Design of a Arduino-Based Wind Power Generator as a STEM Learning Media

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Abstract— The development of media that can show phenomena approaching the actual situation is very necessary especially in supporting STEM learning. Therefore, a learning media was developed in the form of an arduino-based wind power generator. The development was carried out by adapting the 4D method (Define, Design, Develop, and Dissemination) and has an accuracy level of measuring the value of the electric power generated by 97.75%. This value indicates that the developed media is able to show how wind power generators can convert wind into electrical energy close to the original phenomenon. Thus, the arduino-based wind power generator developed is considered feasible to support STEM learning.
Keywords— Arduino; Wind Power Generator; STEM

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I. INTRODUCTION

Advances in technology expect humans to be more productive but must be balanced with efficiency. The industrial revolution 4.0 demands automatic digital technology that is useful for humans. In addition, we have now entered the era of society 5.0 where humans and technology must synergize and run machines automatically together (Gladden, 2019; Ristekdikti, 2018; Salgues, 2018). Therefore, as a developing country, it is necessary to follow technological developments both formally through education and informally in the community through training.

Implementation of the development of science and technology through formal education is needed to produce a superior generation that is ready to face the world. One of the learning models that can accommodate these needs is STEM (Science, Technology, Engineering, and Mathematic) learning (Xie, Fang, & Shauman, 2015). STEM has five main principles, namely the integration of STEM content, problem-centered learning, inquiry-based learning, design-based learning, and cooperative learning (Thibaut et al., 2018).

STEM learning invites students to be able to apply integrated science, technology, engineering, and mathematics [6]–[8]. One of the principles of STEM is inquiry-based learning which invites students to find facts based on findings that are in accordance with the actual situation (Kennedy & Odell, 2014; The Stem Education Review Group, 2016). However, there are not many learning media that support STEM well. In supporting this, the development of media that can show phenomena approaching the actual situation is very necessary. Therefore, a learning media was developed in the form of an Arduino-based wind power generator. With the development of this media, it is hoped that it can help students to learn in a real and integrated way.

II. RESEARCH METHOD

The development of an Arduino-based wind power generator is carried out by adapting the 4D method (Define, Design, Develop, and Dissemination). At the definition stage, a literature review and analysis of previous research is carried out. At the design stage, an initial sketch of the form of learning media was developed. At the develop stage, the learning media is made using the following tools and materials: arduino as a converter of the resulting quantity parameters; a potentiometer used to vary electrical resistance to produce varying power; an ammeter to measure the current generated; 2 fans as a wind source and generator drive; LCD screen to display the value of resistance, current, and electric power; from this value the amount of electrical energy produced can be calculated. At the develop stage, a system test is also carried out to find out

whether the system is working properly and in accordance with the equation that should be used to calculate electrical power. To see the performance of Arduino, the precision and accuracy test of the data displayed on the LCD screen is compared with the results of manual calculations using the electric power equation. At the final stage or dissemination, the user is introduced to the developed media to test its usefulness.

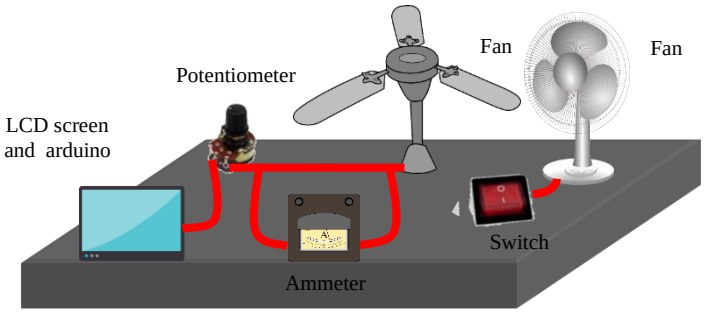

Figure 1. Design of a Arduino-Based Wind Power Generator

III. RESULT AND DISCUSSION

The results of research and development that have been carried out are as follows.

1. At the definiton stage, it is known that there are not many media that support STEM learning, therefore the media developed is able to facilitate students to better understand science, technology, engineering, and mathematics that are integrated in the developed media. In the field of science, students can learn about energy conversion from new renewable energy resources, namely wind which is converted into electrical energy, in the conversion process the power value is determined through physical quantities, namely current strength and electrical resistance. In the field of technology, students can get to know IT technology through Arduino which makes electrical power calculations automatic. In the engineering field, students can learn from the process of applying science and technology in solving human problems, namely the conversion of new and renewable energy with simple tools and materials. In the field of mathematics, students can prove whether the results of the Arduino calculations match the proper electric power equation.
2. At the design stage, the design is carried out by recording the needs for tools, materials, and system code on the Arduino through the Arduino IDE. This stage requires several processes, especially in the coding section because trial and error needs to be done.

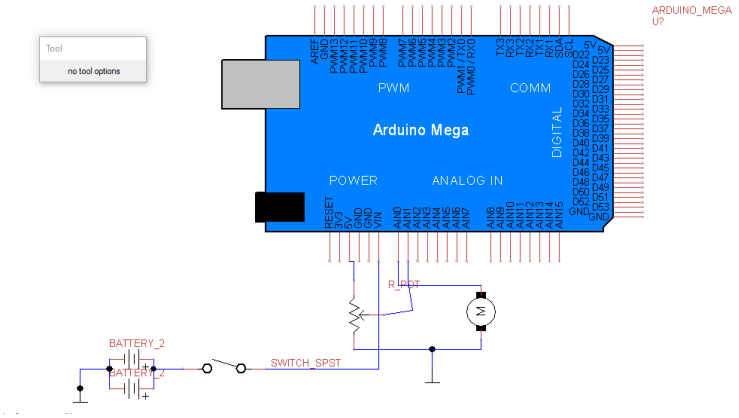

Figure 2. Arduino board design and other devices

Figure 3. Data display of electrical resistance, electric current, and output electric power on LCD screen

Figure 4. Coding used by arduino via arduino IDE

3. After the design is complete, the learning media is developed according to the appropriate design and code as shown in fig.5.

Figure 5. The final product of an Arduino-based wind power generator in STEM learning

System testing is carried out at this stage to find out whether the system is running well, especially on Arduino performance as shown in Table 1 and 2.

Table 1. Arduino-based wind generator system test results.

	Electrical Resistance (Ω)	**Electric current (A)**	**Electric Power (W)**
Data on LCD screen	61	0.55	17
	71	1.43	134
	72	1.71	219
	62	1.17	84
	62	1.58	150
Manual calculation results	61	0.55	18.45
	71	1.43	145.19
	72	1.71	210.53
	62	1.17	84.87
	62	1.58	154.78

Table 2. Result of precision test of arduino performance on wind generator.

Electric Power (P)	**Average Electric Power ($\bar{P}$)**	***P*-$\bar{P}$**
17		-103
134		14
219	120	99
84		-36
150		30
Precision value of data on screen		**0.8**
18.45		-104.314
145.19		14.396
210.53	122.764	87.766
84.87		-37.894
154.78		32.016
Precision value of manual calculation		**0.803**

From table 2, the precision value of the data displayed on the LCD screen is 0.8, which is close to the manual calculation precision value, which is 0.803. This shows that Arduino can work according to code commands.

In addition to the precision test, the system accuracy test was carried out on the Arduino used with reference to table 2. The results of the accuracy test are as follows.

$$\%\ error = \frac{\bar{P}_{calculated} - \bar{P}_{screen}}{\bar{P}_{calculated}} x100\%$$

$$\%\ error = \frac{122.764 - 120}{122.764} x100\%$$

$$\%\ error = 2.25\%$$

From the calculation results above, it is obtained that the percentage error is 2.25% so that the accuracy of Arduino in determining the value of the electric power of the wind power generator is 97.75%.

4. The last stage, namely dissemination, is carried out after all development processes are completed. The introduction of the developed media was carried out at one of the Vocational High Schools that needed media for STEM learning. From the results of the feasibility test carried out on users, namely 30 Vocational High School students, it was found that the learning media was very suitable for use in STEM learning with an average feasibility value of 3.862 from maximum value of 5.

The learning media in the form of a wind generator that has been developed has an accuracy level of measuring the value of the electric power generated by 97.75%. This value indicates that the developed media is able to show how wind power generators can convert wind into electrical energy close to the original phenomenon. Digital technology-based learning media really need to be developed to improve critical thinking skills and real life experiences in the classroom (Buckingham, 2015). In this regard, STEM learning requires an inquiry process (Hsu, Sung, & Sheen, 2020), namely the discovery of concepts or materials that can be facilitated through learning media. Thus, the arduino-based wind power generator media developed is considered feasible to support STEM learning.

IV. CONCLUSION

The development of learning media in the form of a arduino-based wind power generator is an innovation to answer the need for media that supports STEM learning, the media developed has been accurate and feasible to use to support learning. Suggestions that can be given from this research are that it is necessary to develop a larger size so that the energy or power produced is

also greater and to develop other power generation media to better introduce how generators work in complementing STEM learning.

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