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Development of Water Debit Measuring Instruments as Physics Learning Media Using a Flow Meter Sensor

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Abstract

Physics learning aims to ensure that students understand physics concepts completely. Understanding of the concept can be achieved through the help of learning media in the form of teaching aids from physics materials. This research aims to develop learning media for measuring water discharge using a flow meter sensor to improve students' conceptual understanding of dynamic fluid material. This research includes development research through the ADDIE model, carried out until the development stage. Data collection techniques are carried out through the calibration of measuring instruments. The technique for data analysis used is the descriptive analysis of proportions. The study results obtained the following results: 1) The calibration results show that the water discharge measuring instrument as a learning medium has a very small error rate, and 2) The results of the validity assessment obtained by the water discharge measuring instrument have high validity. The water debit measuring instruments can be used to increase understanding of the dynamic fluid material concept. Using this air discharge measuring instrument will help students understand the concept of fluid dynamics, especially in air discharge subjects.

Keywords: Flow meter sensors, Learning media, Physics learning, Water debit instruments

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INTRODUCTION

Physics learning generally studies phenomena that occur in everyday life. The phenomenon occurs close to the student's environment (Wijaya et al., 2021; Wiwin et al., 2020). This is the demand of educators to be more creative in realizing a fun physics learning process. Students' interest in learning largely determines the achievement of learning objectives (Jufrida et al., 2019; Susilo & Sustianingsih, 2021). One of the purposes of physics learning is for students to understand the concepts in each physics material for good application of natural science in everyday life (Jamaludin & Batlolona, 2021). Conceptual understanding is students' ability to record and transfer information from their learning that can be used to solve, analyze, and solve problems (Gunawan et al., 2018).

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Students understand concepts when they can convey scientifically sound topics in their language verbally, computationally, mathematical equations, drawings, graphs, or diagrams (Altan & Eksi, 2015; Dewi et al., 2019; Saepuzaman et al., 2018). Therefore, concept understanding has a big role in the learning process of physics.

The conditions in the field show that students' understanding of concepts is still relatively low. One of the materials of physics is fluid. Fluid material is one of the physics materials that cannot be separated from the problem of understanding concepts (Dewi et al., 2019). According to Dewi et al. (2019), the percentage of understanding the concept is 35.27%. Many factors contribute to the low understanding of students' concepts, including educators, textbooks, learning contexts, and teaching methods by educators (Mufit et al., 2018). Therefore, a solution is needed to support the improved concept understanding of students in a fluid material.

Efforts that can be used to achieve learning objectives can be through the use of learning media (Amar, 2015). Innovation is needed to learn physics (Ye et al., 2016). Educators must be able to visualize physics to make it easier to understand (Suranti et al., 2017). One of the teaching media that can be used so that students understand more about the dynamic fluid concept is visual aids (Illeperuma & Sonnadara, 2017). Students gain more motivation to learn when they use visual aids, and concepts and abilities are easier to understand (Holubova, 2015). In dynamic fluid material, one of the teaching aids that can be developed is a water discharge meter.

Measuring water discharge using a flow meter works with the help of the environment, one of which is water. Water is a fluid whose discharge can be measured using a flow meter sensor. Students can understand the results of discharge measurements to learn fluid concepts, including air discharge. The flow meter sensor measures water flow by counting the water wheel's rotation on the flow meter, which automatically rotates when water flows through it (Wahyuningsih et al., 2019). Arduino Uno is a microcontroller that controls the electronic processes of the developed tools that produce measurement data. So, using a water discharge measuring instrument using a flow meter is suitable for use in physics learning.

A water discharge measuring instrument can be developed using a flow meter sensor assisted by Arduino Uno. Sensors are components that convert physical quantities into electrical quantities, which can then be evaluated with certain electrical circuits. A flow sensor is a sensor that measures fluid discharge (Finawan & Mardiyanto, 2012).

Previous researchers have already developed research on developing a water discharge measuring instrument using Arduino (Herdayanti et al., 2020; Wahyuningsih et al., 2019). But this research was conducted using Arduino, which was developed as a learning medium for dynamic fluid material, especially for measuring water discharge, so that students can understand dynamic fluid concepts and link learning to everyday life through the use of measuring instruments.

Based on the explanation above, this research was conducted to develop teaching media in the form of a water discharge measuring device using a flow meter sensor to support increasing conceptual understanding of students in a dynamic fluid material. This research is expected to help support increasing concept understanding of students' dynamic fluid material.

METHOD

The research conducted included development research through the ADDIE model (Dick & Carey, 1996). The research was carried out until the development stage due to limited time. This research was conducted to develop teaching media in the form of a water discharge instrument for measuring the use of a flow meter sensor to support concept understanding of students' dynamic fluid material.

The research was carried out through analysis, design, and development stages. At the analysis stage, an analysis of the characteristics of students is carried out, as material analysis, concept and analysis of the learning environment, as well as specifications for learning objectives so that it becomes the basis for making media of learning in the shape of teaching aids to measure water discharge to support increasing concept understanding of students in dynamic fluid material. The design stage is conducted by product design, referring to the analysis results that have been carried out. In the development stage, product development is carried out according to the design, and the feasibility of the water discharge measuring instrument is assessed through a calibration process using a water discharge measuring instrument that has been widely developed and used in general. The calibration process is carried out by comparing it with calculating water discharge results using a measuring cup and time. The results of comparing the value of the water debit from the tool and the reference are calculated for the error value using the following formula.

$$\%Error = \frac{Real\ score - measurement\ score}{nilai\ sebenarnya} x\ 100\% \quad \ldots (1)$$

Meanwhile, the error is calculated using the following formula.

$$Ralat = \frac{\%Error}{100\%} x\ real\ score \qquad \ldots (2)$$

The water discharge measuring instrument's validation consists of benefits, presentation, and physical appearance. Data collection techniques through the process of calibrating measuring instruments. Data analysis techniques using V'Aiken.
The validation category of the water discharge measuring instrument developed using a flow meter sensor can be seen in Table 1 (Retnawati, 2016).

Table 1 Validation results categories

Validation score	Category
≤ 0.4	low
0.4 < v ≤ 0.8	medium
0.8 < v	high

RESULTS AND DISCUSSION

This research was carried out to obtain a water discharge measuring instrument as a learning medium to increase students' understanding of dynamic fluids. The water discharge meter here is a visual aid in measuring water discharge.

The preliminary stage of this research is the analysis stage to determine the need for instructional media development in Ngaglik 1 Public High School. At this stage, student characteristics, material analysis, concept and analysis of the learning environment, and specifications of learning objectives are analyzed. Besides that, a literature analysis was also carried out, in which the researcher searched for relevant literature to support product development and looked for previous research related to this research. From the results of the observations, it is known that this school rarely does practicum activities because the infrastructure is inadequate. In addition to laboratories that do not support learning activities, the practicum tools or kits available are not complete, especially for dynamic fluid material (Gunawan et al., 2019).

Based on the problems found, the solution to overcoming the limitations of practicum tools at school is to develop a measuring instrument for dynamic fluid material. The measuring instrument developed is a water discharge measuring instrument using a flow meter sensor with the help of Arduino Uno. Visual aids in learning can help students achieve learning goals (Nomleni & Manu, 2018). According to Uzal (2022), Arduino Uno can be used as a teaching aid because it has many functions and is easy to use. Arduino-based learning has positively affected various variables in Education (Lee, 2020).

The next stage is the design stage, which consists of the design stage and the manufacturing stage. The information obtained at the analysis stage is used as a reference for the design stage. The next stage is making the initial product of the water discharge teaching aid. The product is divided into two components, namely hardware and software.

Hardware

The hardware in this tool is the components that build a water flow meter measuring instrument that has a physical form. The hardware for measuring instruments using Arduino is not that much, so the manufacturing costs are not high. This is in line with the statement (Soong et al., 2018; Uyanik & Catalbas, 2018) that Arduino can replace expensive measuring instruments.

The following are the tools and materials for measuring the water flow meter discharge, and their functions are shown in Table 2.

Table 2 Hardware components for measuring water discharge

Tool	Function
Arduino Uno R3	As a microcontroller to operate the flowmeter sensor in data collection
Yf S201 flow meter sensor module	As a measure of water discharge
LCD I2C 16x2	As a water discharge data viewer and Liters/hours
Project board	As a tool to connect Arduino pins with sensors and LCD
Connecting cable	Used to connect circuits from Arduino to project boards and from project boards to sensors and LCDs

The series of water discharge measuring devices developed is shown in Figure 1.

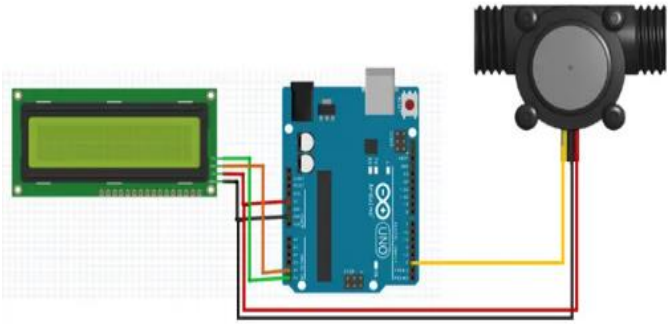

Figure 1 Design of a water discharge measurement tool using a flowmeter sensor

The results of the design of a water discharge measuring instrument using hardware components are shown in Figure 2.

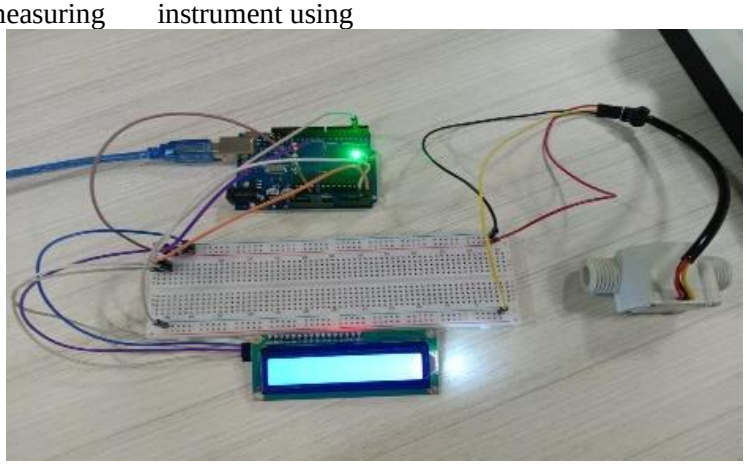

Figure 2 display of a series of flow measuring instruments using a flow meter sensor

Software

The software in this teaching media uses IDE software to program the coding of water discharge measuring instruments. The form of programming to see the results of measuring the water discharge in real-time on the LCD using a flowmeter sensor can be seen in Figure 3.

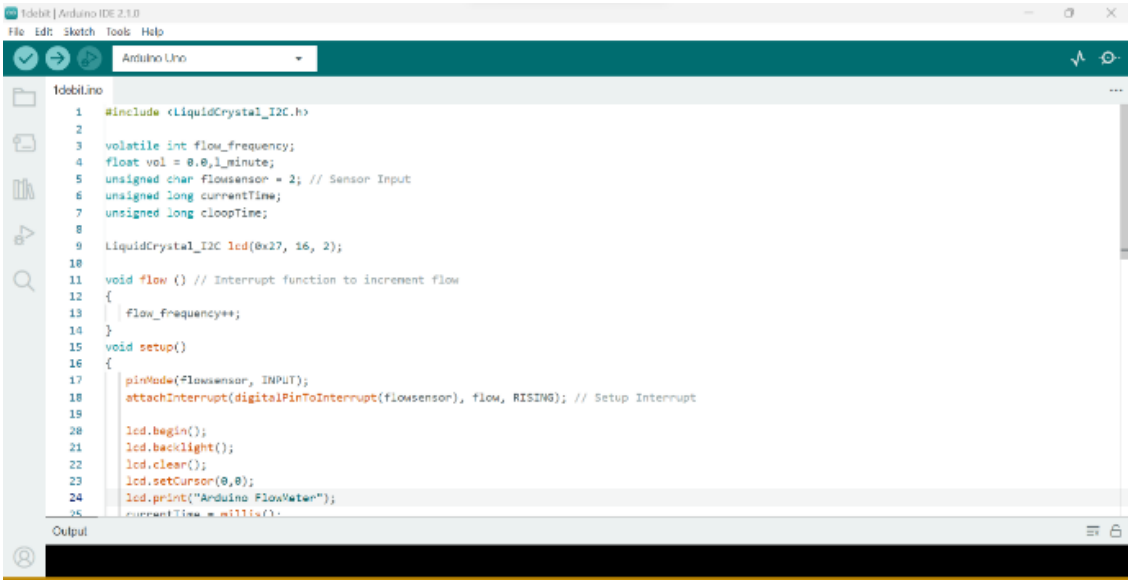

Figure 3 Coding of a Water Discharge Measuring Tool Using a Flowmeter Sensor

Working Principle Water discharge measuring instrument with a flow meter sensor

This water discharge meter calculates the amount of water discharge flowing past the flowmeter sensor in liters/hours, which can later be converted to liters/second. Finawan (2012) the working principle of this flow meter sensor is to calculate the water wheel's rotation on this flow meter, which automatically rotates

if there is a stream of water through it, to measure the water flow. The waterwheel has magnets attached to its rotor, and when rotated, it generates a magnetic field based on the principle of the "Hall effect," which states that there is a magnetic field and no magnetic field, which repeats when the waterwheel rotates to produce a square wave output. This signal will then be calculated to provide the value of the discharge and volume of water that passes through the flowmeter.

The third stage of this development is the development stage. At this stage, tool calibration and product feasibility assessment (validation) are carried out by two validators. Tool calibration is used to test the tool's accuracy by comparing the test results with standard measuring instruments. Calibration is carried out by comparing the water discharge value read by the flowmeter measuring instrument with the calculation results from the water discharge experiment using a measuring cup and a timer (Çiftçi & Sözen, 2021). The experiment was carried out five times. The experimental results are presented in Table 2.

Table 2 Calibration results of water debit measuring instruments

Trial to	The calculation results			Results of measuring water discharge with a flow meter sensor (liters/hour)	Results of measuring water discharge with a flow meter sensor (ml/s)
	Water volume(ml)	Time (second)	Water discharge Calculate Volume/time (ml/s)		
1	500	13.26	37.70	126	35
2	500	17	29.41	94	26.1
3	500	13.23	37.79	112	31.1
4	500	14.5	34.48	112	31.1
5	500	12.65	39.52	136	37.7

For a comparative recapitulation of the test results of the water discharge measuring instrument with a flowmeter, the test results using a measuring cup and timer are presented in Table 3.

Table 3 Recapitulation of the calibration results of water debit measuring instruments

Trial to	Q reference	Qalat	%error	Error
1	37,71	35.00	0.08	35.00±2.92
2	29,41	26,11	0.13	26.11±3.72
3	37,79	31,11	0.21	31.11±8.12
4	34,48	31,11	0.11	31.11±3.74
5	39,53	37,78	0.05	37.78±1.83

Based on the comparison result from measurement values of the teaching aids using a flowmeter sensor with the results calculated using a measuring cup and a timer, it is known that the water discharge is 37.71 L/s with an error rate of 0.08%, the error is 35.00 ± 2.92, the water discharge is 29.41 obtained error rate of 0.13% and error 26.11 ± 3.72, for water discharge 37.79 error rate 0.21% error 31.11 ± 8.12, for water debit 34.48% error 0.11 error 31.11 ± 3.74, while for water debit 39.53 % error 0.05 error 37.78 ± 1.83.

The average error or error level of the water discharge prop with a flowmeter sensor is 0.11% and is relatively small. Thus, based on the data analysis results. We can conclude that the water discharge teaching aid with this flowmeter sensor has good accuracy because the percentage error rate of the tool is very low. However, it lacks precision because there are still differences in data on repeated measurements. The lack of precision of this tool is caused by the sensor's sensitivity, which is influenced by the flowing voltage and the response time on the sensor system, so it is necessary to use a measurement error system.

The tool calibration results show that the error rate obtained from measuring the water discharge is relatively small. This study's results align with the research of Criminisi (2009), who found that the results of the measured tools produce a very low error rate through the calibration results. The developed water discharge meter is considered accurate and can be used to measure water discharge.

The next stage is product validation, which is conducted to see the feasibility of an instrument of water discharge measuring using a flow meter sensor to become a teaching medium. The validated aspects include the usefulness of the tool, its presentation, and its physical appearance. The results of the validation of the feasibility study of the tool are shown in Table 4.

Table 4 Validation results

Aspect	Results	Validity Category
Benefit	0.85	High
Presentation	0.80	High
Physical appearance	0.70	Medium
Average	**0.78**	**High**

Table 4 shows that the water discharge measuring instrument, in terms of the aspects of benefits, presentation, and physical appearance, obtained values ranging from 0.7 to 0.85, where the aspects of benefits and presentation obtained in the high category and for aspects of physical appearance are in the medium category. If reviewed thoroughly, the validation results from the water discharge measuring instrument conducted a value of 0.78 in the high category.

Based on the validation results of the water discharge measuring instrument that has been carried out, it can be concluded that the developed water discharge measuring instrument has high validity, so this water discharge measuring instrument can be applied to support increasing concept understanding of students in dynamic fluid material. The use of a water discharge measuring instrument as a learning medium is in line with research (Mundilarto & Pamulasari, 2017) where learning does not have to be done in class but can take advantage of the environment outside the

classroom to increase concept understanding of students in dynamic fluid material. Using measuring instruments as media for learning can provide students with meaningful learning experiences (Alkan, 2016).

The product that has been created has gone through a calibration process and is valid. Furthermore, a water discharge measuring device using a flow meter in physics learning can be used as a visual aid in a fluid material, which is the subject of water discharge (Martin, 2003). Students will use the tool to be demonstrated in class. Through practice, students can understand the concept of water discharge, namely how the discharge relates to volume and time in one of the dynamic fluid concepts. Wang (2017) explains that hands-on learning experiences are necessary to gain understanding of concepts.

CONCLUSION

Based on the data analysis above, it was concluded that the water discharge measuring instrument with a flowmeter sensor as a learning medium obtained results with a very small error rate, namely 0.11%, which was obtained through the measuring instrument calibration process. The results of the validity assessment showed that the water discharge measuring instrument had a validity of 0.78 in the high category, making it suitable for use as a learning medium to support an increased understanding of concepts in a dynamic fluid material. Using this air discharge measuring instrument will help students understand the concept of fluid dynamics, especially in air discharge subjects.

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