leak holes are parallel to each other. Furthermore, in trials also conducted empirical tests. This empirical test aims to see the level of accuracy of the tool. In the empirical test h_2 is determined that the distance of the leakage hole to the bottom of the tube is fixed. Meanwhile, h is the distance of the leakage hole against the water surface is made varies. Based on the result of empirical test by using observation analysis, the observation data are presented in Table 1.

From Table 1, it is seen that the developed practicum tool has accuracy of 99.954%. That is, the practicum tool is worthy of use as a practical learning media, especially the material sub-theorem Toricelli. Practical tools of development result is used for practical activities of 8 groups of students of class XI MIPA 1 in SMA Negeri 1 Juwana. Data analysis of the result of the practicum done by the students obtained the average speed of the liquid coming out of the leakage hole $(1.360 \pm 0.0005) \text{ nm}$ with accuracy of 99.954 %. The results are close to the results of empirical tests that have been performed where the average velocity of the liquid jets out of the leakage pits is $(1.344 \pm 0.0005) \text{ nm}$. Based on the results of empirical test results and student lab results, it is known that the developed Toricelli tube practicum tool can be used to determine the velocity of the liquid jet emitted from the leak hole. That is, the practicum tool is in accordance with the Toricelli theorem and feasible to be used as a learning media supporting the physic practicum. Also, that the Torricelli tube

was created from the waste material can be used to practical tool on the physics teaching learning [9-11].

Table 1. Empirical test result

No	h (m)	h_2 (m)	X (m)	g (m/s^2)	X^2 (m^2)	v (m/s)	δ	δ^2
1	0.190	0.050	0.193	9.810	0.037	1.912	0.0005	0.00000025
2	0.140	0.050	0.126	9.810	0.016	1.248	0.0005	0.00000025
3	0.090	0.050	0.088	9.810	0.008	0.872	0.0005	0.00000025
\bar{v}						1.344		
$\Sigma\delta^2$								0.00000075
Uncertainty		0.0005						
Δv		0.000612372						
KR		0.046%						
KT		99.954%						

4. Conclusion

Based on the result of the research and discussion, it can be concluded that the Toricelli tubular physicist experiments developed have the following characteristics: (1) Toricelli tube practicum is made of simple and easy to find material in surrounding environment, (2) Toricelli tube practicum can minimize turbulence when used in the practicum process, (3) the liquid shower hole can show the Toricelli event and calculate the speed and spacing of the liquid according to the Toricelli theorem.

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