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Smart Aquarium as Physics Learning Media for Renewable Energy

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Abstract. Smart aquarium has been developed as a learning media to visualize Micro Hydro Power Generator (MHPG). Its used aquarium water circulation system and Wind Power Generation (WPG) which generated through a wheel as a source. Its also used to teach about energy changes, circular motion and wheel connection, electromagnetic impact, and AC power circuit. The output power and system efficiency was adjusted through the adjustment of water level and wind speed. Specific targets in this research are: to achieved: (i) develop green aquarium technology that's suitable to used as a medium of physics learning, (ii) improving quality of process and learning result at a senior high school student. Research method used development research by Borg and Gall, which includes preliminary studies, design, product development, expert validation, and product feasibility test, and vinalisation. The validation test by the expert states that props feasible to use. Limited trials conducted prove that this tool can improve students science process skills.

1. Introduction

The need for renewable energy, start out in the era of fossil energy crisis in the 1970s. In this millennium, the energy crisis will be more alarming as everything need run by machines or automated which is increased needs of energy. Based on a study by Wood Mackenzie, changes in energy consumption patterns will occur in a few years to come. Its state that the demand for natural gas and low-carbon fuels will rise by 60% in 2035. It is mean, the need for coal and oil will touch its peak before 2035. The highest growth occurs in the need of new renewable energy that will rise fivefold in next 20 year. With declining oil demand, new renewable energy projects are rising in almost all countries. New renewable energy needs are expected to rise by 500% over the next 20 years [1].

Indonesia has abundant renewable energy potential that is feasible to be developed to meet domestic energy needs. Sources of renewable energy that need to be explored include plants containing carbohydrates, such as high organic compounds (corn oil [2] and palm oil [3]), or biomass (micro algae) [4], sugar cane waste [5], and castor seed [6]). Utilization of natural energy in Indonesia such as wind, solar, and water, each of it has been utilized to build wind power plants in *Bantul, Jogyakarta*; *Karangasem Bali* solar power plant; and hydroelectric power plant in *Singkarak* [7].

Research on the sources and benefits of renewable energy in the laboratory scale is also increasing. Seung et al [8], utilizes wind power as a source of electricity for water treatment by coagulation techniques. The electrical energy that flows into the electrocoagulation cell, oxidizes the anode to the hydroxide salt which will coagulate the colloid particles that can be found in the waste water. Utilization of solar energy as a source of electrical energy or better known as solar cells has also been



used as a source of electrical energy for room heater [9]. Bilal [10] designed a micro hydro power plant with the help of the matlab simulink program with turbine type, flow rate, and flow height parameters. The results show that cross flow turbine with head 5 m and 1.0 m³ / second flow rate produces better electrical energy compared with using Pelton or Caplan turbine.

Micro hydro power can also be used as a source of electrical energy for the aquarium. The results of the preliminary study showed that the use of micro hydro power produces only about 20% of the electrical energy needed. Therefore, to meet the needs of electrical energy, other electrical energy sources are needed.

Smart Aquarium is the application of the concept about renewable energy in the aquarium, in the form of a combination of engineering MHPG and Wind Power Generation. It can be used as a model of renewable energy which can be applied to the fulfillment of energy needs on a small scale. Installation of energy in smart aquarium, has some connection with physics concepts, such as renewable energy (MHPG and WPG), circular motion and wheel connection, energy changes, electromagnetic impacts, and AC power circuit. Replacing the wind source with a fan, can change the smart aquarium from just a renewable energy application model into a physics learning medium for some material. To see the feasibility and effectiveness of the smart aquarium as a medium of learning, it is necessary to used expert validation and use trials in physics learning.

2. Literature Review

2.1. Instructional Media

In the education and learning field, renewable energy has started giving from high school to college level, for diploma programs, undergraduate programs as well as for master's and doctoral programs. Tara and Lars [11], reported syllabus and curriculum at several universities that run master's and doctoral programs for renewable energy. Some universities are also building renewable energy research centers such as the Institute of Technology Delhi, the Solar Energy Research Center (SERC) and the European Solar Engineering School (ESES) at Dalarna University, Borlange (Sweden).

Desnita [12] reported a syllabus for Biodiesel material applied to a physics education program at the State University of Jakarta. In another study, Desnita [13] used project based learning method on physics learning with renewable energy material. The results showed that problem-based learning can improve the skills and motivation of physics students of UNJ.

Anas et al. [14] conducted a survey of Jordan's high school students' perceptions of renewable energy. The results of his study of 617 students, indicating that students can not distinguish sources of renewable energy sources and non-renewable energy. 50% of students are not familiar with the terms biofuel, biodiesel and bioethanol. While 87% of students believe that renewable energy is a sustainable energy. In contrast, students in Germany show they prefer renewable energy to everyday activities, such as preferring to ride a bike to travel and always turn off the light when not in use [15]. Its also found for students in Finland who are very concerned about bioenergy [16]. In contrast, UK students' concern for biomass as a source of renewable energy is very low [17].

Robin and Nicholas [18] have compiled a teaching manual to introduce the concept of renewable energy to junior and senior high school students through experiments covering the manufacture of solar cells, biodiesel and assembling micro hydro. In addition to syllabus and curriculum, instructional media is also needed in teaching and learning process. Learning media is a tool used to convey the subject matter in the learning process and also to facilitate students to understand the material teaching. Furthermore, the function of learning media (i) to clarify information or learning messages, (ii) to facilitate the students to better understand certain concepts, principles and skills by using the most appropriate media in accordance with teaching materials, (iii). different and varied learning experiences that further stimulate students' interest and motivation to learn, (iv) cultivate certain attitudes and skills in that students use or operate the media directly.

According to Kemp and Dayton in Susilana [19] the use of instructional media in teaching and learning process makes learning more interesting, learning goes two ways, more quality learning, learning time becomes more effective and efficient.

2.2. *Micro Hidro Power Generator (MHPG)*

MHPG is a power generation system that can convert water potentials with certain heights and discharges into electricity, using water turbines and generators. MHPG works by utilizing the height difference and the amount of water discharge per second available in irrigation channel, river or waterfalls. This water flow will rotate the turbine shaft to produce mechanical energy. This energy then drives generators and generate electricity. A micro hydro scheme requires two things: water discharge and head height to generate power that can be utilized. This is an energy conversion system of altitude and flow (potential energy) energy into the form of mechanical energy and potential electric energy of water that can be converted into electrical energy The higher the water fall the greater the potential energy of water that can be converted into electrical energy (Serway and Jewett 2004).

In the smart aquarium is not only utilized potent water energy, but its also used kinetic energy or water pressure. Because water is driven using a water pump commonly used in the aquarium itself.

The most important part of MHPG is turbine. The principle of turbine work is to change the potential energy of the water, into the kinetic energy of the water that turns the mill, then the mill turns the turbine, using the gear, the turbine spins the generator so that the rotation of the magnetic coil occurs and produces an electromotive force between the two ends of the coil. When connected with the resistor will produce an electric current. GGL generated AC or DC, determined by the type of dynamo used. In this research used DC dynamo.

2.3. *Wind Power Generator (WPG)*

Wind power is a power plant that uses wind as a source of electrical energy, by turning wind power into electricity with the help of windmills or wind turbines. The wind will rotate the propeller on the turbine or windmill. As a result of the rotation of the propeller then, the rotor of the generator will rotate, causing flux changes in the stator cross section. This flux change produces an electromotive force. The electromotive force produced which can be AC or DC, depending on the type of dynamo used. In this research used AC dynamo.

3. Research Methods

The research objectives achieved by applying research and development method, Borg and Gall model, with required analysis, design, tool development and expert validation, testing, and evaluation stage. This research was conducted at Media Development Laboratory of Physics Education Study Program, Faculty of Mathematic and Natural Sciences, Universitas Negeri Jakarta.

Required analysis is conducted by used a survey of the existence of learning media renewable energy and other materials that have been mentioned in school. The expert validation using a questionnaire contains four aspects, such as security and practicality, usefulness, functionality of media, and competency achievement. Four aspects are translated into 25 items of instrument. Also validated by high school physics teachers using a questionnaire containing six aspects including forty-seven instrument items. The category of media assessment is considered feasible, if the average score of all experts and teachers ≥ 80 .

The effectiveness of the smart aquarium as a learning medium is seen from the skills of the science process, which is assessed using the observation format and the practicum report written by the students. Instrument consists of four aspects described into 10 points assessment. The role of smart aquarium in learning is said to be effective if the value of science skills of students ≥ 70 good category.

4. Results and Discussion

4.1 Results

4.1.1. Smart aquarium display

After several construction changes related to materials, size, layout, and installation system as a whole, final result for Smart aquarium was shown in the Figure 1 to 4.



Figure 1. Installation of smart aquarium



Figure 2. WPG

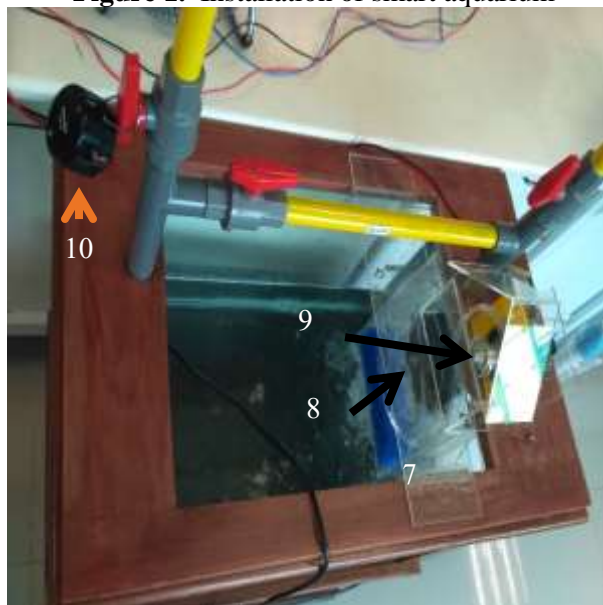


Figure 3. Instalation of MHPG

Information:

(1) windmill arm (2) fan blades, (3) dynamo AC, (4) wind turbine stand, (5) out put cable, (6) wind turbine shaft, (7) home turbine, (8) windmill, (9) gears, (10) counter, (11) power outlet (12) batteries, (13) inverters, (14) controllers, (15) switches, (16) input voltmeter, (17) input amperage, (18) output voltmeter, and (19) output amperemeter.

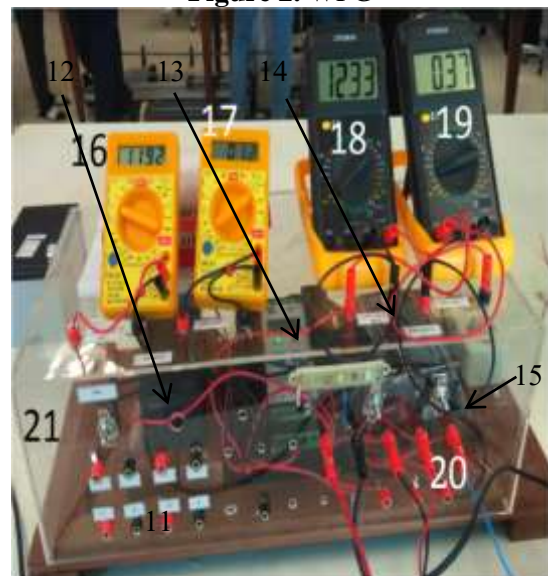


Figure 4. Electric circuit

4.1.2. Smart Aquarium Performance Test Results

Smart aquarium performance test aims to measure the output of electric power generated by the installation of smart energy aquarium. One experimental performance test tool for fifty measurements, presented in Table 1.

Table 1 Smart Aquarium output power

P (watt)								
WPG	MHPG	TOTAL	WPG	MHPG	TOTAL	WPG	MHPG	TOTAL
3.042	7.08	10.12	5.72	7.36	13.01	4.74	7.70	12.45
3.225	7.25	10.48	5.66	7.53	13.16	4.90	37.1	12.03
3.444	8.19	11.63	5.98	7.88	13.85	4.93	7.18	12.11
3.476	9.052	12.53	4.28	7.43	11.71	4.85	7.42	12.27
3.76	8.064	11.82	4.0	8.0	12.0	4.58	7.31	11.89
4.508	6.82	11.33	4.22	7.44	11.65	5.15	7.81	12.96
4.182	7.93	12.11	3.78	6.89	10.67	4.75	7.17	11.92
4.2	8.024	12.22	4.0	7.25	11.25	4.66	7.25	11.9
4.508	8.004	12.52	4.66	7.08	11.73	6.27	7.69	13.96
4.116	7.125	11.24	4.51	7.63	12.14	6.34	7.41	13.75
4.324	7.686	12.01	5.05	7.94	12.99	5.61	7.89	13.50
5368	7.296	12.66	5.24	74.34	12.67	4.8	7.66	12.46
4.223	6.669	10.89	5.39	7.14	12.53	5.80	7.08	12.88
5.6.5	7.192	12.84	5.26	7.38	12.65	5.19	6.9	12.09
4.14	7.192	11.33	5.2	7.75	12.95	5.2	6.96	12.16
7.375	6.832	14.21	5.38	7.95	13.31	6.08	7.19	13.80
5.985	7.788	13.77	4.87	7.56	12.44	5.72	7.32	13.04

4.1.3. Results of Correct Validation

The average score by five validators ranged from 82 to 96. The lowest score was given to item 22 on the ability of the smart aquarium to create enjoyable learning. The highest score is given for numbers 3, 4, 5, 10, 12, 17, 18, 20, 21, and 25. The mean scores for each grain awarded by expert are presented in Figure 5. Recapitulation of expert to four aspects of assessment (1) safety and practicality, (2) usefulness, (3) functionality of the media, and (4) competency attainment tested, presented in Figure 6.

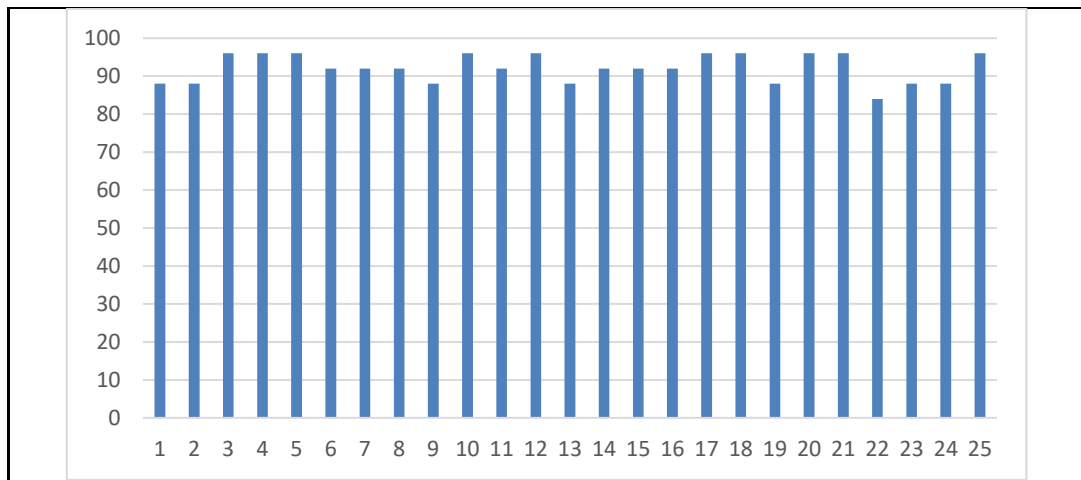


Figure 5. Results of expert validation

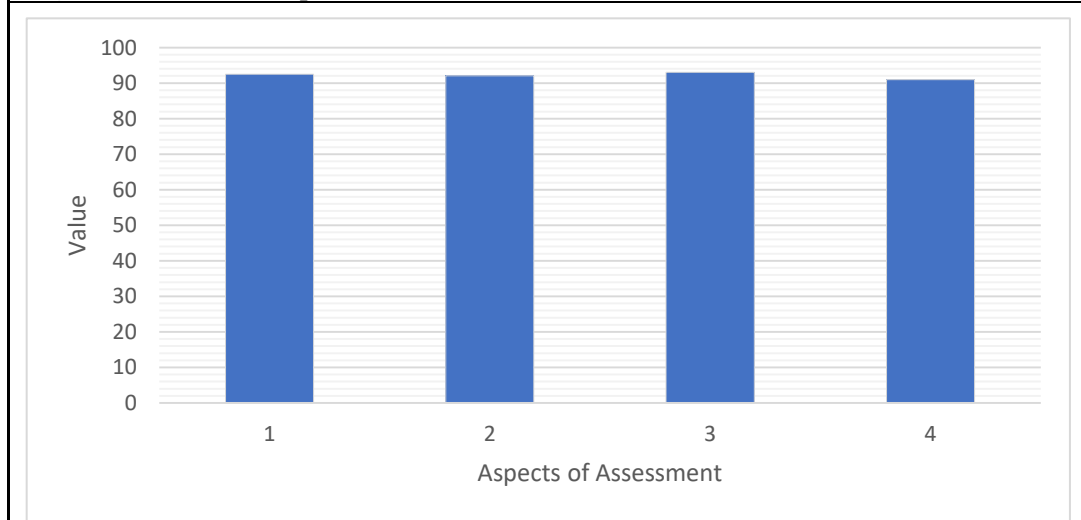


Figure 6. Expert validation

4.1.4. Teacher's Perception about the Smart Aquarium

Before students use the smart aquarium as a learning medium, the tool is assessed by the teacher. Assessment by teacher includes (1) objectives, (2) content, (3) language, (4) design, (5) conformity, (6) practice, (7) effectiveness, (8) science process skills, and (9) student worksheet. The mean values given by the teacher for each assessment aspect ranged from 75 to 88, with an average of 82.4, the distribution of scores for each aspect of the assessment by the teacher is presented in Figure 7.

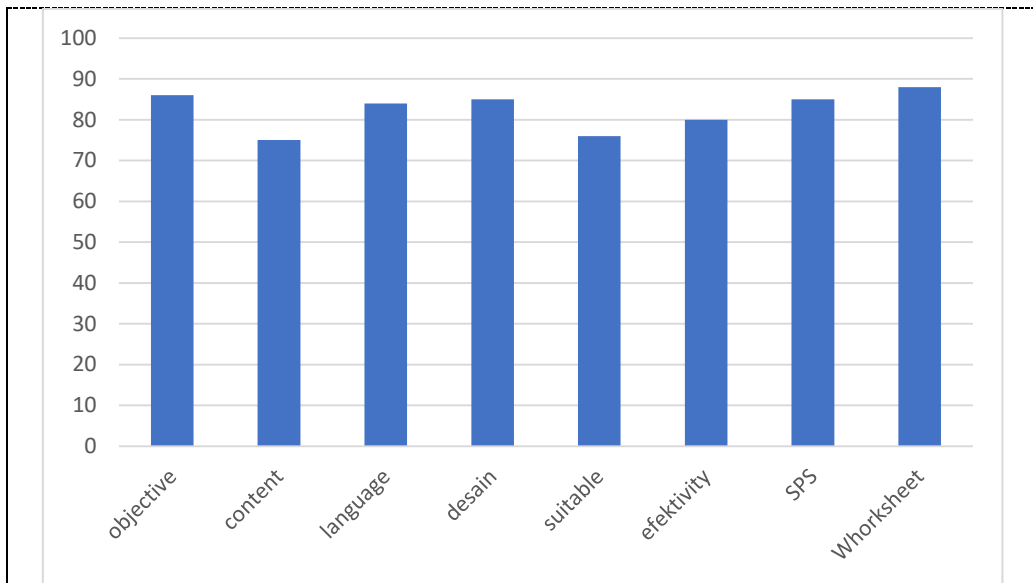


Figure 7. Teacher perception about the Smart Aquarium

4.1.5. Science Process Skills of the Student

Trial of smart aquarium use by students aims to see the effectiveness of the tool as a medium of physics learning. The effectiveness of practicum tools, among others, can be seen from the value of students' science process skills. In this research, the students science process skill consists of five aspects: planning the experiment, conducting the experiment, processing the experimental data, reporting the experimental results, and presenting, which consist of 10 skills such as (1) selecting tools and materials, (2) checking the condition of the appliance prior to use, (3) performing measuring tools, (4) assembling tools, (5) observing and measuring, (6) recording measurement results, (7) variable setting, (8) data processing, (9) drawing conclusions, and (10) presenting.

The scores of students' science process scores ranged from 73-100 with an average of 81.7. The lowest value to present and the highest value equalize the unit. The mean value distribution of the 60 students sampled is shown in Figure 8. Recapitulation of the value of science process skills to the five assessed aspects is presented in Figure 9.

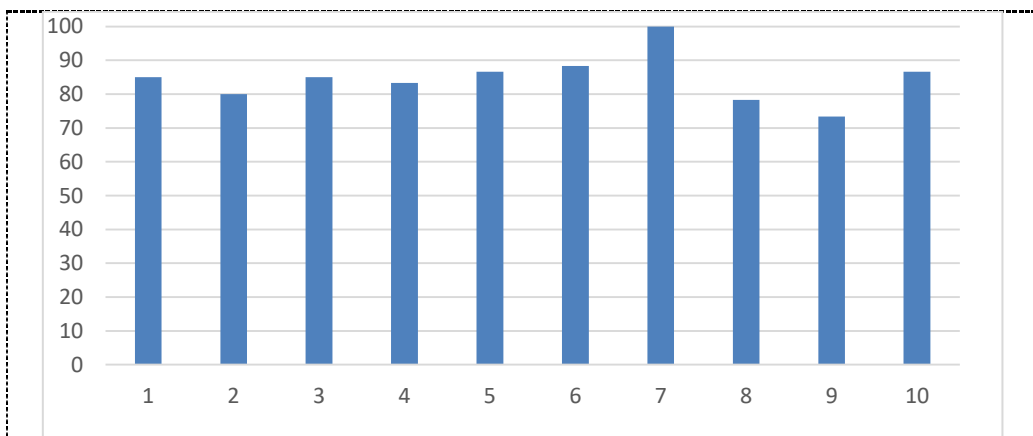


Figure 8. Score of the science process skills of the students

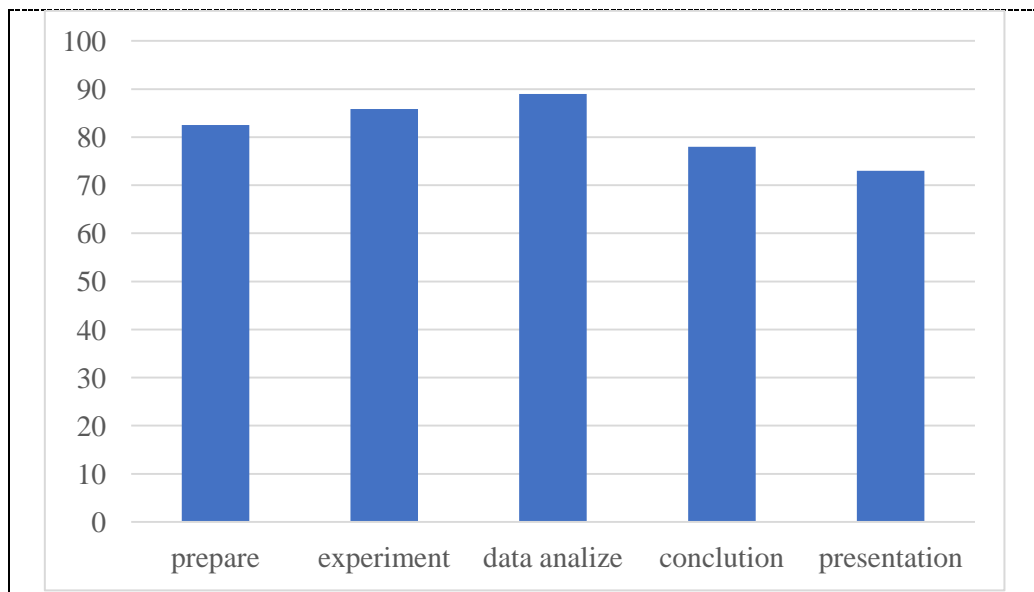


Figure 9. Score of the science process skills of the students

4.2 Discussion

Smart aquarium as a learning media is a real example of renewable energy that is utilized for aquarium pump operations. All components of energy installations are demonstrated. So that the stages of energy generation process and its utilization observed. Physics quantities associated with each stage and components are also measurable, because smart aquarium equipped with measuring devices as needed. The energy production from aquarium water circulation can be seen; as shown in figure 1 - 4. This tool gives users the opportunity to using different physical quantities, such as wind speed, number of blades, and arm length at wind power. High water fall level at a micro hydro power plant can also be varied. The energy generated by both energy sources can be used to operate the pump, turn on the fan, or for the practical purposes of the AC circuit.

The complete installation of energy from smart aquarium and various variations of physical quantities that can be arranged by students, enabling this tool can be used as a medium of learning for some subject matter physics. Practicum that can be done using this tool is renewable energy, especially wind power and micro hydro power plant, circular motion and wheel connection, electromagnetic impact, energy change, discharge, and AC power circuit.

The real application of renewable energy and multifunction are the two advantages of this tool as a learning medium. Because currently in school rarely found a renewable energy learning media that provides opportunities for students to change the amount of physics at the time of experiment. Nor are there any sources of renewable energy that can be used to study other physics in addition to renewable energy. These advantages as well as the attraction of these tools as a medium of physics learning.

Output power ranging from 10.12 to 13.04 is equivalent to 6 - 8 dry batteries commonly used in physics laboratories. Even more interesting is the voltage generated by this AC tool. The small and varied AC voltage is difficult to find in laboratorium. To meet the needs of the experiment is usually used inverter. For a micro hydro and wind power generation the micro power of this instrument is relatively large. Experiments show that the power can be used to operate the fan and small electrical appliances.

The advantages of this tool attract expert and convince them that this tool will be effective for the achievement of a number of physics competencies. So it makes sense if five colleagues as experts in physics and physics learning to give a very good appreciation of the smart aquarium as a medium of learning. Packaging tools in such a way, have considered the security for the user and also the practicality. When the tool is not used as a learning medium, it can be used as an aquarium as usual.

The multi function properties of the tool is a high value of usefulness for the tool. So it is only natural that colleagues appreciate very well for the aspect of usefulness. Many variations that might be done by the students, allowing the students to explore their own physical knowledge through the tool. Surely this will make it easier for them to achieve competence. Being directly involved in building knowledge. Teachers' duties become lighter and certainly facilitate the delivery of subject matter. Because many students work independently. The role of the teacher is only as a motivator and facilitator. Of course this is the factor that encourages expert to appreciate very well. The same is true for aspects of competency achievement. Stable power output, diverse diversity, and immediate experience that occurs with students during learning, make them very appreciative for this aspect.

Assessment with a very good category provided by expert showed that smart aquarium as a medium of learning is scientifically appropriate. Both as seen from a physics and pedagogic point of view. When this tool is used in learning, it is expected to have a positive impact on the quality of process and learning outcomes. This tool is eligible and suitable for use as a medium of physics learning.

Physics teachers are the ones that are directly related to physics learning. Teachers better understand the use of media in learning. By observing the design and display of media as well as testing the learning media, the teacher is able to predict how much the benefits of the media for the learning of physics. Though expert from higher education and learning media demonstration centers in PPIPTEK assess this media very well, based on their expertise. The teacher's opinion about the media is needed, because their experience is dealing directly with the students in the class. So before the tool used by students, first needed to validated by the teacher. Teacher's assessment of smart aquarium as a medium of learning, covering aspects of media content and content is in good category. While the other six aspects of goal, language, design, effectiveness, science process skills, and student worksheets are considered very good. The average score that the teacher gives to all aspects of the assessment is in very good category. Assessment categories provided by teachers describe, that smart aquarium worthy to be used as a medium of learning.

The main purpose of development and use of smart aquarium as a learning media is to facilitate students to achieve competence. One of the competencies that can be achieved through the use of this tool is the skill of the students' science process. The results of the average science process skills of sixty students for the five aspects considered to be in the category of good and very good. Good category for aspects of concluding and presenting. As for the aspects of preparing, implement, and analyze the data is in very good category. The average score of the aspects of the assessment of science process skills is 81.7 very good categories.

The value category of science process skill is very good showing that this tool has good ability to train the skill of the science process. Because one tool provides the opportunity to practice on a number of practical activities, it is positive to the built up their science process.

The category of expert assessment, teachers, and test results of students was in line, because it is in the same category; good and very good. This data shows that smart aquarium is suitable to be used as a medium of physics learning. The tool can be used to train students' science process skills. In other words, smart aquarium can improve the quality of the process and the results of physics learning.

5. Conclusions

Has been successfully developed smart aquarium as physics learning media for renewable energy. The smart aquarium feasible to use for instructional media for renewable energy. The smart aquarium has been able to improve student's science process skills.

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