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Developing A Viscometer Educational Aid Using Arduino Uno to Increase Scientific Attitude

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Abstract: The research aims to: (1) produce a viscometer educational aid using Arduino Uno to increase scientific attitude; (2) determine the appropriateness and quality of the Viscometer educational aid using Arduino Uno; (3) describe the students' response about educational aid, and (4) describe the effectiveness of the tool to improve scientific attitude. This study uses the ADDIE model which consists of the stages of analysis, design, development, implementation, and evaluation. The feasibility and quality of teaching aids are tested by expert judgment. Student responses to the use of media using a questionnaire. The appropriateness and quality, of the student responses were analyzed descriptively. The effectiveness of the tool in improving students' scientific attitude is analyzed with n gain. The results showed that a viscometer educational aid using Arduino Uno was very feasible. Student response to the use of media is very good. The use of a viscometer educational aid using Arduino Uno improves student attitudes with an n-gain of 0.7 in the medium category.

Keywords: Arduino; Educational aid; Fluids; Viscometer

Introduction

The Sustainable Development Goals (SDGs) in the field of Education direct inclusive, quality, lifelong education fairly and equitably. Competence of anticipatory, thinking skills, collaboration, problem-solving, self-awareness, and normative need to be realized to achieve quality education SDGs (UNESCO, 2017).

Industrial Revolution 4.0 requires individuals to care, be responsible, have character, respect each other, and be critical (Gleason, 2018). This foundation shows that important attitudes are mastered by students. The lack of interaction between students and their environment causes attitudes in learning science (scientific attitudes) not to develop optimally. Research has shown the problem of low scientific attitudes, namely: 18.5% and 61.5% of international students have low and moderate scientific attitudes (Paul et al., 2020), 40 students in conventional laboratories in Indonesia get a score of 39 (Astuti et al., 2020) and 58% of students in Pontianak City have a low scientific attitude (Hadiati et al., 2019a). This shows the scientific attitude needs to be improved. Development of laboratory experimentation models. Arduino-based laboratory work can improve scientific attitudes and HOTS (Hadiati et al., 2022). Digitalization of measurements using Arduino reduces subjectivity and measurement bias thereby sparking a scientific attitude (Hadiati et al., 2019b).

The use of Arduino for laboratory experimentation models, namely: determination of the kinetic friction coefficient (Çoban, 2020), light sensor (Sámano et al., 2019), and an investigation of Newton's Second Law (Van Bien et al., 2019). Other research is related to Arduino experimental tools, namely polarization and magnetic field experimental devices for remote laboratories (Ishafit et al., 2021, 2020). The weakness of this research is that the Arduino device was developed only as a measuring tool that has not focused on improving scientific attitudes. Another crucial weakness is that students do not develop their capacity, character, and values in line with their contribution to society (Gross et al., 2017).

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Therefore, it is necessary to develop a viscometer educational aid using Arduino Uno to Improve Students' Scientific Attitudes toward Quality Education SDGs. Arduino is used because the programming language is user-friendly. Sensor initialization is also easy to use. The use of arduino as a teaching aid control system can help improve scientific attitude.

Method

Research Procedure

This study uses the ADDIE model for product development. The ADDIE model consists of 5 stages, namely analysis, design, development or production, implementation or delivery, and evaluations (Sugiyono, 2017) as shown in Figure 1.

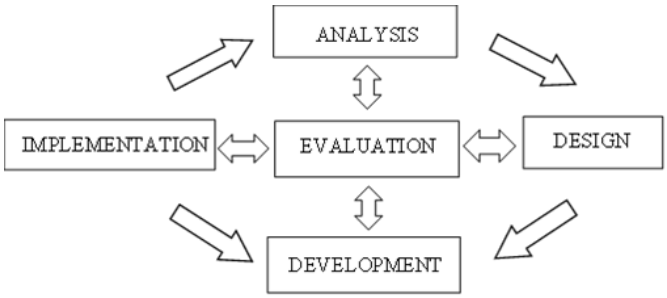

Figure 1. Stages of the ADDIE development model

An analysis was carried out for the development of a viscometer educational aid using Arduino as a support for physics learning practices on the topic of fluids. In the design phase, a schematic model of the hardware and software products will be developed in full in Figures 2 and 3.

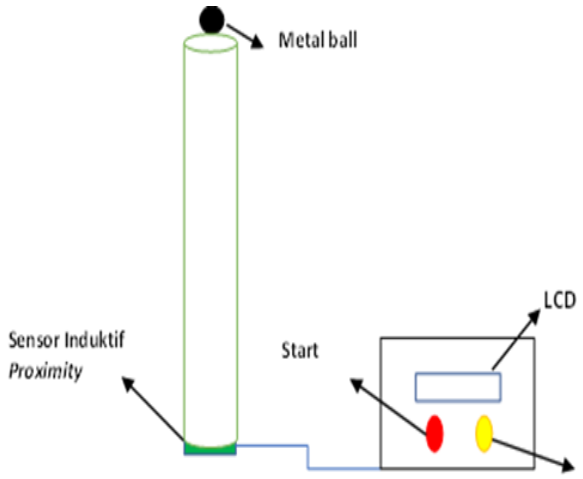

Figure 2. Plans for a viscometer educational aid using arduino uno

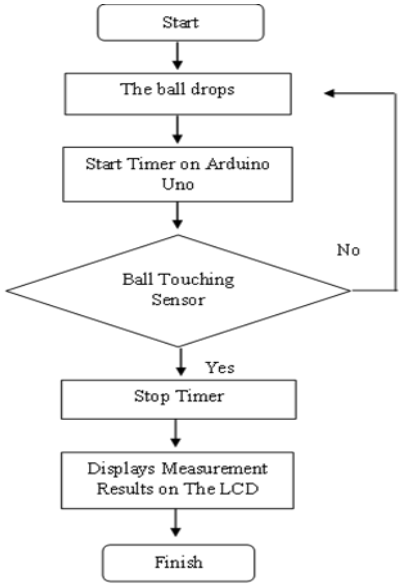

Figure 3. Work System a viscometer educational aid using arduino uno

The software system used is arduino uno software, using the C programming language, Arduino uno-based programming datasheet, page screen type serial monitor 9.600, used basis microcontroller ATmega3286, the program database is 20 digits on the LCD, the program system chip uses a 12C module with the Wire.h and Module libraries HX722.h with library HX711.h, transmitter system (triage) and receiver system (echo pin), and use the COM3 port. The hardware system used is as follows: Arduino UNO type microcontroller, an inductive distance sensor LJ18A3-8-Z/BX, 20x4 Character LCD, a box measuring 20 cm x 21 cm x 10 cm, a tube measuring 50 cm, diameter 36mm, and metal ball.

The development stage was validated by material experts and media experts. The implementation phase is carried out by applying the media developed to determine student responses and the effectiveness of a viscometer educational aid using Arduino Uno. The evaluation phase is carried out by repairing the tool referring to the results of the validation and testing.

Research Subject

This study uses two data subjects. The first subject is an expert, who is a material expert and media expert to assess product feasibility. The second subject was Physics Education students at IKIP PGRI Pontianak, West Kalimantan, to see the response and effectiveness of applying a viscometer educational aid using Arduino Uno on fluid topics.

Research Instruments

The research instruments used were validation questionnaires and response questionnaires. The questionnaire was made using positive statements with

a Likert scale range of 4 with answer choices, namely: Very Eligible (SL), Eligible (L), Not Eligible (TL), and Very Inadequate (STS). Student response questionnaires with answer choices, namely: Strongly Agree (SS), Agree (S), Disagree (TS), and Strongly Disagree (STS). The aspects assessed by material experts were content quality, accuracy of material coverage, and language. The aspects assessed by media experts are durability, accuracy, and efficiency. Aspects assessed by students include aspects of learning motivation and understanding of fluid concepts using learning media, the operation and performance of learning media, and the quality of learning media.

Data Analysis Techniques

The percentage of product feasibility and student responses to product assessments are calculated by Equation 1 (Sugiyono, 2017).

$$Percentage = \frac{questionnaire\ score}{maximum\ score} x\ 100\% \quad (1)$$

Based on the calculation of the results of the validation questionnaire and student responses, the score criteria of the expert validation questionnaire and student responses to the viscometer educational aid using Arduino Uno are presented in Table 1.

Table 1. Criteria for the Eligibility of Teaching Aids and Student Responses (Damayanti et al., 2018)

Criteria	Mark
Very feasible	$76\% \leq p \leq 100\%$
feasible	$51\% \leq p \leq 75\%$
Not Feasible	$26\% \leq p \leq 50\%$
Very Unfeasible	$0\% \leq p \leq 25\ \%$

The effects of the three types of lab work on scientific attitudes were analyzed by analysis of variance (ANOVA). The improvement of scientific attitude is determined with the formula of gain as follows.

$$g = \frac{posttest\ \ score - pretest\ score}{maximum\ possible\ score - pretest\ score} \quad (2)$$

The criteria for gain index with g> 0.70 high category; 0.30 <g <0.70 medium category; and g ≤ 0.30 low category (Hake, 1998).

Result and Discussion

The results of interviews with practicum instructors revealed that practicum is an important part of lectures. Practicum needs to facilitate the development of student's scientific reasoning and attitudes. 21st-century competence requires students to have a scientific attitude. One of the successes of the practicum is determined by the scientific attitude of students. The experimental tool used so far is a conventional measuring instrument that does not yet use a microcontroller and sensor, so there is a need for innovation in the form of a viscometer educational aid using Arduino Uno.

Product design is designed and arranged according to the components used to reduce excessive costs. Component layout design can save time in making the developed product as shown in Figure 4.

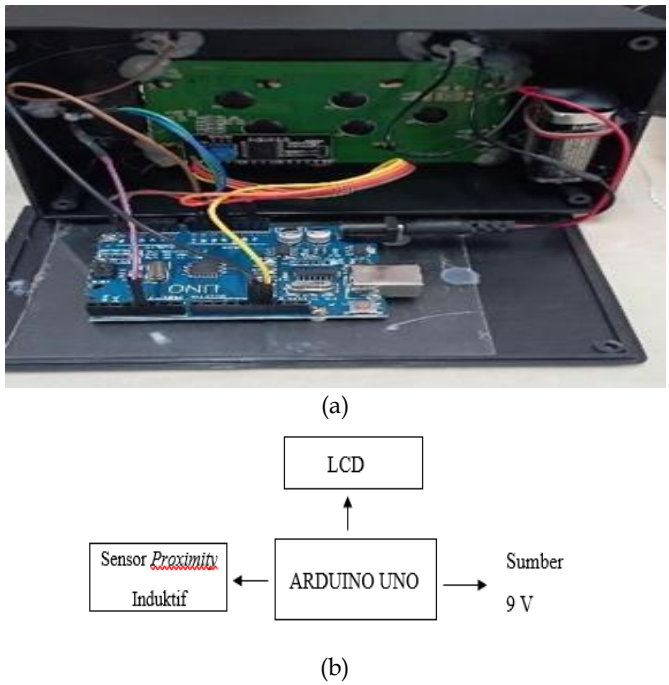

Figure 4. (a) Design of viscometer educational aid using arduino uno (b) Arrangement of system component design

The process of making a product starts with making a hardware system by bringing together all the components used. The components used in making the product are Arduino Uno Atmega328, an inductive proximity sensor. The appearance of the initial and final products is shown in Figure 5.

Figure 5. A viscometer educational aid using arduino uno

After making the hardware system, the next step is making the system software. In the system software, it is done to call each function of the components used to be able to read the results and display them on the LCD screen. The display of the programming software is shown in Figure 6.

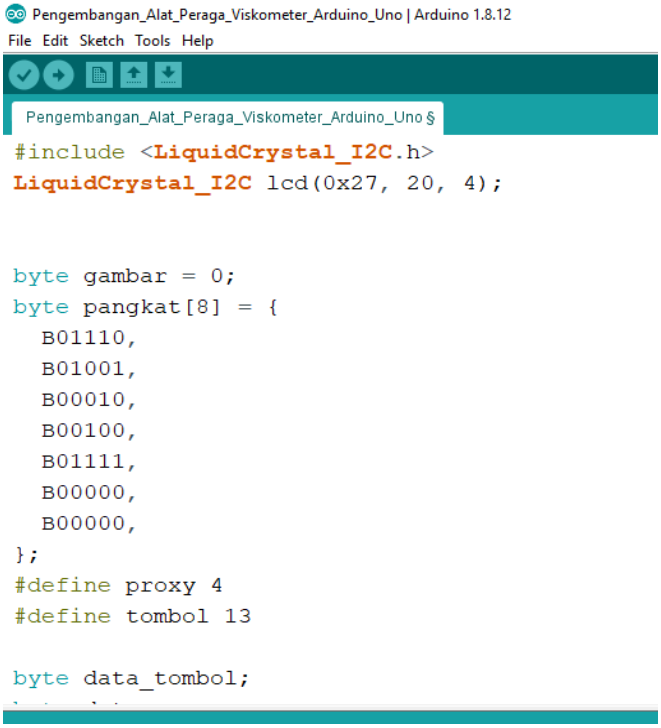

Figure 6. Programming software display

The feasibility of the developed learning media was carried out by 2 material experts. This assessment consists of the relevance of teaching materials, educational value, tool efficiency, and tool aesthetics. The results of the material validation are listed in Table 2.

Table 2. Product Assessment based on Material Expert Validation

Aspect	Percentage	Criteria
Content quality	94%	Very feasible
Accuracy of material coverage	96%	Very feasible
Language	94%	Very feasible
Average	95%	Very feasible

Based on the results of the assessment of the aspect of the Content quality, it has an average percentage value of 94%, and an accuracy of material coverage value of 96%, which means that the viscometer teaching aid has been able to explain phenomena related to the viscosity of the material properly. The Language has a percentage of 94%, which means that teaching aids have good readability. The media validation results are listed in Table 3.

Table 3. Product Assessment based on Media Expert Validation

Aspect	Percentage	Criteria
Durability	83	Very feasible
Accuracy	90	Very feasible
Efficiency	94	Very feasible
Average	89	Very feasible

Based on the validation results of media experts in Table 3. In the aspect of durability, an average percentage of 83% is obtained, which means that the visual aids are resistant to the effects of temperature and air, the props are not easily damaged, and the props can be used repeatedly. In the aspect of the Accuracy an average percentage of 90%. With the validation results, it means that the viscometer is very feasible because it can show and provide accurate results and data and meet the accuracy criteria. With the validation results, it means that the viscometer trainer is very feasible because it can show and provide accurate results and data and meet the accuracy criteria.

In the aspect of the efficiency an average percentage of 94%. This indicates that the props are easy to operate, the props are easy to maintain, and easy to clean, do not require a long time to operate, the viscometer props also have components that function well overall, and the props are also easy to implement. and applied. With the provisions of these values, the two media experts stated that the viscometer teaching aid was very feasible and valid. The results of student responses to a viscometer educational aid using Arduino Uno are shown in Table 4.

Table 4. Student Responses to a Viscometer Educational Aid Using Arduino Uno

Aspect	Percentage	Criteria
Learning motivation and understanding of fluid concepts	84	Strongly agree
Operation and performance of teaching aid	88	Strongly agree
Quality	85	Strongly agree
Average	86	Strongly agree

Based on the results of student responses in Table 4 it was obtained aspects of learning motivation and understanding of the concept of viscosity as a learning media with an average percentage of 84%, on the aspects of the operation and performance of learning media obtained an average percentage value of 88%. Aspects of the quality of learning media get an average percentage value of 85%, which means that the viscometer teaching aid can present the concept of the material. In addition, props also have simple properties and have strong resistance, and are not easily damaged when used.

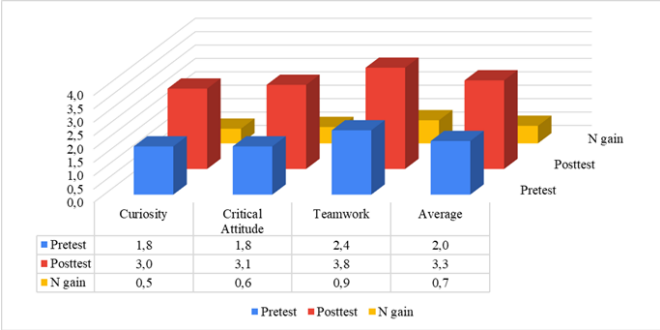

Figure 7. The improvement of scientific (curiosity, critical attitude, and teamwork)

Figure 7 shows the improvement in scientific attitudes (curiosity, critical attitude, and teamwork) with a gain of 0.7. Calculation of n-gain shows an increase in scientific attitude in the medium category. This shows that the use of a viscometer educational aid using Arduino Uno in learning improves student attitudes. Arduino-based teaching aid is an easy and simple way for students to prove physics concepts such as the concept of fluid viscosity (Alamsyah et al., 2022; Hikmah et al., 2021). Research suggests that props with sensors usually have high accuracy so they are feasible to use (Tissos et al., 2014). Scientific attitudes change during project-based science and technology learning in the laboratory (Price et al., 2013; Romine et al., 2017). Experiment-based physics learning activities can develop students' scientific attitudes in each learning phase, including curiosity, open-mindedness, objectivity, honesty, persistence, and delaying decisions (Ekawati, 2017). A learning model can enhance scientific attitudes (Fitriani et al., 2020). The laboratory activities can increase positive attitudes, creative and critical thinking skills, as well as being able to get scientific results and understand scientific rules (Hugerat et al., 2014; Palic et al., 2012; Wilcox et al., 2016).

The results of observations on the learning process indicate a change in the attitude of students. This refers to the affective domain of Krathwohl's theory which consists of receiving, responding, valuing, organizing, and characterizing (Boyd et al., 2006). At the stage of formulating the problem and studying the theory, receiving occurs which is indicated by the willingness of students to accept or pay attention to an object to be studied. At the experimental design stage, responding occurs, which is indicated by the ability of students to react to an object in the form of a critical attitude, cooperation, and caution in designing experimental instruments.

Valuing and organizing students will appear in the activities of conducting experiments and analyzing the results. This is demonstrated by the ability to provide an assessment of the correctness of the experimental results and organize activities that are deemed appropriate or inappropriate for experimenting. The highest level is characterizing which is indicated by the ability to question, show empathy, solve problems, and modify behavior seen from activities in revising inappropriate experimental results.

Conclusion

Based on the results of the feasibility test given by material experts and media experts, a viscometer teaching aid using Arduino Uno is very suitable to be a learning medium. Overall, the validation results obtained for the viscometer teaching aid using Arduino uno microcontroller with a percentage of material experts at 95%, and media experts at 89%. With these results, the teaching aids are very feasible and valid to become learning media. Based on the results of the analysis and the results of student responses, it is known that the viscometer educational aid using Arduino Uno is a learning medium that is of interest to students. In addition to helping students understand the basic concept of fluid viscosity material, students also feel enthusiastic, happy, and not bored with the material presented. This is also supported by the results of the student response questionnaire with a percentage of 86%, which means that students strongly agree that the viscometer teaching aid is a learning medium. The use of a viscometer educational aid using Arduino Uno improves student attitudes with an n-gain of 0.7 in the medium category.

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Author Contributions
Conceptualization, Adi Pramuda; methodology, Soka Hadiati.; validation Wani Safitri; investigation, Matsun. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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