The Utilization of Low-cost and Simple Materials on Physics Learning

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Keywords: Media, low-cost materials, learning outcomes, information literacy.

Abstract: Media made from low-cost and simple materials is one solution to overcome the limitations of physics laboratory facilities. This paper aims to describe the use of low-cost and simple media from a teacher's perspective as a learning planner. The results showed that in the utilization of media made from low-cost and simple materials, information literacy skills, the involvement of other experts such as universities as a teacher partner, good English skills, and involvement of learners were all required. Selection of low-cost media is based on consideration of time, cost, availability of tools and materials and conformity with teaching materials. The impact on learning shows an increase in cognitive learning outcomes of learners.

1 INTRODUCTION

The use of instructional media is a supporting tool that can improve efficiency and effectiveness in the learning process (Afolabi et al., 2012: 2; Idris, 2015: 186; Cecep Kustandi and Bambang Sitjibto in Nasution, nd: 4; Hasibuan, 2015: 196; Hanum, 2013: 94; Mahnun, 2012: 27; Haryoko, 2009: 4; Primary, nd: 3). Learning process can be tedious if it does not make use of learning media. Therefore, in the implementation of learning, teachers cannot be separated from the learning media (Sutrisno, 2016: 5).

Learning media are grouped from simple to sophisticated. The use of low-cost material is an example of a simple learning media. Media made from low-cost materials are usually used in schools that do not have a laboratory (Schramm in Sadiman, 2012: 27), while sophisticated media are used in schools that have sufficient support in facilities.

The utilization of low-cost media on physics learning is still rarely performed because in general the laboratories in schools use the ready-made media purchased from the manufacturers. If they do not have ready-made laboratory equipment, the teacher does not do practical works at the laboratories. Teachers prefer to use laptop media, projectors and focus on books, and learning activities are in the form of reading and working on questions (Wandana, personal communication on April 1, 2017).

The utilization of media made from low-cost and simple materials can be used to overcome the limitations of media on learning physics. Previous research has proved the effectiveness of the use of low-cost materials in the learning process (Siarni, nd; Widiyatmoko, 2012; Zdenek, nd; Janbuala, 2013; Koudelkova, 2008; Akarsu, 2011). The use of low-cost materials as a medium of learning can increase learners' motivation. Learners are more active in learning, improve content understanding, learn to conclude the learning, be creative or produce something as a result learning (Dvorak, 2011; Rediansyah, 2015).

A number of studies have investigated the use of low-cost and simple media. However, the studies mostly discuss the point of view of learners as the subject of learning. No studies that discuss the use of low-cost and simple material media from teacher's point of view as learning planner were found. Teachers are important factors in implementing the use of low-cost and simple materials. Teachers must have literacy, confidence and ability to implement the use of materials. Therefore, this study discusses teachers' skills, experience and perceptions, why and how teachers use the materials in physics learning, what constraints cause teachers to inhibit creativity in using the materials on the learning of physics and what impact does on learning.

Nuryantini, A. and Wandana, I.
The Utilization of Low-cost and Simple Materials on Physics Learning.
In *2nd International Conference on Sociology Education (ICSE 2017)*, pages 27-31
ISBN: 978-989-758-316-2

2 METHODS

The research was conducted in SMK Bakti Nusantara 666. The object of the research was one of the pre-service teacher who taught physics to 31 students of Animation XI class. The research was descriptive using survey research design. Data were collected using questionnaires, structured interviews and documentaries. Data were analyzed qualitatively and quantitatively. Information from questionnaires, structured interviews and documentaries was obtained from the pre-service teacher. Data showing the results of learning were obtained from test consisting of 17 questions.

3 RESULTS AND DISCUSSION

3.1 Physics Learning in SMK Bakti Nusantara 666

Physics is taught to students majoring in animation and software engineering at SMK Bakti Nusantara 666. The school does not have a physics laboratory. Thus, learning media commonly used is a projector by displaying experiments through animation. Learning models are often conducted in the form of lectures and discussion. Experiments are only done occasionally using the media available at school (Wandana, private communication on April 1, 2017). To overcome these conditions, teachers make efforts to learn by utilizing low-cost and simple materials.

3.2 The Steps in Lesson Planning

Before doing the learning, the teacher analyzed the curriculum and teaching materials. To select learning media, teachers seek information related to low-cost and simple materials from journals, web, blog and YouTube and consult with experts from universities. Media were selected by considering time, cost, availability of tools and materials and conformity with teaching materials. The teacher subsequently conducted a media trial. If media trials were successful, the teacher set tools and materials. Furthermore, the teacher wrote the experimental procedure in the form of learner worksheet.

3.3 Learning Media Selection Related to Electricity

In the physics learning process the concept of static electricity teachers chose three types of experiments. The first experiment was concerning the electrostatic interaction event of two electric charges. The purpose of the first experiment was to identify the electrostatic interaction event of two electric charges and explain the notion of electrostatic interaction of two electric charges. The second was trial of Coulomb Law. The purpose of the second experiment was to identify the electrostatic interaction event of two electrical charges and to explain the electrical interaction between the two charges to the Coulomb force and to qualitatively define the relationship between the magnitude of the electric force and the distance between the electrical charges correctly. The third experiment was on electric fields. The purpose of the third experiment is to define the electrical field definition, explain the lines of the electric field, analyze the electric field lines, compare the experimental results with the concept of electric field lines.

The media used, the type of experiment performed, and the reference sources used by the teacher are shown in Table 1.

Table 1: Learning media, experimental activities, and references used by the teacher.

Type of experiment	The name of experiment	Tools and materials	References
Electrostatic interaction	*Bubble trouble*	PVC pipe, wool yarn, soap bubble, patchwork, washcloth, and straw, plastic	https://www.youtube.com/watch?v=ViZNgU-Yt-Y
	Can can go	PVC pipe, wool yarn, patchwork, and soft drink cans.	https://www.youtube.com/watch?v=ViZNgU-Yt-Y
	Water bender.	PVC pipe, wool yarn / patchwork, plastic cup.	https://www.youtube.com/watch?v=ViZNgU-Yt-Y
Coulomb Law	*Ballon fight*	Balloons, PVC pipes, wool yarn, patchwork, and washcloth.	(https://www.youtube.com/watch?v=ViZNgU-Yt-Y)
Magnetic Field	Mosquito racket to show the magnetic field	Mosquito racket, small plastic container, filter liquid/tea filter, crocodile clamp/clips, metal wire, grass / dried leaves and baby oil	http://iopscience.iop.org/article/10.1088/0031-9120/50/6/690/pdf

3.4 Constraints faced by Teachers in the Use of Low-cost and Simple Media

There are several obstacles experienced by teachers in the use of cheap and simple material media on learning physics. First, to prepare for learning by using instructional media, teachers need extra time and effort. Teachers should seek reading sources as references to define tools and materials, test tools and the preparation of student worksheets. Media trials may take a long time, especially if the references do not give details of the experimental procedure. For example, electric field experiments using mosquito rackets are very time-consuming for teachers because teachers have to try several times. The example of figuring out how to keep the grass placed over baby oil needs much time to complete. Second, the references found on the internet mostly use English, and teachers have lack of proficiency in English causing teachers to do extra work to understand the experiment. Thirdly, the time available for physics learning in the classroom is so limited that it is difficult to conduct experiment and explaining the phenomena.

3.5 Students' Learning Progress

To examine the impact of using low-cost and simple media on learning, a test are given to students. Students' learning outcomes are obtained based on the results of pre-test and post-test. The test has six indicators of learning outcomes namely, remembering, understanding, applying, analyzing, evaluating and creating. The average pretest, posttest, and N-gain values of learners in static electricity are listed in Table 2.

Tabel 2: The average scores of Pretest, Posttest, and N-Gain.

Average Scores		*N-gain*	Interpretation
Pretest	*Posttest*		
52	72	0.4	Moderate

The details of the number of learners who experienced improvement in learning outcomes are shown in Table 3, with categories based on N-gain.

Tabel 3: Percentage of Number of Students Each Progress Category.

Number of students	Percentage (%)	Category
8	26	Low
22	71	Moderate
1	3	High

The mean values of pretest, posttest, and N-gain for each cognitive aspect of the learner are listed in Table 4 below.

Tabel 4: The average scores of *pretest*, *posttest*, and *N-gain* for each cognitive aspect.

Cognitive aspect	Questions no	Average			
		Pretest	*Posttest*	*N-Gain*	Interpretation
C1	1,2,3	73	84	0,4	Moderate
C2	4,5,6	53	67	0,3	Moderate
C3	7,8,9,10,11	48	70	0,4	Moderate
C4	12,13,14	52	75	0,5	Moderate
C5	15,16	44	73	0,5	Moderate
C6	17	26	55	0,4	Moderate
Rata-rata		53	72	0,4	Moderate

4 DISCUSSION

Based on the observations on the school condition, innovation and creativity that must be done by physics teachers is needed. Although the school does not have a physics laboratory as a supporting physics learning, teachers should be encouraged to provide learning media. Media is very important to use in learning. About 98% of all information coming into the learner's brain comes through the senses. More than 87% of learners in the class prefer to learn in visual and tactile ways. Learning will fail if the primary teaching method is auditory (Tileston, 2003).

The selection of low-cost and simple media is the right choice due to limited facilities and financing (Schramm in Sadiman, 2012: 27). The steps performed by the teacher in planning the learning are appropriate. The teacher searched information from various sources and consulted experts from the universities. As a center of science development universities can be a partner for teachers. The contribution of knowledge from universities to the economic and social development of society is expected. This recognition has drawn attention to the role of higher education institutions, such as in research. Universities have the task of teaching and

conducting research, also have a role in society (Kaino, et al, 2014; Colombo, Adda and Piva, 2010; Nilsson, Rickne and Bengtsson, 2010).

References teachers use to search for experimental ideas are web, YouTube blogs, and papers published in journals. But teachers prefer to refer YouTube to other sources, such as books or papers in journals that discuss the use of low-cost and simple media. Reading papers in journals is more complicated than looking at practical examples directly on YouTube. The language journal papers are too formal and there are many equations that are difficult to understand. Experimental procedures written in the journal are not detailed and indirectly successful to be implemented. Teachers should perform experiments many times by modifying the instructions contained in the journal (English, private communication on 16th August, 2017).

Searching information is one of the literacy skills in the 21st century. As information develops rapidly and openly, teachers must have information literacy skills. There is a strong relationship between teacher literacy skills and the ability to arrange lesson plans (Xu and Chen, 2016). The use of foreign languages in many references also shows that teachers must have the ability to use the global language of English. English proficiency is a necessary requirement in today's global era (Crystal, 2003).

The limited time and extra effort of the teacher can be overcome by involving learners in the preparation stage of the media. Involving learners encourages them to be more creative, and will give them academic experience. A highly engaged student is devoted to learning, spending a lot of time on campus, actively participating in the organization, and often interacting with other learners (Astin, 1999).

The results after using media made from low-cost and simple media shows that students have shown improvement in learning. The most significant improvement in cognitive learning outcomes was found in indicators of analyzing and evaluating with N-Gain of 0.5 meaning moderate level, and the lowest increase in cognitive learning outcomes found in indicator C2 or understanding with N-gain of 0.3 meaning a moderate level.

5 CONCLUSION

The results showed that the use of low-cost materials as a medium of learning can improve learning outcomes of cognitive learners. Therefore, the media can be an alternative to overcome the limitations of physics laboratory facilities. In implementing the media, teachers must improve some skills to overcome obstacles encountered. Some of the skills include information literacy skills, and English speaking skills. Teachers should also be able to cooperate with experts from universities and should be able to involve students in planning of instructional media.

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