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Development of Arduino-Based Flowmeter Sensor Props for Measuring Water Flow in Dynamic Fluid Materials

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Abstract

The purpose of this study is to describe the validity of an Arduino-based flowmeter sensor tool to measure water flow in dynamic fluid materials, as well as the suitability of an Arduino-based flowmeter sensor tool to measure water flow in dynamic fluid materials compared to the theory of continuity principles. Development research using the ADDIE model is the method used (Analysis, Design, Development, Implementation, Evaluation). The validity of the Arduino-based flowmeter sensor is determined by the results of a professional lecturer validator and the accuracy of the test results or the level of accuracy using teaching aids. The accuracy calculation was used to assess the suitability of the Arduino-based flowmeter sensor application for the theory. Based on the data that has been obtained, the validation results, and the accuracy level of the teaching aid have a percentage of 61%, so the validity level of the Arduino-based flowmeter sensor for measuring water flow is included in the very good category. The validation of teaching aids resulted in a percentage of 93.1%, while experimental data using an Arduino-based flowmeter sensor resulted in an average accuracy rate of 99.19%. Meanwhile, the accuracy of teaching aids to the concept of continuity principle was obtained with an average accuracy rating of 98.12%. By holding this practicum activity, students can better understand the concept and improve students' critical thinking. Given that during practical activities, students are required to solve a problem. The accuracy of teaching aids is included in the very good category on the interpretation scale.

Keywords: Water Discharge, Flowmeter Sensor, Dynamic Fluid

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INTRODUCTION

Along with the rapid progress of science and technology, education plays an important role in life. As a result, the Indonesian government has undertaken several initiatives to improve education. To improve the quality of education, the government through the Ministry of Education and Culture issued a policy on education quality assurance in the Education Quality Assurance System (SPMP) (Sulaiman & Wibowo, 2016)

Success in the teaching and learning process is determined by many factors; the teacher is not the only determinant of the success of the teaching and learning process, but there are still other factors that are still needed in the teaching and learning process to achieve the success process and increase student activity. One of the important factors in learning is the media and methods used by teachers to achieve maximum student learning outcomes (Yasir, 2017). The teaching-learning process is an interaction between two human elements, namely students as learners and teachers as teachers, with students as the main topic (Sardiman, 2008). The purpose of a realization comes from the realization of the National Education Law through the process of teaching and learning activities independently in an educational institution.

Physics is one of the Natural Sciences (IPA) that is used in everyday life. One of the topics of Physics is holistic physics, which discusses matter, energy, and natural events or phenomena, both macroscopic and microscopic, which are associated with changes in energy or matter (Sumarsono, 2009). Thus, in studying physics, it can be obtained from observing events exclusively in nature. In general, there are three aspects of the physics dimension: (1) behavioral aspects; (2) process aspects, and (3) knowledge aspects (Suverinus, 2013). The purpose of learning Physics is so that students can understand the subject in more depth, so an interesting learning media is needed.

Learning media are teaching and learning process aids that can be used to stimulate students' thinking patterns, feelings, attention, and learning skills (Sadiman, 2019). Thus, learning media can be one of the determining factors for success in the learning process (Zahro, et al., 2017). For example, learning that is accompanied by teaching aids in the form of experiments can help students gain experience in developing skills and attitudes in scientific processes and understanding related to Physics concepts. According to (Sanjaya, 2009), personal experience in learning activities is very useful, because by experiencing something personally or directly, it can minimize the occurrence of misunderstanding of concepts. Therefore, this teaching aid is very much needed by students in understanding the concept of the material that has been given, one of which is dynamic fluid material in the water discharge sub-chapter, which is one of the physics subject matter at the odd semester class XI high school level.

Fluids are substances that can flow and follow the shape of their container. If it is at equilibrium point, the fluid is unable to resist the shear or tangential forces. All fluids cannot be compressed or what is known as the degree of compressibility (Giles, 1984). Fluids are grouped into two, namely static fluid (still) and dynamic fluid (motion) which are not the same in nature and are widely applied in everyday life, both in simple technology and advanced technology.

The results of previous research conducted by (Shidqi & Anggaryani, 2020), have developed a flowmeter sensor-based teaching aid to apply the continuity equation. Electromagnetic flowmeter works according to Faraday's law on electromagnetic induction materials to measure flow processes. The signal voltage level corresponds to the average flow velocity induced at the electrode as a conductive liquid flows through a magnetic field at a given velocity. However, in this study there are still some shortcomings in the teaching aids. The shortcomings of teaching aids are: the absence of a fluid filter, so that if fluid used dirty can inhibit the wheel on sensor and causes the data obtained to be less in accordance. In additional, the LCD used in this teaching aids is relatively small, so when used as a learning media in class data displayed on the LCD less visible.

Development of a flowmeter sensor tool and an Arduino fluid is expected to be able to improve students conceptual understanding in learning topic. Based on the description that has been stated above, need to be developed of an Arduino-Based Flowmeter Sensor Tool for Measuring Water Flow in Dynamic Fluid Materials in terms of validity, level of accuracy and accuracy of the Arduino-based flowmeter sensor to determine the flow of water in fluid materials. By holding this practicum activity, students can better understand the concept and improve students' critical thinking. Given that during practical activities, students are required to solve a problem.

METHOD

The type of research developed in this research is ADDIE development model research (Analysis, Design, Development, Implementation, and Evaluation). The development in question is developing a Static Fluid learning media in the Water Discharge sub-material. According to (Branch, 2009) the ADDIE method is very suitable when used in development research. The following are the five phases contained in the ADDIE model development method.

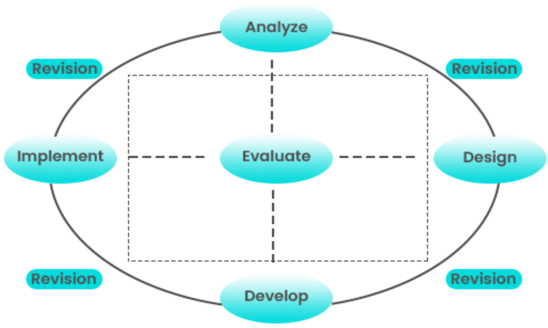

Fig 1. ADDIE Development Method Schematic (Branch, 2009)

The Analysis stage is a data collection process that aims to find out what the needs of the research object are. At this stage, researchers analyzed the need to develop an Arduino-based flowmeter sensor to measure water discharge in its development.

In the Design phase, the initial design of the visual aid was developed and designed for the design of an Arduino-based flowmeter sensor for measuring water flow.

The Development stage is the product reality stage. At this stage, several activities are carried out including making, buying, and modifying teaching aids as a medium in learning to achieve predetermined learning objectives.

The Implementation stage is the stage of testing teaching aids as learning media that have been developed. The validation process is carried out in two stages, namely testing the validity of teaching aids and testing props. At the validity test stage, it is carried out by giving validation instruments to the validator to provide an assessment of the validation of the Arduino-based flowmeter sensor to measure the water flow that has been developed. Meanwhile, the experimental test phase was carried out using validation instruments, learning instruments (LKPD, RPP, and syllabus) and instructions for using an Arduino-based flowmeter sensor to measure water flow. This research was conducted at the Physics Department, State University of Surabaya in the even semester of the 2021/2022 academic year.

In the Evaluation stage, an improvement process is carried out for a better system; the researcher processes the data that has been obtained from the previous stages that have been carried out. At this stage, it can be seen the advantages and disadvantages of teaching aids that have been developed based on some input from expert lecturers and experimental data obtained.

The analytical technique used in this development research was carried out in two stages, namely the analysis of the validity of the teaching aids and the analysis of the suitability of the teaching aids data. The validity of the teaching aids was analyzed in two stages, namely the analysis phase of the validation results and the analysis of the level of accuracy of the teaching aids.

The validation of teaching aids can be analyzed using a Likert Scale as shown in the table below:

Table 1. Scores Likert Scale

Rating Indicator	Scale Value
Excelent	5
Good	4
Enough	3
Less	2
Very Less	1

(Riduwan, 2013)

After that, the percentage of assessment that has been obtained is calculated using the following formula:

$$P = \frac{K}{n} x\ 100\% \quad \dots\dots\dots (1)$$

Description:
P = Percentage of ratings obtained
K = Number of ratings earned
n = Maximum score

Based on the results of calculations using the formula, it can be determined the feasibility of teaching aids according to the score interpretation criteria as in table 2:

Table 2. Score Interpretation Criteria

Percentage (%)	Criteria
0 – 20	Very Less
21 - 40	Less
41 – 60	Enough
61 – 80	Worthy
81 – 100	Very Worthy

(Riduwan, 2013)

The results of the validation of the water discharge display in Table 2 can be classified as feasible if its percentage is more than equal to 61%.

After analyzing the validation of the teaching aids, an analysis of the level of accuracy of the teaching aids was carried out. The level of accuracy of these teaching aids can be seen from the results of experiments using teaching aids. The experimental results using an Arduino-based flowmeter sensor to measure the water flow that has been developed are analyzed through the following stages:

a) Uncertainly (ΔX)

$$\Delta X = \frac{(Xmax - Xmin)}{2} \quad \dots\dots\dots\dots (2)$$

$$SE = \frac{(\Delta X)}{Xrata - rata} x\ 100\% \quad \dots\dots\dots\dots (3)$$

(Tim Laboratorium Fisika Dasar, 2020)

Dimana:
ΔX = X Data Uncertainty
$Xmax$ = Maximum X data
$Xmin$ = Minimum X data

b) Level of Accuracy (TK)

$$TK = (100 - SE)\% \quad \dots\dots\dots\dots (4)$$

Dimana:
TK = Level of Accuracy
SE = ***Standard error***

The results of the calculations with these formulas are analyzed based on the score interpretation criteria in Table 2, where the level of accuracy of the Arduino-based flowmeter sensor for measuring airflow can be said to be good if the percentage is more than equal to 61%.

In this second stage, an analysis of the suitability of the Arduino-based flowmeter sensor is carried out for measuring water flow. This analysis is carried out by comparing the suitability of the data obtained based on theory or real data with the data that will appear on the display of the props read by the sensor. The analysis of the suitability of the props can be done as follows:

c) Accuracy

Accuracy is the measurement result of a measuring instrument against a standard value or against a correct value (Nasution & Rahmawati, 2019). In some applications, this accuracy can be interpreted as the limit of deviation in measurement or the limit of intrinsic error.

The relative accuracy is expressed by:

$$A = 1 - \left|\frac{Yn - Xn}{Yn}\right| \qquad \ldots\ldots\ldots\ldots(5)$$

Dimana :
A = Relative Accuracy
Yn = True Value
Xn = Measured Value
Accuracy can also be expressed in percent accuracy as follows:

$$Accuracy = A\ x\ 100\% \qquad \ldots\ldots\ldots\ldots(6)$$

An Arduino-based flowmeter sensor for measuring water flow can be said to be in accordance with the theory if it has an accuracy percentage of more than or equal to 61%.

RESULTS AND DISCUSSION

Teaching aid is a tool that can be used in teaching and learning activities (KBM) which serves to help students achieve learning goals (Nomleni & Manu, 2018).The existence of these teaching aids can be used as a solution to the constraints of the space dimension and also the time dimension; as a result, students can have free access to learning resources and learning media that can make it easier to understand the concept of the material perfectly and thoroughly.

These educational teaching aids are arranged according to the principle that any knowledge that exists in humans is received or captured through the five senses as a gift from the Almighty; thus the more tools humans use in obtaining information, the clearer the knowledge obtained will be. Things that happen due to the function of the props themselves, namely, being able to direct the human senses towards an object, can facilitate understanding.

Based on the opinion of (Asyar, 2012) Learning media can be understood as anything that can convey or distribute messages originating from a source on a scheduled basis, so that an efficient and effective learning process can be created or a conducive learning environment can be realized. In addition, learning media can also be interpreted as something that can channel messages, stimulate the thoughts, feelings, and willingness of students so that they are able to encourage the creation of a learning process in students. One of the learning media that can be used is the use of teaching aids.

Teaching aid is a tool that can function as a support for students in understanding abstract concepts to be clear. Therefore, the existence of this teaching aid is able to increase thoughts, attention, interest, and be able to provide more experience to students in direct practicum activities (Affida & Prabowo, 2017)

In this research, an Arduino-based flowmeter sensor will be made to measure water flow. This teaching aid is designed by using several electrical components as well as the main components. The electrical components consist of a flowmeter to measure the current flow, an Arduino nano microcontroller to manage sensor data and controlling the system, a DC voltmeter to measure the voltage at a DC pump, a buck converter to adjust the size of the DC pump supply voltage, a 5V buck converter to supply a microcontroller, 12V adapter to convert 220VAC to 12VDC, 1 channel relay to set on/off DC pump and push button to on/off. The main components consist of a 12 V DC pump, the main water storage area, a water measuring cup, a board for the base, wooden support poles, and a water supply hose.

Here is the design of the props that will be used:

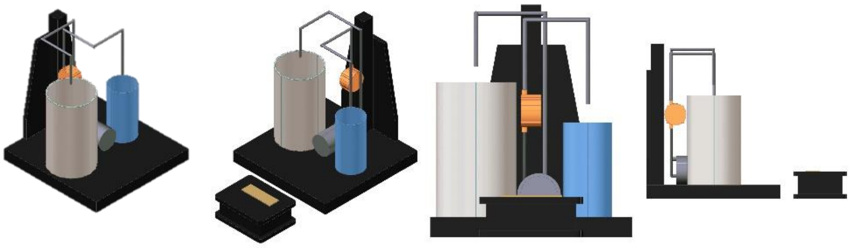

Fig 2. Arduino Based Sensor Flowmeter Teaching Aid Design For Measuring Water Flow
(Source: Personal Documents)

The material that is the subject of this research is fluid material. Fluid in the physical sense is a substance that can flow and follow a state based on the geometry of its container. Fluids cannot withstand tangential or shear stresses if they are in equilibrium. All fluids have a degree of compressibility (inability to be compressed) and provide a minimum resistance to deformation (Giles, 1984).

An ideal fluid, as defined by Halliday in his 2004 book *"Fundamentals of Physics, 7th Edition,"* is one whose flow is constant, incompressible, non-viscous, and non-rotating. The path traveled by particles in a moving fluid is called a flow line. Stream line and turbulent flow are two possible fluid flows that can occur in a flowing fluid.

Water discharge is the volume of fluid that flows through a certain cross-section at a certain time interval as a result of fluid flow. Mathematically it can be stated as follows:

$$Q = \frac{V}{t} \quad \dots\dots\dots\dots (7)$$

Where, Q = Fluid discharge (m^3/s)
V = Fluid Volume (m^3)
t = Time (s)

The discharge of water flowing in the pipe can be described as follows:

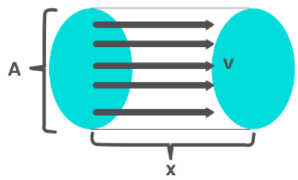

Fig 3. Fluid flow in the pipe
(Source: Personal Documents)

Sensors are electronic components that convert physical quantities into electrical quantities that can be checked using certain electrical circuits. A flowmeter sensor is a type of sensor that measures liquid flow. The flowmeter sensor is a component of the flowmeter.

A flowmeter is a device that measures the amount and rate of fluid flow through a pipe. The Hall Effect, which is based on the effect of a magnetic field on charged particles, is used in this sensor (Ayubi *et al*., 2015) .Primary devices plus secondary devices make up this tool. As the flow rate has been disrupted, the primary device generates a signal that responds to the flow, while the secondary device receives a signal from the primary device and displays, records, or transmits it as a result of the flow rate (Koestoer, 2004).

The way the flowmeter sensor works is by calculating the rotation of the waterwheel in the flowmeter, which will then rotate automatically if there is a flow of water passing through it. A rotor with magnets inside a waterwheel generates a magnetic field as it rotates, based on the "Hall Effect" principle, which is the presence or absence of a magnetic field.

Fig 4. Flowmeter sensor
(Source: create.arduino.cc)

A microcontroller is a micro controller in an electronic circuit that acts as a controller to regulate the work process of an electronic circuit. In contrast to a microprocessor that performs data processing, the entire computer system is packaged on a chip that includes a CPU, supports input/output (I/o), memory, and even an ADC that performs one or more specific tasks.

Arduino is an electronic prototype device based on a microcontroller with open source hardware components. Arduino is a development platform that combines powerful hardware, a programming language, and an Integrated Development Environment (IDE). An IDE is a piece of software that acts as a program writer, decodes the binary code, and uploads it to the memory of the microcontroller.

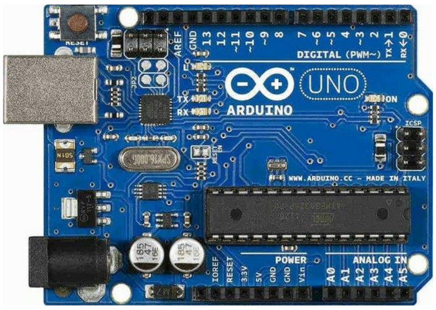

Fig 5. Arduino Nano Uno Microcontroller
(Source : Elektrologi.iptek.web.id)

This study uses the ADDIE model where this model consists of several stages including the Analysis, Design, Development, Implementation, and Evaluation stages. The following are the results of each stage of the research:

1. *Analysis*

At this stage of analysis, the results of curriculum analysis, material analysis and analysis of teaching aids have been obtained as follows:

1.1. Curiculum Analysis

The curriculum that is the reference in this research is the 2013 Curriculum (K-13) with revisions. In accordance with the implementation of the 2013 curriculum, it includes the development of attitudes, knowledge, and skills competencies. In the process of learning science, especially physics, it cannot be separated from practical activities. (Woolnough & Terry, 1985)suggest that there are four reasons why science practicum activities are important. First, practicum is able to generate students' learning motivation. Second, practices can develop basic skills in conducting experiments or experiments. Third, practicum can be a vehicle or means in learning the scientific approach or commonly referred to as the scientific approach. Fourth, the practicum is able to support the subject matter.

This experimental activity is very important in the learning process so that the media used to conduct experiments or practices is also very important. With the development of teaching aids, students can conduct experiments to improve skills as well as a form of application of the knowledge they have gained when learning in the classroom.

1.2. Material Analysis

This material analysis was carried out by analyzing the basic competencies contained in the syllabus and lesson plans used in the Arduino-based flowmeter sensor to measure water flow. The material in this teaching aid is the material for Dynamic Fluids in the Continuity Principles sub-chapter, with basic competencies (KD) 3.4 and 4.7, namely:

3.4. Apply dynamic fluid principles to technology.

4.7. Modify simple project ideas that apply fluid dynamics principles.

In order for the basic competencies mentioned above to be achieved, students must conduct experiments on the Dynamic Fluids material; here we conduct experiments on the sub-chapter on the Principle of Continuity. In conducting the practicum, it is necessary to have media in the form of teaching aids to help the learning process of students. Therefore, it is necessary to develop an Arduino-based flowmeter sensor to measure water discharge as a learning medium so that students can do practicals or experiments so that these basic competencies can be achieved.

1.3. Analysis Props

The analysis of teaching aids is done by analyzing previous research. This research is based on research conducted by (Shidqi & Anggaryani, 2020) at the Physics Department, State University of Surabaya in the first semester of the 2019/2020 academic year.

The advantage of the teaching aids in this study is to use 2 flowmeter sensors and a pipe that is firmly installed. The weakness of the teaching aids in this study is that the teaching aids are very large, so they are not flexible to be carried anywhere. From these weaknesses, it can be seen that the teaching aids developed by (Shidqi & Anggaryani, 2020) still need some development so that the teaching aids can function optimally.

Based on the analysis of teaching aids that have been carried out, in this study, a flowmeter sensor based on Arduino Uno nano was developed to determine the flow of water in dynamic fluid materials. The props use digital calculations which then the data will be displayed on the LCD so that users can read it easily. The LCD will display the volume value that is read on the measuring cup and the water discharge value based on digital calculations. In addition, in measuring the time required, there is no need to use a manual stopwatch, because it can be programed using data that has been coded, and can determine the desired time.

2. ***Design***

The second stage of the ADDIE model research is the Design stage. The second stage is to make and develop the initial design of the visual aid as well as the process of making an Arduino-based sensor flowmeter to measure water flow. The following is the design of teaching aids that will be developed by researchers:

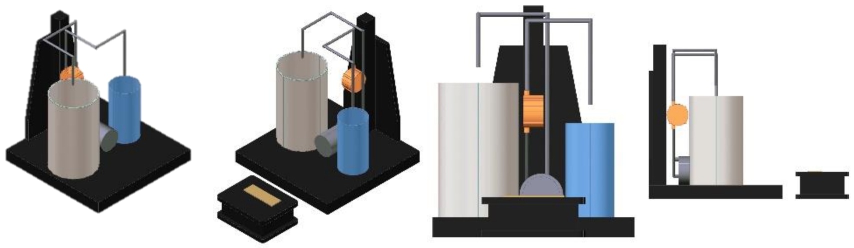

Fig 6. Arduino-based Flowmeter Sensor Trainer Design for Measuring Water Flow (Source: Personal Documents)

The following is a form of Arduino-based flowmeter sensor for measuring water flow that has been developed:

Fig 7. Arduino-based Flowmeter Sensor Trainer for Measuring Water Flow
(Source: Personal Documents)

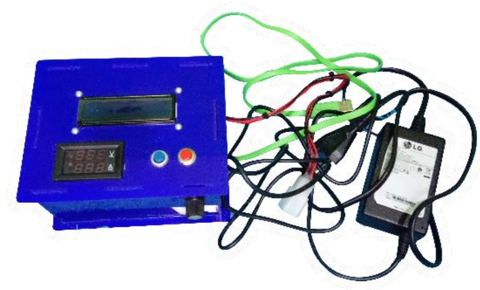

Fig 8. Box Electric
(Source: Personal Documents)

Some of the tools and materials used in the development of this teaching aid are as follows:

Main Component:

1. 12V DC Pump for Pumping Water.
2. Main water storage.
3. Measuring glass.
4. Board for pedestal.
5. Wooden poles for hose supports.
6. Hose for channeling water.

Electric Component:

1. Flow meter for measuring current flow.
2. Arduino Nano microcontroller for managing sensor data and controlling system.
3. Push button for ON/OFF.
4. DC Voltmeter to measure the voltage on a DC pump.
5. Buck Converter to adjust the size of the DC pump supply voltage.
6. Relay 1 Channel to set ON/OFF DC pump.
7. 12V adapter to convert 220VAC to 12VDC.
8. Buck Converter 5V for microcontroller supply.
9. 2x16 display to display measurement data.

The variables used in the props that will be developed in this study are as follows:

Trial 1

a. Control variable : measuring cup, water storage tube, arduino program, voltage (T)
b. Manipulation variable : time (t)
c. Response variable : water volume (V), water discharge (Q)

Trial 2

a. Control variable : measuring cup, water storage tube, arduino program, time (t)
b. Manipulation variable: voltage (T)
c. Response variable : water volume (V), water discharge (Q)

3. *Development*

The development stage is the product reality stage. The development of an Arduino-based flowmeter sensor to measure water flow is carried out according to the design that has been made. Furthermore, the Arduino-based flowmeter sensor to measure water flow will be validated by expert lecturers. In the validation process, the validator uses an instrument that has been compiled. At this stage the validator is asked to provide an assessment of the Arduino-based flowmeter sensor tool to measure the water flow that has been developed based on the feasibility aspect and to provide suggestions and comments that are used as a benchmark as material for evaluation, improvement, and refinement of the teaching aids.

4. *Implementation*

The implementation stage is the testing stage for the Arduino-based flowmeter sensor to measure the water flow that has been developed. Testing the Arduino-based flowmeter sensor to measure water flow was carried out in two stages, namely testing the validity of the tool and testing the instrument experiment.

4.1. Props Validity

The validation of the Arduino-based flowmeter sensor to measure water flow was carried out by two expert lecturers from the Department of Physics, State University of Surabaya, using a validation sheet that refers to the Likert scale. The validity of teaching aids is reviewed from several aspects, namely aspects of relevance to teaching materials, aspects of educational value, aspects of teaching aids resistance, aspects of teaching aids accuracy, aspects of teaching, aid efficiency, safety aspects of teaching aids, and aesthetic aspects. The following is a table of validation results from an Arduino-based flowmeter sensor for measuring water flow in dynamic fluid materials:

Table 3. Recapitulation of Validation Results

Number	Eligibility Aspect	Rating Result		Total
		Validator 1	Validator 2	
1	Linkage with Teaching Materials			
	a. Concepts Taught	5	5	10
	b. Level of need for learning	5	5	10
2	Education Value			
	a. Conformity with the intellectual development of students	5	5	10
	b. Kompetensi yang ditingkatkan pada peserta didik	5	5	10
3	Props Resistance			
	a. Weather resistance	4	5	9
	b. Ease of storage of props	4	5	9
	c. Ease of maintenance of props	4	5	9
	d. Resistance of components in position	4	4	8
4	Props Accuracy			
	a. The precision of installation of each component	4	4	8
	b. Measurement accuracy	4	4	8
5	Props Efficiency			

	a. Ease of assembling props	4	5	9
	b. Ease of use of props	4	5	9
6	Safety Props			
	a. Safety for students	5	5	10
	b. Safe construction of teaching aids for students	5	5	10
7	Aesthetics			
	a. Colour	5	5	10
	b. Shape	5	5	10
	Total			**149**
	Validation Percentage			**93.13%**

Based on Table 3, the validation results of two expert lecturers from the Department of Physics, State University of Surabaya, above, obtained the validation percentage of 93.13%. The Arduino-based flowmeter sensor prop to measure water discharge with a validation percentage of 93.13% is said to be very feasible based on the percentage of the props feasibility assessment (Riduwan, 2013).

In the validation, there were also some inputs from the validators of two expert lecturers as a form of improvement to the teaching aids that were developed in order to function better. The following are suggestions and improvements based on the validation results of the props:

1) More attention is paid to the assembly of props components.
2) Conceptually, it can represent the principle of continuity and must also be distinguished from Bernoulli's law in dynamic fluids for students to be able to think critically.
3) Provide understanding and application of the Principle of Continuity in everyday life.

4.2. Props Data

For experiments with Arduino-based flowmeter sensors to measure water flow, two experiments were carried out. The first experiment was carried out by manipulating the time (t) and controlling the voltage value (T) six times and each time three repetitions were carried out. In the second experiment, the manipulation of the voltage value (T) and controlling the time (t) was carried out five times and for every 1 voltage, three repetitions were carried out. The repetition of the first and second experiments was carried out to get the best results. The following are the results of experiments that have been carried out using props that have been developed:

4.2.1. Experiment Data Props

1. First Try

The first experiment uses a voltage (T) of 6 volts (V)

Table 4. First Trial Data

Numb	t (s)	V (mL)		Q (mL/s)			
		Display	Measur-ing cup	Display	Display average	Measur-ing cup	Measuring cup average
1	2	19.54	20	9.77	9.81	10	10
		20.04		10.02			
		19.30		9.65			
2	3	35.05	35	11.68	11.56	11.67	11.67
		34.80		11.60			
		34.23		11.41			

3	4	49.31 49.81 48.96	50	12.33 12.45 12.24	12.34	12.5	12.5
4	5	64.16 63.76 63.85	65	12.83 12.75 12.77	12.78	13	13
5	6	77.53 77.88 77.76	80	12.92 12.98 12.96	12.95	13.33	13.33
6	7	91.78 92.77 93.80	95	13.11 13.24 13.40	13.25	13.57	13.57

2. Second Try
   The second experiment uses a time (t) of 5 second (s)

Table 5. Second Trial Data

Numb	T (V)	V (mL)		Q (mL/s)			
		Display	Measur-ing cup	Display	Display average	Measur-ing cup	Measuring cup average
1	4	34.92 34.95 33.94	35	6.98 6.99 6.79	6.92	7	7
2	5	49.26 49.56 49.11	50	9.85 9.91 9.82	9.86	10	10
3	6	63.67 63.76 63.55	65	12.73 12.75 12.71	12.73	13	13
4	7	77.36 77.41 78.22	80	15.47 15.48 15.64	15.53	16	16
5	8	93.35 93.06 92.42	95	18.67 18.61 18.48	18.58	19	19

In the first experiment, manipulation of the time value (t) in units of second (s) was carried out and controlling the value of voltage (T) in volts (V) of 6 volts (6 V). In this experiment, time manipulation was carried out six times, in which each time value manipulation (t) was repeated three times to produce more accurate values. Based on the data obtained, it can be concluded that the greater the time value (t) used, the greater the volume of bullae (V) produced, therefore the value of the water discharge (Q) will be even greater, this is in accordance with the following equation i.e. Q= V/t. So it can be concluded that the relationship between time (t) and water discharge (Q) is directly proportional.

In the second experiment, manipulating the voltage value (T) in volts (V) and controlling the time value (t) in seconds (s) worth 5 seconds (5 s). In this experiment, five times the manipulation of the stress value was carried out, in which each manipulation of the stress value (T) was repeated three times to produce a more accurate value. Based on the data obtained, it can be concluded that the greater the value of the voltage (T) used, the greater the volume of bullae

(V) produced. Therefore, the value of the water discharge (Q) will be even greater. So it can be concluded that the relationship between voltage (T) and water discharge (Q) is directly proportional.

The response variable is the volume of water (V) in milliliters (mL) that appears on the display and the measuring cup on the props, where the results of the two will be compared, to the difference. In addition, the display also shows the water discharge value (Q) in milliliters per second (mL/s) while in the experiment (measuring cup) to determine the water discharge value (Q) is calculated using the following equation: $Q = \frac{V}{t}$. This is in accordance with the definition of the water discharge itself; the water discharge is the volume of a fluid flowing through a certain cross-section at a certain time interval.

4.2.2. Value of Uncertainly Props (Δx) and Level of Accuracy Props (TK)

$$\Delta X = \frac{(Xmax - Xmin)}{2} \quad \ldots\ldots\ldots\ldots (8)$$

$$SE = \frac{(\Delta X)}{Xrata - rata}\ x\ 100\% \quad \ldots\ldots\ldots\ldots (9)$$

(Tim Laboratorium Fisika Dasar, 2020)

Where:
ΔX = X data uncertainty
$Xmax$ = Maximum X data
$Xmin$ = Minimum X data

$$TK = (100 - SE)\% \quad \ldots\ldots\ldots\ldots (10)$$

Where:
TK = Accuracy level
SE = ***Standard error***

Table 6. Analysis of the Uncertainty Value and Level of Accuracy of the First Experimental Teaching Aid

Numb	t (s)	Q (mL/s)	∑Q/3	Δx	SE (%)	TK (%)
1	2	9.77 10.02 9.65	9.81	0.19	1.94	98.06
2	3	11.68 11.60 11.41	11.56	0.14	1.21	98.79
3	4	12.33 12.45 12.24	12.34	0.11	0.89	99.11
4	5	12.83 12.75 12.77	12.78	0.04	0.31	99.69
5	6	12.92 12.98 12.96	12.95	0.03	0.23	99.77
6	7	13.11 13.24 13.40	13.25	0.15	1.13	98.87
Average Accuracy Level						**99.04 %**

In the first experiment, it can be seen that the level of accuracy (TK) on the Arduino-based flowmeter sensor for measuring water flow is 99.04%.

Table 7. Analysis of the Uncertainty Value and Level of Accuracy of the Second Experimental Teaching Aid

Numb	T (V)	Q (mL/s)	∑Q/3	Δx	SE (%)	TK (%)
1	4	6.98 6.99 6.79	6.92	0.1	1.45	98.55
2	5	9.85 9.91 9.82	9.86	0.05	0.51	99.49
3	6	12.73 12.75 12.71	12.73	0.02	0.16	99.84
4	7	15.47 15.48 15.64	15.53	0.09	0.58	99.42
5	8	18.67 18.61 18.48	18.58	0.1	0.54	99.46
		Average Accuracy Level				**99.35 %**

In the first experiment, it can be seen that the level of accuracy (TK) on the Arduino-based flowmeter sensor for measuring water flow is 99.35%.

From the two experiments, the average level of accuracy of the Arduino-based flowmeter sensor for measuring water flow was obtained, namely:

$$\frac{\sum TK\ 1 + \sum TK\ 2}{2} = \frac{99{,}04\ \% + 99{,}35\ \%}{2} = \mathbf{99{,}19}\%$$

Based on the value of the average level of accuracy, it can be concluded that the Arduino-based flowmeter sensor for measuring water flow is classified as very good.

4.2.3. Appropriateness of Props (Accuracy)

The relative accuracy is expressed by:

$$A = 1 - \left|\frac{Yn - Xn}{Yn}\right|$$

Dimana:

A = Relative Accuracy

Yn = True Value

Xn = Measured Value

Accuracy can also be expressed in percent accuracy as follows:

$$Accuracy = A\ x\ 100\%$$

Based on the above equation, we can analyze the suitability of the Arduino-based flowmeter sensor to measure the flow of water in dynamic fluid materials, here is the analysis table:

Table 8. Analysis of the Suitability of Props in the First Experiment

Numb	t (s)	V (mL)		AccuracyV		Q (mL/s)		Accuracy Q	
		Display	Measu-ring cup	A	A%	Display	Measu-ring cup	A	A%
1	2	19.63	20	0.981	98.1	9.81	10.00	0.981	98.1
2	3	34.69	35	0.991	99.1	11.56	11.67	0.990	99.0
3	4	49.36	50	0.987	98.7	12.34	12.50	0.987	98.7
4	5	63.92	65	0.983	98.3	12.78	13.00	0.983	98.3
5	6	77.72	80	0.971	97.1	12.95	13.33	0.971	97.1

6	7	92.78	95	0.977	97.7	13.25	13.57	0.997	99.7
		∑A%/6 = 98.2 %				∑A%/6 = 98.2 %			

In the first experiment, it can be seen that the Arduino-based flowmeter sensor for measuring water flow has an average accuracy value of 98.2%.

Table 9. Analysis of the Suitability of Props in the Second Experiment

Numb	T (V)	V (mL)		Accuracy V		Q (mL/s)		Accuracy Q	
		Display	Measu-ring cup	A	A%	Display	Measu-ring cup	A	A%
1	4	34.60	35	0.988	98.8	6.92	7	0.988	98.8
2	5	49.31	50	0.986	98.6	9.86	10	0.986	98.6
3	6	63.66	65	0.979	97.9	12.73	13	0.979	97.9
4	7	77.66	80	0.971	97.1	15.53	16	0.971	97.1
5	8	92.94	95	0.978	97.8	18.58	19	0.978	97.8
		∑A%/5 = 98.04%				∑A%/5 = 98.04 %			

In the first experiment, it can be seen that the Arduino-based flowmeter sensor for measuring water flow has an average accuracy value of 98.04%.

From these two experiments, the average accuracy value of the Arduino-based flowmeter sensor for measuring water flow is:

$$\frac{\sum A\%\,1 + \sum A\%\,2}{2} = \frac{98{,}2\% + 98{,}04\%}{2} = \mathbf{98{,}12}\%$$

Based on the score interpretation criteria table, the Arduino-based flowmeter sensor for measuring water flow can be said to be in accordance with the theory and is in the very good category.

5. *Evaluation*

Based on the implementation results that have been described, it can be concluded that the validation value of the Arduino-based flowmeter sensor for measuring water flow obtained through validity testing by two expert lecturers obtained a validation percentage value of 93.13% and is included in the very feasible category. The level of accuracy of teaching aids in the first experiment obtained a percentage value of 99.04% and in the second experiment a value of 99.35% was obtained. For the average value of the accuracy level of teaching aids; the results were 99.19%. Based on the score interpretation scale, the accuracy of the teaching aids is in the very good category. In the experimental test of teaching aids, the accuracy of teaching aids in the first experiment was 98.2% and in the second experiment it was 98.04%. For the average value of the accuracy of teaching aids, the results were 98.12%. Based on the scale of interpretation, the accuracy of the teaching aids is in the very good category.

The advantage of the Arduino-based flowmeter sensor for measuring water flow is that the data processing is done digitally, which is then displayed on the LCD display in the form of the water volume and the water discharge value obtained, so that users can see it easily. In addition, in measuring the time required, there is no need to use a manual stopwatch, because it can be programmed using data that has been coded, and can determine the desired time.

The drawback of teaching aids in the research that has been developed is that the LCD used in these teaching aids is relatively small, so that when used as a learning medium in the classroom, students must approach the teaching aids to see the results.

CONCLUSION

The results of the development of an Arduino-based flowmeter sensor tool for measuring water flow in dynamic fluid materials that have been tested and validated by two expert lecturers show that the teaching aid is in a very suitable category for use with a percentage of 93.13%, this is based on the criteria Likert scale, the results of the validation of the Arduino-based flowmeter sensor for measuring water flow can be said to be feasible if it has a percentage of more than or equal to 61%.

In addition, based on experimental data that has been carried out, the level of accuracy of the Arduino-based flowmeter sensor to measure water flow is 99.19% and the accuracy value is 98.12%, based on the scale of interpretation of the teaching aids score in the very good category.

RECOMMENDATION

The Arduino-based flowmeter sensor props for measuring water flow in dynamic fluid materials can be used by teachers to carry out practical activities for dynamic fluid materials in the continuity principle sub-chapter in the classroom.

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