Proceeding International Conference on Religion, Science and Education (2023) **2**, 161-166

Implementation of *Toriduino* (Toricelli Berbasis Arduino) as a Physics Learning Media in XI IPA SMA Negeri 15 Bandung

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Abstract: The development of learning media has been carried out based on the results of interviews with physics teachers who stated that schools still experience limitations in the manufacture, use of learning media and the physics learning outcomes of students on the concept of dynamic fluid which is still relatively low. This development aims to produce Toriduino (Arduino-based Toricelli) learning media on dynamic fluid material Toricelli sub chapter. This research uses the Research and Development method using the ADDIE model. At the Analysis stage, a needs analysis is carried out, the Design stage is carried out designing arduino-based learning media using a flowmeter sensor as a tool to measure the discharge of water that comes out in the toricelli experiment, the Development stage is carried out making learning media products and also testing tools, the Implementation stage of Toriduino teaching media is carried out at SMA 15 Bandung with a sample of 30 students, and the last stage Evaluation is carried out analyzing the results of the implementation which results in recommendations for Toriduino learning media. Research data collection was carried out using worksheet, response questionnaires to find out the response of students to the Toriduino, interviews were conducted to further analyze the results of the worksheet and questionnaire analysis. Analysis of the majority of learner response questionnaires showed positive responses, with student responses strongly agreeing and agreeing, with 50% and 40% stating that Toriduino learning media worked well. I was. Toriduino helps students understand the concept of dynamic fluids. 33% completely agree and 40% agree with Torricelli's sub chapter. The results of the worksheet analysis, survey responses, and interviews, it was concluded that Toriduino Media still has some shortcomings and needs further development. Specifically, improve the worksheet instructions and complete the Arduino programming to read the output unit m/s.

Keywords: Learning media, Toricelli, Arduino, Sensor flowmeter.

Introduction

Improving the quality of learning is one of the important things that must be considered in a learning process to improve the quality of education (Ahmad Zaki, 2020). This is the task of each school and the most important thing is for teachers as teaching staff. Teachers must always be creative and innovative in conducting learning so that students can more easily understand the material presented and are enthusiastic in participating in the teaching and learning process, so that the learning carried out is of high quality and the achievements of students are satisfactory.

Learning media is one of the supporting factors that becomes a tool to achieve the success of the learning objectives themselves. Media as one of the components in the system, has a function as a means of non-verbal communication. As one of the system components, it means that the media absolutely must exist or must be utilized in every lesson. It is said so because if one of the components does not exist, the results obtained will not be maximized (Magdalena et al., 2021).

Basically, media is a communication tool used in the teaching and learning process. As a communication tool, learning media according by Oemar Hamalik in Zaki (2020) has a wide range of

ISSN 2829-3355 | EISSN 2828-8467

functions including: (a) The educative function of communication media, namely that every communication media activity contains educational properties because it provides educational influence. (b) The social function of communication media, communication media provides actual information and experience in various fields of social life of people. (c) The economic function of communication media, communication media can be used intensively in the fields of commerce and industry. (d) The political function of communication media, in the political field, communication media can function, especially the politics of development, both material and spiritual. (e) The function of art and culture of communication media, the development to the field of art and culture can be spread through communication media.

Based on research conducted by Magdalena et al, (2021), he concluded that there are three fundamental reasons for the need to use media in the learning process in the classroom, namely first, some material, especially abstract material, needs to be visualized so that it becomes more real in the form of learning media. Second, the use of media can arouse students' interest and motivation to learn, reduce or avoid verbalism, generate regular, systematic reasoning, and to foster understanding and develop values in students. Third, learning using media can provide meaningful experiences for Learners because with the use of media Learners can witness firsthand the things that happen around them.

Media utilization in teaching should be a part that should receive attention from teachers as facilitators in every learning activity. Therefore, every educator needs to learn how to choose and determine learning media so that the achievement of learning objectives in the teaching and learning process is optimal. Even though this learning media is still often ignored for various reasons including (Tafonao, 2018).

The development of technology in Era 5.0 has made many significant changes including in the world of education. The use of learning media has also developed. One proof of the use of technology in making learning media is the use of Arduino microcontrollers in various devices in learning media.

According to Arisandi (2016) who is a LAPAN researcher, the development of microcontrollers has progressed very quickly when compared to 10 years ago. Knowledge of semiconductor material science greatly influences the development of IC (integrated circuit) manufacturing technology. The arduino system is an open source system both in hardware and software. The development of the arduino software system is adjusted to the development of its hardware. There are several types of arduino hardware, namely arduino uno, arduino mega, arduino leonarda and so on. The selection of an arduino module can be adjusted to the needs of the application to be designed.

Arduino UNO is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz Crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The Arduino UNO contains everything needed to support a microcontroller, easily connect it to a computer with a USB cable or supply it with an AC to DC adapter or use a battery to start it up (Adriansyah, 2013).

Flowmeter is a device for measuring the amount or flow rate of water from a fluid flowing in a pipe or open connection. This tool consists of a primary device, which is referred to as the main device and a secondary device. The primary device produces a signal that responds to the flow because the flow rate has been disturbed while the secondary device receives the signal from the primary device and displays, records, and/or transmits it as a result of the flow rate.

Water flow sensor is a sensor that is commonly used for the measurement of flowing water discharge. This water flow sensor is made of plastic in which there is a rotor and hall effect sensor. When water flows past the rotor, the rotor will rotate. The speed of this rotation will depend on the speed of the water flow. The hall effect sensor will issue a pulse output according to the amount of water (Wijayanto et al., 2016).

Based on the results of interviews with physics teachers at SMA Negeri 15 Bandung who stated that schools still experience limitations in the

manufacture and use of learning media and the physics learning outcomes of students on the concept of dynamic fluid which is still relatively low. So the development of Toriduino learning media (arduino-based Toricelli) was carried out to learn the concept of Toricelli in dynamic fluids. Based on the results of research conducted by Sirait (2017) states that the YF-B1 water flow meter sensor has an average accuracy of ± 91.00% and a reading error of ± 9%. Because of the relatively easy use of arduino Uno and its ability to be able to display the physical quantities observed through the variables of observation results very clearly and the high level of measurement accuracy on the flowmeter sensor is the background of making Toriduino media (Arduino-based Toricelli) as a learning medium for dynamic fluid material at SMAN 15 Bandung.

Materials and Methods

In the concept of dynamic fluid, one of the applications in everyday life can be observed through the phenomenon of leakage in the tank which is one of the applications of Bernoulli's equation. When the fluid flows out of a faucet located at the bottom of the tank, the velocity can be calculated using the Bernoulli equation (Douglas, 2014).

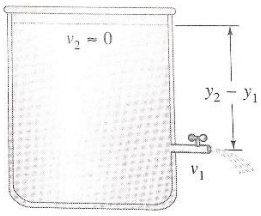


Figure 1. *Leaky Tank*

Based on Bernoulli's principle, the velocity value at the leaking hole can be found:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

At the hole of the faucet (1) and the top surface of the liquid (2) are open to free air, so the pressure at these two points is the same. $P_1 = P_2$ and $v_2 = 0\ m/s$ then the above equation can be simplified:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$\frac{1}{2}\rho v_1^2 + \rho g y_1 = \frac{1}{2}\rho(0) + \rho g y_2$$

$$\frac{1}{2}v_1^2 + g y_1 = g y_2$$

$$v_1^2 = 2g y_2 - 2g y_1 = 2g(y_2 - y_1)$$

$$v_1 = \sqrt{2g(y_2 - y_1)}$$

Microcontroler Arduino Uno

Figure 2. *Arduino Uno*

Arduino Uno is one of the microcontrollers based on Atmega38. The function of Arduino Uno is to control various electronic components such as LEDs, DC motors, relays, servos, modules, and all types of sensors. Make it easy for users to do prototyping, program microcontrollers, make sophisticated tools based on microcontrollers. (Leksono, et.al, 2019)

Waterflow Sensor

Figure 3. *WaterFLow Sensor*

It contains a pinwheel sensor to measure how much liquid has passed through it. There is an integrated magnetic hall effect sensor that outputs an electrical pulse with each revolution. The hall effect sensor is sealed off from the water pipe and allows the sensor to remain safe and dry. The sensor comes with three wires: red (5-24VDC power), black (ground) and yellow (Hall effect pulse output). By counting the pulses from the sensor output, it can easily calculate the water flow. Each pulse is approximately 2.25 milliliters. The measured value of this sensor is Liter/minute (Arifiah, 2017)

Procedur

In the development of Arduino Uno-based Toricelli learning media, the author designs and develops a tool to measure the speed of water in a leaking container by using a waterflow sensor. This development uses the Research and Development (R&D) research method with the ADDIE (analysis, design, development, implementation, evaluation) model.

The Analysis stage is carried out analyzing the needs of learning media at SMA 15 Bandung conducted by interviewing class 11 physics teachers where the results of the interview show that schools are still lacking in the use of learning media and also students still do not understand dynamic fluid material. The Design stage is carried out designing learning objectives according to the results of the analysis, designing appropriate learning media, and designing instruments to be used. The Development Stage is carried out making products that have been designed in the previous stage in the form of arduino-based learning media, arduino programming on waterflow sensors, instrument development and independent testing of tools.At the Implementation Stage after the arduino-based toricelli learning media functions properly then used to students. Implementation of learning media will be carried out at SMAN 15 Bandung class XI with 30 students. Finally at the Evaluation stage, this stage is carried out an assessment both in achieving learning objectives, learning media design, instrument design, data collection.

Data analysis

Data analysis is carried out to process data that has been obtained from the results of implementation in the form of LKPD and questionnaires. Data processing is carried out in accordance with the data that has been obtained, the data analysis is described as trails:

Analysis of Learner's Worksheet

Learning Worksheet analysis based on quantitative descriptive method. This quantitative descriptive analysis by calculating the percentage of student learning outcomes on each item number. The percentage value of student learning outcomes uses the equation below, Sugiyono (2017) :

$$\%\ Student\ Learning\ Outcomes = \frac{Sum\ of\ total\ scores}{Sum\ of\ Ideal\ Scores} x\ 100\%$$

Analysis of Student Response Questionnaire

Analysis of the positive response questionnaire of students to Toriduino learning media is by quantitative descriptive analysis. Quantitative descriptive analysis refers to Sugiyono (2017) by calculating the average score of each respondent's answer, based on a predetermined score on a scale of 1-5. Then the value is converted into a percentage of the positive response of students to Toriduino, with the following equation:

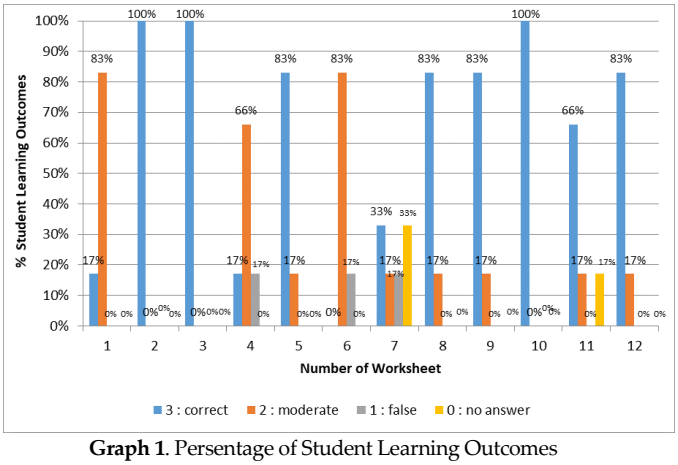
$$\%\ Student\ Positive\ Response = \frac{Sum\ of\ total\ scores}{Sum\ of\ Ideal\ Scores} x\ 100\%$$

Based on the percentage results in the questionnaire, interviews were then conducted with several students to further analyze.

Results and Discussion

Results of Student Worksheet Analysis

Processing of student data using worksheet to analyze the speed of water flow from the Toriduino learning media flowmeter sensor The results of observations and analysis of student worksheet are presented in graph 1.



Graph 1. Persentage of Student Learning Outcomes

Results of Student Response Questionnaire Analysis

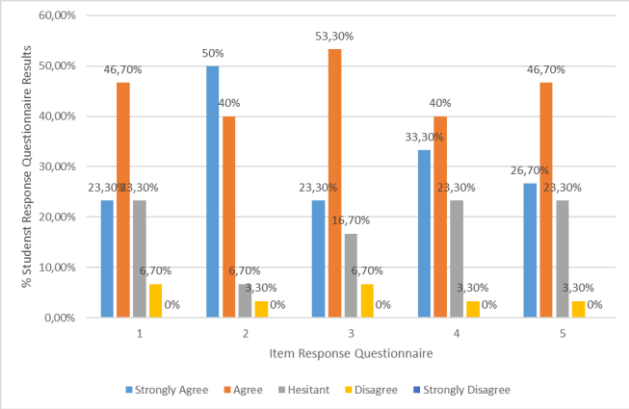
At the end of the lesson, students were asked to fill out a response questionnaire related to the learning

media used. The statements from the student response questionnaire are shown in table 1.

Table 1. Student Questionnaire Response Items

Number	Statements
1	I feel interested in learning physics dynamic fluid material using Toriduino learning media
2	Toriduino is functioning properly
3	Information in Toriduino is easy to understand
4	This Toriduino helps me understand the concept of dynamic fluid sub tire Toricelli
5	Toriduino adds to my curiosity in learning dynamic fluids

The results of the students' positive response questionnaire are shown in the following graphic.



Graph 2. Percentage of Student Response Questionnaire Results

Discussion

Item number 4 resulted in a percentage of 17% of the total students who answered incorrectly because they still did not understand and only answered based on observations in the experiment. In item number 7, a percentage of 33% of the total students did not answer because the collection time had run out 17% of the total students answered incorrectly. In item number 11, a percentage of 17% of the total students did not answer because the collection time had run out.

Item 1, the largest percentage of student responses was 46.7%, namely agreeing that students felt interested in learning physics dynamic fluid material using Toriduino learning media. As for the smallest percentage of 6.7%, they disagreed, indicating that they were not interested in the use of Toriduino learning media.Item 2, the largest percentage of student responses was 50%, which strongly agreed that students that Toriduino functioned well. While for the smallest percentage of 3.3% stated disagree which indicates that Toriduino functions well. The largest response in item 3 from student responses was 53.3% who agreed that the information in Toriduino is easy to understand. Meanwhile, the percentage of student responses of 6.7% disagreed which indicates that the information generated by Toriduino is difficult to understand. The largest response in item 4, 40%, agreed that the Toriduino learning media made it easier for students to understand the Toricelli concept. Meanwhile, the percentage of student responses of 3.3% disagreed, indicating that the Toriduino learning media did not make students understand Toricelli's material. The largest response in item 5, 46.7%, stated that they became more curious about dynamic fluid material. Meanwhile, a percentage of 3.3% disagreed, indicating that the Toriduino learning media did not make these students want to know more.

After analyzing the answers to the worksheet and the response questionnaire, it turned out that there were several students who had low scores and low responses. Then, an interview was conducted to find out the cause of the low score, according to students assembling Arduino with sensors was still difficult because the instructions on the worksheet were still unclear. In addition, there are students who have high scores and low responses, according to students the data generated is still L/min, so students still find it difficult to convert to m/s and affect the answer to the worksheet.

Conclusions

After analyzing the answers to the worksheet along with the response questionnaire, it can be concluded that students can understand the dynamic fluid material of the Toricelli principle sub chapter by using learning media as a practicum tool. This is supported by the questionnaire results on item 4 which states that this Toriduino helps me understand the concept of dynamic fluid Toricelli sub chapter, the majority of 73.3% of students agree that they understand Toricelli's material. In addition, students can understand the dynamic fluid material of Toricelli sub material by using Toriduino learning media. Students can distinguish the speed of fluid flow at the depth of the sensor, this is in accordance with questionnaire response item 3, namely the information in Toriduino is easy to understand, the majority of 76.6% of students agreed. Although the majority of students gave a positive response, but according to the criticisms and suggestions from the results of interviews with several students this learning needs further development in the form of:

1. Work procedures are made simpler and clearer;
2. The arduino programming must be set again so that it produces an output of meter/second units.

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