e-ISSN: 2355-620X
DOI: 10.12928/jrkpf.v9i1.27

Development of Arduino Uno-based real learning media for measuring density of objects

Matsun
Physics Education, IKIP PGRI Pontianak, Indonesia
Email: matsunzaidan@gmail.com

Boisandi
Physics Education, IKIP PGRI Pontianak, Indonesia
Email: bsandi2012@gmail.com

Ira Nofita Sari
Physics Education, IKIP PGRI Pontianak, Indonesia
Email: iranofitasari@gmail.com

Soka Hadiati
Physics Education, IKIP PGRI Pontianak, Indonesia
Email: sokahadiati@gmail.com

Mikael Trimon Zadrianus
Physics Education, IKIP PGRI Pontianak, Indonesia
Email: trimon459@gmail.com

Abstract. The purpose of developing Arduino Uno-based physics learning media to measure density is to determine the level of feasibility based on the assessment of media experts and material experts, as well as to determine student responses to the development of learning media carried out. This study uses the ADDIE model which consists of 5 stages, namely analysis, design, development, implementation, and evaluation. Based on the data analysis, it can be concluded that the validation of the Arduino Uno-based physics learning media by two media experts obtained an average percentage score of 92.08% with very decent criteria and by two material expert validators obtained an average percentage score of 88, 75% with very decent criteria. Student responses to the Arduino Uno microcontroller-based physics learning media obtained an average percentage score of 84.58% with very decent criteria. The implication of this research is that teachers and students can use tools developed digitally and can compare them with manual experiments.

Keywords: development real, ardouno uno, density

I. Introduction

A real laboratory is a laboratory where simple tools and materials are used to conduct experiments. Conducting experiments in real laboratories will increase students' learning motivation and strengthen memory about the material being experimented with [1]. In doing a practicum in a real laboratory, students will experience: a. introduction of tools and materials; in the introduction of physics tools and materials, students can see directly, the teacher explains the function or use of physics tools and materials so that in conducting experiments they do not damage physics tools and materials, b. measurement, measurement is comparing a quantity with other similar quantities that are used as a standard, in measurement students can see directly the tools used, so students need skills to read measuring instruments, c. observations, students observe seriously from the experiments carried out and write the experimental results on the observation table, d. In the experiment, students, before experimenting, first read the practicum instructions that were already on the student worksheet so that in experimenting, they got the correct data [2].

Educational research has developed various methods, and learning models appropriate in the era of the industrial revolution 4.0 [3], has developed training and demonstration facilities related to Industry 4.0

technology. These facilities are built in both industrial and university settings [4]. Further, develop the cooperation between the industrial environment and universities. As part of the community element, schools must also be the center of attention in facing the era of the industrial revolution 4.0. Students should be provided with knowledge of industrial technology through digital learning. Digital literacy is directed at improving the ability to read, analyze, and use information in the digital world. Preparation for the industrial revolution 4.0 requires good cooperation between all elements of society, including academics, in research and development to realize Industry 4.0 [5]. Therefore, efforts will be made to develop an Arduino microcontroller-based textbook in this research.

Manufacturing is driven by four factors: 1) increased data volume, computing power, and connectivity; 2) emergence of business analytics, capabilities, and intelligence; 3) the occurrence of new forms of interaction between humans and machines; and 4) improvement of digital transfer instructions to the physical world, such as robotics and 3D printing [6]. Meanwhile, the basic principle of Industry 4.0 is the merging of machines, workflows, and systems, by implementing intelligent networks along the production chain and processes to control each other independently [4]. The world of education must be able to adapt quickly to adapt to industry revolution 4.0. One thing that needs to be developed in the era of the industrial revolution 4.0 in education is learning in the classroom using a microcontroller.

The microcontroller is a chip in the form of an IC (Integrated Circuit) that can receive input signals, process them and provide output signals according to the program loaded into it. The microcontroller input signal comes from the sensor and information from the environment. In contrast, the output signal is addressed to the actuator, affecting the environment. So in simple terms, the microcontroller can be likened to the brain of a device/product that can interact with the surrounding environment. Arduino is one of the microcontrollers often used in learning physics in the classroom.

Learning in the classroom must be coupled with the innovation of a teacher because the teacher has a very important role in the learning process in the classroom. From the interviews with teachers and students, it was found that the learning media at SMA Negeri 3 Sungai Kakap, Kubu Raya Regency was still relatively lacking. The media used by the teacher are learning books, power points, learning videos, projectors, and teaching aids. In the teaching and learning process, teachers often use learning books. When teaching, teachers only lecture, so many students are not interested in learning the material being studied because it is boring. Practical tools in schools only use existing practicum tools, while Arduino Uno-based teaching aids with sensor-assisted and technology-based teaching aids do not yet exist.

The problem that exists at the school is that there are no Arduino Uno-based teaching aids with sensor-assisted or technology-based tools, one of which is developing an Arduino Uno microcontroller-based automation laboratory tool to measure density. Efforts that can be made to overcome the problems above are that there must be alternative renewal and development in the use of functional laboratory equipment. Research conducted [7] is still limited to measuring density for ordinary objects. The update of the tool is aligned with the progress of science and technology in the era of the industrial revolution 4.0. This update means that the tools developed are digital-based tools or technology automation to make it easier for students to take measurements and prepare students to face the challenges of technological advances in the current era. The measure development can be observed by switching from a manual or analog system to a digital system [8]. One of the things needed is developing an Arduino Uno Microcontroller-based automation laboratory tool. This study aimed to measure the density, namely to determine the level of feasibility based on the assessment of media experts and material experts and to assess student responses to the development of learning media carried out.

II. Materials and Methods

This research uses research and development (R&D) research methods. This study uses the ADDIE (Analysis, Design, Development, Implementation, and Evaluations) [9]. Considerations using the ADDIE approach model because this model is easy to apply, structured, and easy to learn for researchers who are just doing development research. This research only reached the development stage. Due to the limited workforce, time and co, the researchers were only limited to testing the feasibility level of the product or learning media that was made based on validation by media experts, materials, and student responses without disseminating the product. Subjects in this research and development include two subjects. The first subject is a validator, consisting of two material expert lecturers and two media expert lecturers to assess physics-based learning media products, Arduino Uno. The second subject was a class XI student at the State Senior High School 3 Sungai Kakap to try out the Arduino Uno microcontroller-based physics learning media.

The following are the stages of the flow used in this study, as illustrated in the flowchart below:

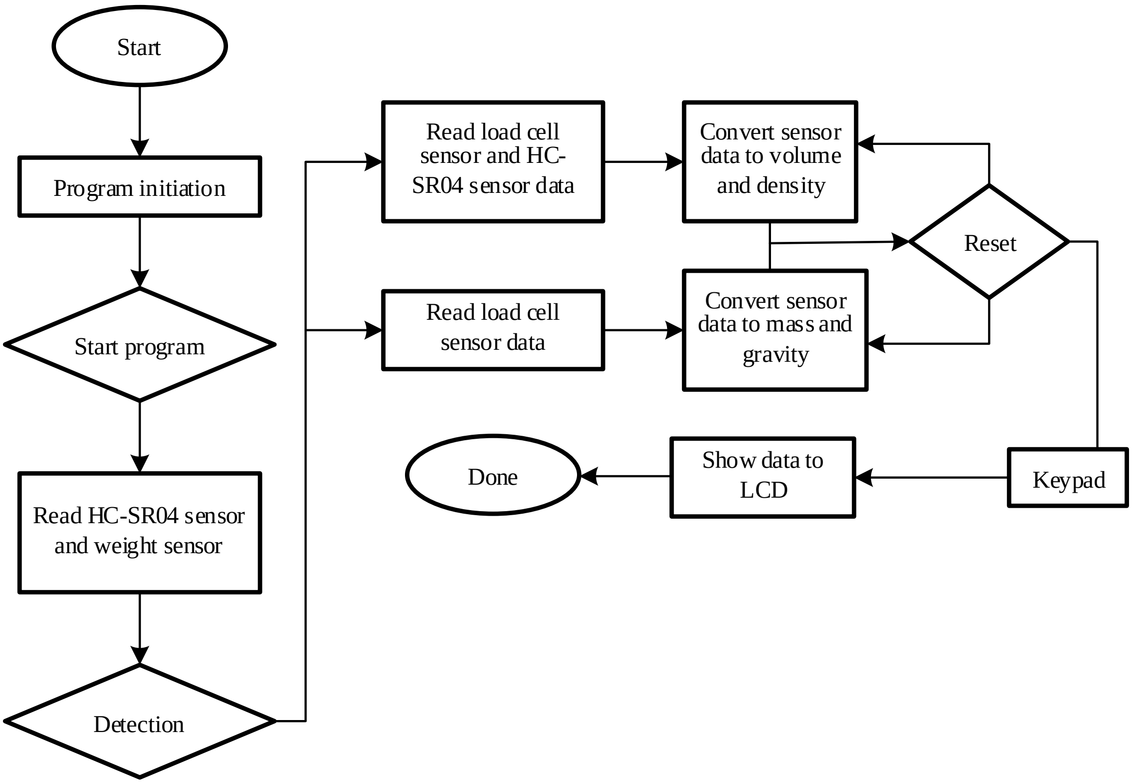

Figure 1. Design of Arduino Uno-based real media to measure the density of objects

Figure 1 above explains that the system's working process of measuring the density of regular objects begins by measuring object mass. Measure object mass using a load cell by placing objects on top of the sensor. When the object's mass has been measured, it is inputted into the Arduino system. Ultrasonic sensors are used to measure length, width, and height. The ultrasonic sensor readings will be inputted into the Arduino system. The work of the system of measuring the density of the irregular object begins with measuring the object's mass. Measure object mass using a load cell by placing objects on top of the sensor. When the object's mass has been measured, it is inputted into the Arduino system. Things whose mass has been measured are then measured in volume according to the learning media that has been designed. The volume measured in this experiment is the volume of stone. The stone volume to be measured consists of several variables, namely the initial and final volume. Measure the volume of the stone using a measuring cup filled with water. The water-filled into the measuring cup is then measured using an ultrasonic sensor as the initial volume of the object. The stone is then put into a measuring cup to find the final volume of the thing. The ultrasonic sensor readings will be inputted into the Arduino system. The equation $\rho = m / v$ is used to calculate the density of objects conceptually. All variables in the Arduino system will be displayed on the LCD as the Arduino system screen.

A feasibility assessment of the learning media was carried out to test the feasibility of the product. Media and material experts carry out the feasibility test. Test data analysis uses a Likert scale questionnaire. The Likert scale measures attitudes, opinions, and perceptions of a person or group of people about social phenomena [10].

Table 1. Criteria for assessment of material experts and media experts

Description	Value
Very Eligible	$80\% \le p \le 100\%$
Eligible	$60\% \le p \le 80\%$
Fairly Eligible	$40\% \le p \le 60\%$
Less Eligible	$20\% \le p \le 40\%$
Not eligible	$0\% \le p \le 20\%$

After the product feasibility test is carried out and declared suitable for use, the next stage is a limited trial of the tool to students. The problem was conducted at SMA Negeri 3 Sungai Kakap. The analysis test used a Likert to determine the criteria for the learning media after being tested. The criteria used can be seen in Table 2 below.

Table 2. Criteria for assessment of student response questionnaires

Description	Value
Strongly Agree	$80\% \le p \le 100\%$
Agree	$60\% \le p \le 80\%$
Doubtful	$40\% \le p \le 60\%$
Disagree	$20\% \le p \le 40\%$
Strongly Disagree	$0\% \le p \le 20\%$

III. Results and Discussion

Result

This research produces a product in the form of physics learning media based on the Arduino Uno microcontroller to measure the density of objects. The developed learning media has met the valid and effective criteria. Researchers used the ADDIE development model to develop this learning media, but the research development stage was limited to the development stage. The locations of research carried out include the steps of analysis, design, and development. The following are the activities carried out at each stage:

Analysis

This research begins with the analysis; there are several stages at this stage, including problem analysis, material analysis, and research model analysis. In analyzing the problem, the researcher conducted observations, interviewed physics subject teachers, and interviewed students to discover potential problems in the physics learning process at SMAN 03 Sungai Kakap. The interview results determined that the density material was a medium to be developed because this material still did not have a practical tool. To the results of interviews, learning media on density material is also needed. Besides that, there are no Arduino Uno-based learning media at the school with sensor-assisted or technology-based learning, one of which is developing an Arduino Uno microcontroller-based automation laboratory tool. The results of the analysis of the research model in this research, the model used are the ADDIE research model. The ADDIE model can be used for product development such as models, learning strategies, learning methods, media, and teaching materials [11].

Design

The stages of product design to be developed are as follows:

1. System Design and Development

The initial stage before making a learning media system as a control circuit starts with creating a system circuit, as shown in Figure 2 below. Completing the circuit aims to determine the location of the system to be made. Besides determining the layout of components, the system circuit also reduces high budget costs. After making the schematic, the next step is to solder the components according to a predetermined layout so that the components are well connected.

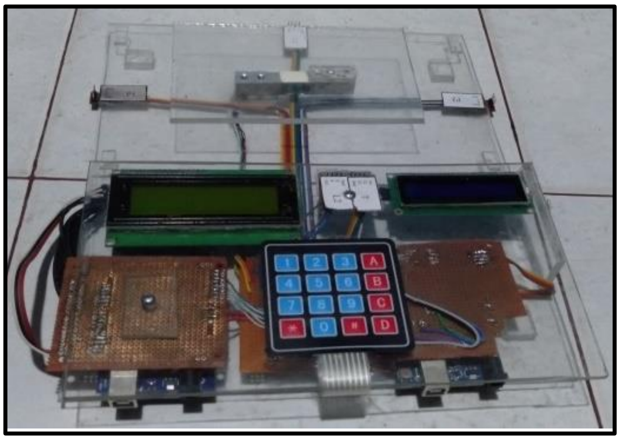

Figure 2. Design and manufacture a system

2. Tools and Materials

After designing and making the system, the researcher prepares the materials needed to make learning media. The tools used are PCB (Printed Circuit Boards). The materials used are Arduino Uno, 20x4 LCD (Liquid Crystal Display), load cell, HX711 module as an amplifier, ultrasonic sensor HC-SR04, keypad, acrylic glass, resistors, jumper cables, and other components.

3. Making Hardware Learning Media System

Making learning media hardware has a control system that functions to process Arduino IC data which contains a program system to access data from ultrasonic sensor readings and load cells used to calculate the volume and mass of an object. The hardware can be seen in Figure 3. The sensor will be given an order by Arduino to automatically calculate the volume and mass of the thing whose output or value from the sensor reading will be displayed on the LCD. In addition, Arduino will also receive an incoming signal from the keypad, which serves to input the mass of objects.

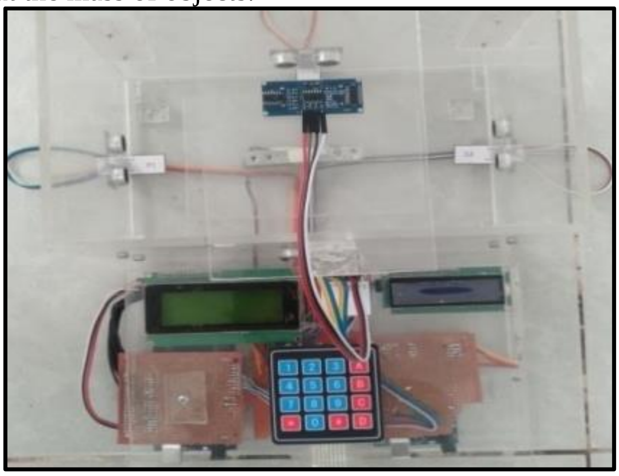

Figure 3. The form of hardware in the learning media

4. Making Software Learning Media System

Design of the learning media software in this study was carried out by programming the Arduino system. The software language can be seen in Figure 4. This programming is done to regulate the main function of the learning media as a counter to the value of the density of regular objects and the mass of irregular objects resulting from ultrasonic sensor measurements and load cell sensors. The software is created to activate the work function of the ultrasonic sensor as a measure of the volume of objects. The load cell sensor measures the mass of things, and the keypad is an input button in the Arduino system.

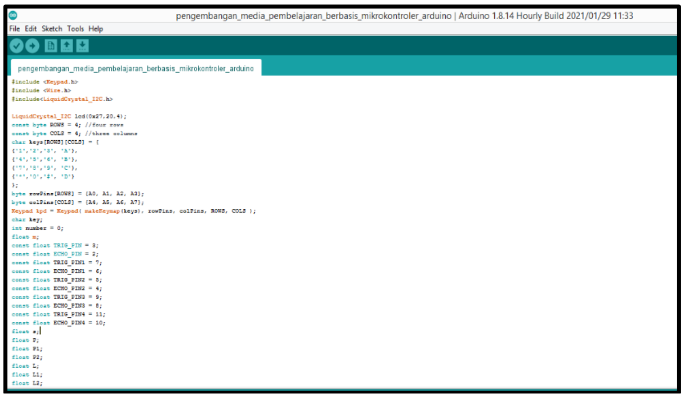

Figure 4. Display software programming

Development

At this stage, the activities are testing the feasibility of learning media. The feasibility test was carried out by validators of media experts and material experts. The assessment process by media experts, namely the feasibility of the product in the form of learning media, is carried out by providing products in the form of teaching media along with an assessment sheet in the form of a validation sheet consisting of 6 assessment aspects including aspects of tool resistance, tool accuracy, tool system speed in reading measurement results, tool efficiency, and security. The media expert's assessment results based on these six aspects can be seen in Table 3.

Table 3. Obtaining Aspects of Media Validation Sheets

No	Aspects Assessed	Percentage	Criteria
1	Tool Resistance	90 %	Very Eligible
2	Tool Accuracy	100 %	Very Eligible
3	Tool System Speed in Reading Results Measurement	92.5 %	Very Eligible
4	Tool Efficiency	90 %	Very Eligible
5	Aesthetics	83.3 %	Very Eligible
6	Security	90 %	Very Eligible
	Total	**545,8 %**	
	Average Percentage	**92,08 %**	**Very Eligible**

Calculation of data in Table 3, From the above aspects, it can be concluded that the product developed has an average score of 90% with very feasible criteria from durability. Judging from the part of the accuracy of the tool got a score of 100% with very decent criteria. For the aspect of the speed of the tool system in reading the measurement results, an average score of 92.5% was obtained with very proper criteria, then in the aspect of tool efficiency, an average score of 90% with very decent criteria. Then reviewed on the aesthetic element, it got an average score of 83.3% with very proper criteria. It got an average score of 90% on the security aspect with very decent criteria. Based on the data calculation above, the average percentage of all aspects got a score of 92.08%, with very decent criteria. Based on these results indicate that in the media aspect, the learning media developed is feasible to use.

For material experts, the aspects tested consist of 3 aspects of assessment, namely aspects of relevance to teaching materials, educational values, and aspects of efficiency. The material expert's assessment results based on these three aspects can be seen in Table 4.

Table 4. Obtaining Aspects of Material Validation Sheet

No	Aspects Assessed	Percentage	Criteria
1	Relation to Teaching Materials	90 %	Very Eligible
2	Educational Value	90 %	Very Eligible
3	Tool Efficiency	80 %	Very Eligible
	Total	**260 %**	
	Average Percentage	**88.75 %**	**Very Eligible**

After validation tests were carried out by media experts and material experts on learning media and were declared suitable for use, the next stage was a limited trial to students to find out the response of the learning media being tried. The student response test consists of 3 assessment aspects: learning motivation and understanding of the concept of density as a learning medium, aspects of the operation and performance of learning media, and aspects of the quality of teaching media. The student response test results based on these three aspects can be seen in Table 5.

Table 5. Obtaining Student Response Aspects

No.	Aspects of	Percentage	Criteria
1	Learning Motivation and Understanding of Density Concepts as Learning Media	90 %	Strongly Agree
2	Operation and Performance of Learning Media	81.25 %	Strongly Agree
3	Learning Media Quality	82.5 %	Strongly Agree
	Total	**253.33 %**	
	Average Percentage	**84.58 %**	**Sangat Setuju**

Based on table 5 above. it is known that the percentage of the results of the assessment of student responses to physics learning media based on the Arduino Uno microcontroller on the density material from each aspect. Aspects of learning motivation and understanding the concept of density as a learning medium obtained a percentage score of 90%. which means its included in the category of strong agreement. The operational and performance aspects of learning media obtained a percentage score of 81.25%. which means the interpretation of student responses is included in the category strongly agree. Assessment of the quality aspect of learning media obtained a percentage score of 82.5%. which means the interpretation of student responses is included in the category of strongly agree. Overall. the average score of the three aspects is 84.58% which is included in the criteria for strongly agree. Based on these results. the media developed is generally suitable for use in the learning process.

Discussion

The assessment carried out by two media experts on the real physics tools made is included in the very feasible category. Analysis of the data has stated that the teaching aids for real physics learning based on the Arduino Uno microcontroller to measure density have met the requirements and are suitable for use as a medium for learning physics for high school students. In line with research that has been conducted by [12]. it stated that the results of the feasibility of teaching aids obtained an average score of 95%. It includes very feasible criteria by media experts. The development of sensor lamp props based on Arduino Uno on the material energy has been very good and has gotten a positive response. In addition. research carried out [7] found that the media's eligibility for teaching aids obtained an overall average score of 77% with appropriate criteria by media experts.

Research conducted [13] stated that the media feasibility test results obtained an overall average percentage of 82.85% with very feasible criteria by media experts. From the description above. it can be stated that the real physics tools developed have met the indicators set by media experts. The material expert indicators can be described as follows: 1) In tool durability. the average percentage score obtained is 90%. with the assessment criteria very feasible. These results indicate that the teaching aids have a resilience that can be used in the learning process. Because the fundamental physics tool based on the Arduino Uno to measure the density of the box object is made using acrylics. this shows that the teaching aids developed are suitable for use in the physics learning process in the classroom. 2) In the aspect of tool accuracy. the average percentage score obtained is 100%. with the assessment criteria very feasible. These results indicate that the real physics tool based on the Arduino Uno to measure the density of objects developed has high accuracy. 3) On the aspect speed of the tool system in reading the measurement results. the percentage score obtained is 92.5%. with very decent assessment criteria. These results indicate that the real physics tool based on the Arduino Uno for measuring the density of objects developed has received a good assessment by the validator when used. The developed tool has a good response when operated. If the tool is turned on and asked to perform the tool. the Arduino Uno-based real physics tool to measure the density of objects immediately displays the results. 4) In the aspect of tool efficiency. the average percentage score obtained is 90%.

The use of simple physics tools based on Arduino Uno to measure the density of objects is very efficient because the developed tool is packaged with an attractive and efficient model in terms of shape and benefits. 5) In the aesthetic aspect of the tool. the average percentage score obtained is 83.3% in the very good category. The aesthetics of real physics tools based on Arduino Uno to measure the density of objects have a high aesthetic value. Its because the tools developed are made to be more attractive to make students interested. 6) The average percentage score obtained is 90% on the security aspect. The simple Arduino Uno-based physics tool to measure the density of objects is designed for a safety system so that students and teachers don't worry about using the tool. In addition. the tool developed uses a small electric voltage of 9 volts so that it is safe for students and teachers to use. From these six aspects. the Arduino Uno-based real physics tool to measure the density of objects is declared to meet the requirements and is suitable for use in schools.

Based on table 4. the average percentage score obtained from the assessment of material experts is 88.75%. with very decent criteria. The average score of the material expert's assessment of the teaching aids developed is included in the very feasible criteria. The results of the data analysis described previously show that the fundamental physics tool based on the Arduino Uno for measuring the density of objects has met the requirements and is feasible to be used as a physics learning medium. In line with research [14]. Based on the feasibility of teaching aids. the average score for the overall assessment of teaching aids was 96%. with very feasible criteria by material experts. The development of mathematical pendulum teaching aids based on Arduino microcontrollers to train process skills Science high school students have been very good and gotten a positive response. Based on research conducted by [15]. Judging from the feasibility of the material on the teaching aids. an overall average score of 78% was obtained with appropriate criteria by material experts. Research conducted by [16] based on the feasibility of the material on the teaching aids obtained an average score of the overall assessment of teaching aids is 87%. with very feasible criteria by material experts.

Based on the student response analysis results in Table 5. the average percentage score obtained is 84.58%. The average score of student responses to the developed teaching aids is included in the criteria for strongly agree. Judging from the results of the analysis of student responses to the real physics tool based on Arduino Uno to measure the density of objects in Table 4. the results obtained from the assessment aspect are as follows: 1) In the aspect of learning motivation and understanding the concept of density material with teaching aids as media. the score the percentage obtained is 90% with the assessment criteria strongly agree. In this aspect. the teaching aids made can motivate students to learn. These results can be seen from the assessment responses of students who get very good criteria. In addition. the use of teaching aids can make students active in the learning process because students' high curiosity to use tools makes the physics learning process more active and efficient so that the planned learning objectives can be achieved properly [17]. 2) In the aspect of operation and performance of teaching aids. the percentage score obtained is 81.25%. with the assessment criteria strongly agree. These results indicate that the props developed are easy to operate and use. When run. the performance of the teaching aids does not experience *system errors.* so the measurement results obtained are more optimal. 3) On the quality aspect of learning media. the percentage score obtained is 82.5%. with the assessment criteria strongly agree. In this aspect. the points assessed are the tool's robustness. the system's performance. and the understanding of students' concepts. In the aspect of understanding the concept of teaching aids that were developed. it received a good response from students. This result shows that the teaching aids designed can explain the basic concepts of material study to students. Students are helped by the existence of teaching aids that can be used to improve their understanding of material concepts [18].

IV. Conclusions

Through the process of development and discussion. it can be concluded that the product of Arduino Uno-based physics learning media to measure density is suitable for use in schools as teaching media. From the research results. it can be concluded: According to media experts. the average percentage score is 92.08%. with very decent criteria. According to material experts. an average percentage score of 88.75% was obtained with proper criteria. Student responses to the Arduino Uno microcontroller-based physics learning media received an average percentage score of 84.58%. with the criteria of strongly agreeing.

Acknowledgments

The researchers would like to thank the National Research and Innovation Agency Deputy for Research and Development Strengthening (BRIN). who has funded this activity through the Insinas 2021 grant. and the IKIP PGRI Pontianak institution. which provided support and facilities in this research.

References

[1] A. Rizal. R. I. Adam. and S. Susilawati. "Pengembangan Laboratorium Virtual Fisika Osilasi." *J. Online Inform.*. vol. 3. no. 1. p. 55. 2018. doi: 10.15575/join.v3i1.140.

[2] A. K. Triatmaja and M. Khairudin. "Study on Skill Improvement of Digital Electronics Using Virtual Laboratory with Mobile Virtual Reality." *J. Phys. Conf. Ser.*. vol. 1140. no. 1. 2018. doi: 10.1088/1742-6596/1140/1/012021.

[3] H. Prasetyo and W. Sutopo. "Industri 4.0: Telaah Klasifikasi Aspek Dan Arah Perkembangan Riset." *J@ti Undip J. Tek. Ind.*. vol. 13. no. 1. p. 17. 2018. doi: 10.14710/jati.13.1.17-26.

[4] S. Pfeiffer. "The Vision of 'Industrie 4.0' in the Making—a Case of Future Told. Tamed. and Traded." *Nanoethics*. vol. 11. no. 1. pp. 107–121. 2017. doi: 10.1007/s11569-016-0280-3.

[5] C. Straight and M. Materials. "Design Physics Props Based on Arduino Nano Sensors on Irregularly." vol. 5. no. 1. pp. 26–30. 2021.

[6] W. Indrasari. C. E. Rustana. and Zulfikar. "Development a practicum tools to measure the speed of the air using Arduino Uno Microcontroller." *J. Phys. Conf. Ser.*. vol. 1816. no. 1. 2021. doi: 10.1088/1742-6596/1816/1/012109.

[7] A. U. Mentsiev. Z. A. Gerikhanov. and A. R. Isaev. "Automation and IoT for controlling and analysing the growth of crops in agriculture." *J. Phys. Conf. Ser.*. vol. 1399. no. 4. 2019. doi: 10.1088/1742-6596/1399/4/044022.

[8] T. P. Otomatis and S. Ultrasonik. "Pengembangan Media Trainer Pintu Otomatis dengan Sensor Ultrasonik . RFID . dan Pir Berbasis Arduino pada Mata Pelajaran Mikroprosessor dan Mikrokontroler Kelas X di SMKN 1 Driyorejo Deva Feggantara Pakshi Jenaro S1 Pendidikan Teknik Elektro . Fakultas Te." pp. 11–18. 2021.

[9] S. Arikunto. *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: Rineka Cipta. 2010.

[10] M. Matsun. D. Ramadhani. and I. Lestari. "Pengembangan Bahan Ajar Listrik Magnet Berbasis Android di Program Studi Pendidikan Fisika IKIP PGRI Pontianak." *J. Pendidik. Mat. dan IPA*. 2018. doi: 10.26418/jpmipa.v9i1.23703.

[11] M. Matsun. H. Darmawan. and L. Fitriyanti. "Pengembangan Media Pembelajaran Fisika Berbasis Macromedia Flash Topik Bahasan Pesawat Sederhana." *J. Pendidik. Mat. dan IPA*. 2019. doi: 10.26418/jpmipa.v10i1.25861.

[12] Y. R. Liana. S. Linuwih. and S. Sulhadi. "Internet of Things Based Learning Media with Problem Solving Approach: Its Effect on Higher Order Thinking Skills." *J. Ilm. Pendidik. Fis. Al-Biruni*. vol. 9. no. 2. pp. 225–239. 2020. doi: 10.24042/jipfalbiruni.v9i2.6313.

[13] R. A. Atmoko. R. Riantini. and M. K. Hasin. "IoT real time data acquisition using MQTT protocol." *J. Phys. Conf. Ser.*. vol. 853. no. 1. 2017. doi: 10.1088/1742-6596/853/1/012003.

[14] Y. R. Liana. S. Linuwih. and Sulhadi. "Science activity for gifted young scientist: Thermodynamics law experiment media based IoT." *J. Educ. Gift. Young Sci.*. vol. 8. no. 2. pp. 757–770. 2020. doi: 10.17478/JEGYS.657429.

[15] M. Idayu *et al.*. "Pembuatan Set Eksperimen Gerak Vertikal Bawah Berbasis Sensor Ping Dan Sensor Photogate Dengan Tampilan PC." vol. 12. no. 1. pp. 22–29. 2019.

[16] W. Priharti. A. F. K. Rosmawati. and I. P. D. Wibawa. "IoT based photovoltaic monitoring system application." *J. Phys. Conf. Ser.*. vol. 1367. no. 1. 2019. doi: 10.1088/1742-6596/1367/1/012069.

[17] Y. Ma. W. Wu. and Q. He. "Algorithm for Object Detection using Multi-Core Parallel Computation." *Phys. Procedia*. vol. 33. pp. 455–461. 2012. doi: 10.1016/j.phpro.2012.05.089.

[18] A. Rizky. A. Pramesti. and H. K. Rustam. "Edukatif : Jurnal Ilmu Pendidikan Peningkatan Prestasi Belajar Siswa dengan Menerapkan Kecerdasan Emosional dan Dukungan Sosial pada Siswa SMA." vol. 3. no. 4. pp. 1699–1707. 2021.