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Archiduino as a Media for Learning Physics: A Laboratory Study

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ABSTRACT
Physics concepts and quantities in Physics subjects at school can be presented realistically through a series of practical activities and demonstrations using learning aids. An Arduino-based Archimedes' law teaching aid (Archiduino) has been designed as a physics learning medium. The research method adapts the ADDIE model which consists of Analyze, Design, Development, Implementation and Evaluation. In order to determine the suitability of the teaching aids, equipment trials and product validation have been carried out by physics material experts and media experts. Based on the research results, it was obtained: (1) The Arduino-based Archimedes' Law teaching aid which was designed to meet the valid criteria based on the results of the assessment by media experts obtained an average percentage of 88.31% in the valid category and the results of the assessment by material experts obtained an average percentage of 87.96%. in the valid category. (2) The Arduino-based Archimedes' Law teaching aid met the practical criteria in a limited trial of 10 students, and received student responses to the teaching aid in the aspects of benefits, presentation of the tool and physical appearance with an average percentage of 86.86% in the very good category. Thus, the Arduino-based Archimedes' Law teaching aid is valid and practical so it can be used as an alternative teaching aid in physics learning.

INTRODUCTION

Curriculum Practical activities in physics subjects are learning activities that examine natural events that occur systematically and purposefully [1]. In one of the physics learning materials, namely the theoretical concept of Archimedes' Law in Static Fluid material, this is material that in the learning process requires a specific realization picture to facilitate understanding of the material concept. The picture of this realization can be visualized with practical activities. Archimedes' Law Practicum aims to determine the magnitude of the upward pressure or upward force received by an object and to find out what factors influence the magnitude of the upward force.

Practical activities cannot be separated from the teaching aids used to visualize and realize theoretical concepts in learning material. Visual aids are all kinds of tools used as learning aids to demonstrate and visualize learning material [2]. Using teaching aids will help students understand the learning material presented. The subject of Archimedes' Law in Static Fluid material is material that needs to be presented clearly and in detail so that teaching aids are needed as learning media so that the material can be well received by students [3].

Progress in Science and Technology is one of the factors that supports renewal in various fields. Technology that continues to develop is very helpful in the process of improving learning, especially in the use of modern technology-based learning media [4]. Learning media is a set of tools or complements in a learning activity that are used by educators in order to improve communication between educators and students [5]. Learning material delivered using learning media will be clearer, more complete and more interesting. Learning media is also able to present material that can arouse curiosity, stimulate students to react physically and emotionally so that learning activities can be carried out effectively. Learning media needs to be adapted to modern technological developments to support learning activities. So teaching aids are needed that are integrated with emerging technological advances which refer to Minister of Education and Culture Regulation No. 65 of 2013 which states that the learning process in educational units must be carried out in an interactive, inspiring, fun, challenging manner, motivate students to participate actively, and provide sufficient space for initiative, creativity,

Based on the results of interviews conducted by researchers with the Head of the Laboratory and students of the Physics Education Study Program, Muhammadiyah University, Purworejo, information was obtained that lecture activities, especially in the Basic Physics Practicum I course in the Archimedes Law practicum, still use conventional practicum tools so that it still makes it difficult for students to understand and still requires practicum time. relatively long. The lack of proper digital physics teaching aids in the laboratory is also still an obstacle to supporting effective learning which causes students to still have difficulty understanding the concepts of physics material well. So we need facilities to support interesting and efficient learning activities to increase students' understanding, especially on the subject of Archimedes' Law. One of the means that can support learning activities is using teaching aids that are based on modern technology and are digital.

This problem is similar to the results of research conducted by Pratiwi & Linuwih [6] which states that the use of Archimedes' Law teaching aids as a medium for learning the subject of Archimedes' Law in Static Fluid material is good by utilizing a variety of objects used as practical objects so that the influence of objects on the magnitude of the upward force can be known. However, it is less effective in collecting data which is still done manually so it takes a relatively long time.

Research that supports this problem was also carried out by Palupi [7] which states that teaching aids with traditional components and used manually are prone to data collection errors and the data obtained tends to take time because of the many processes that must be passed. Teaching aids can be developed innovatively and creatively in line with current technological advances and in accordance with learning objectives.

Based on this description, one of the main materials in physics learning that requires new innovations in the learning process is Archimedes' law. Archimedes' Law requires clear and attractive visualization to make it easier for students to understand learning material and improve students' psychomotor skills. Referring to the development of the times which demands all aspects of life, including in the field of education, demands to create new innovations in learning activities, especially new breakthroughs in creating learning media, especially in practical learning in the form of teaching aids by utilizing technological advances to improve the quality of learning.

Based on the explanation of the problem, in general laboratory room facilities are available, but the practicum activities carried out have not been effective due to the lack of digital teaching aids, so the

researcher designed an Arduino-based Archimedes' Law teaching aid (Archiduino) as a physics learning medium.

METHOD

The method used in this design research modifies the ADDIE development model which consists of Analyze, Design, Development, Experimentation, and Evaluation. The first stage of designing Archimedes' Law teaching aids is an analysis of the needs for teaching aids which aims to find out what is needed in designing an Arduino-based Archimedes' Law teaching aid. The things needed in designing an Arduino-based Archimedes' Law teaching aid are materials, as well as the tools and materials that will be used. Apart from that, the need for Archimedes' Law teaching aids in the laboratory was the fundamental reason for carrying out this research.

The second stage, namely material analysis, is carried out by identifying the material that will be taught using demonstration tools and based on literacy results through several studies of research results. Analysis was also carried out using various references as considerations for researchers to determine the tools and materials that will be used in designing Arduino-based Archimedes' Law teaching aids. The design stage is a stage that aims to design the tool. At this stage the final result will be obtained which is called Prototype I. The design of the props created can function well in determining quantities in Archimedes' Law material. The Arduino programming process starts from reading the water level before and after the load is applied. then using the Fa button the V variable data is calculated into a Fa value (upward force) by multiplying the V value by the density of water (ρ) and gravitational acceleration (g). The results of the upward force measurement are then called up to be displayed on the LCD with a data accuracy level of two numbers behind.

In order to test the function of the teaching aids, trials are carried out in the laboratory by testing the sensors and system 10 times to obtain data and calculate the uncertainty value from the test data. Based on the data from the test results, the accuracy and precision of the teaching aids that have been designed can be determined. This stage aims to produce a revised Prototype II.

The next stage, in order to determine the usefulness and readability of the tool, is validated by a media expert validator and a material expert validator. The results of this test will provide an average value which will later become a reference for whether the teaching aids can be said to be appropriate or not. Expert validation results do not only contain assessments but also criticism and suggestions. This revision stage aims to revise the results of Prototype II in accordance with the criticism and suggestions provided by the validator. Based on the validity category of a media, the validation test data is then analyzed based on the Aiken index validation data calculation guidelines [8]. These references can be seen in Table 1.

Table 1. Props evaluation criteria

No	Score Intervals	Category
1	$V > 0.80$	Tall
2	$0.40 \leq V \leq 0.80$	Currently
3	$V < 0.40$	Low

Based on the data from the validation test results, it can be seen whether the teaching aids that have been designed meet the validity values. At this stage a product is produced which is referred to as Prototype III.

The next stage is a practical test by involving students in using the teaching aids. This stage was carried out after Prototype III obtained valid criteria from the validation test [9]. The sample that the researcher will use is 10 physics education students at Muhammadiyah University, Purworejo, using a student questionnaire. During the practicality test, the aspects measured include benefits, presentation

and physical appearance. The data from these tests is then analyzed to identify potential problems, limitations, or deficiencies that might affect the performance of the tool in a real environment. These references can be seen in Table 2 [10].

Table 2. Criteria for Student Response Data Analysis

No	Score Interval (%)	Category
1	86-100	Very good
2	76-85	Good
3	60-75	Enough
4	55-59	Not enough
5	≤54	Very less

Based on the results of this analysis, it can be seen whether the teaching aids that have been designed meet practical values.

The final stage is an evaluation carried out by assessing the quality of the product according to the results of laboratory tests, validation tests and practicality tests that the researchers have carried out.

Research subject
The subject used in this research is an Arduino-based Archimedes' Law teaching aid which is then called Archiduino

Research Instrument
Instruments are tools used by researchers to collect information and data in a study [11]. The instruments used in this research include (1) Observation sheets which have been prepared according to the assessment rubric developed and then given to physics education students at Muhammadiyah University, Purworejo. This observation was carried out to obtain information regarding teaching aids and find problems in the physics learning process in accordance with the objectives of the research. (2) The validation sheet in this research consists of media and material expert validation instruments which aim to validate the product and determine the suitability of the teaching aids being developed. Validation is carried out to determine the validity of the teaching aids designed before implementation. The validation results are also used as a basis for making improvements to the designed tool. The assessment is carried out by giving a range of 4 values, namely: (4) very good; (3) good; (2) less good; and (1) not good. The product validation grid for Archiduino and the teaching aid manual can be seen in Table 1 for validation from media experts. (3) Student response questionnaire sheet used to obtain data on student responses to the Archimedes' Law teaching aids that have been developed.

RESULTS AND DISCUSSIONS

Archiduino design research will be realized in February – August 2023 at the Integrated Physics Education Laboratory. The following stages of props design are carried out:

Analyze
At this stage, the first step taken was an initial analysis carried out on the head of the physics education laboratory and students at Muhammadiyah University, Purworejo. The results showed that there were no Arduino-based Archimedes' law practicum tools available, there was still a lack of digital teaching aids in the laboratory, and learning activities carried out in the classroom. So far, classical methods have been used in the form of material explanations and classroom demonstrations using conventional (manual) teaching aids.

Analysis of the objectives and material used, namely Static Fluid material on the subject of Archimedes' Law. Archimedes' law states: "The upward force on an object immersed in a fluid is equal to the weight of the fluid displaced by that object."This means that the fluid transferred refers to

the volume of fluid which is the same as the volume of the part of the object that enters the fluid. If an object is dipped into a container that is initially completely filled with water, the water that spills from the container is the volume of water displaced by the object [12]. Mathematically, Archimedes' Law can be written in equation 1.

$$Fa = \rho \cdot g \cdot V \quad (1)$$

Information :
Fa = Archimedes force (N)
ρ = Density of liquid (kg/m3)
g = Gravitational acceleration (m/s2)
V = Volume of submerged object (m3)

The aim of the Archiduino designed is to find the value of the upward force received by an object inserted into a fluid. It is hoped that the output results from this Archimedes' Law teaching aid can provide an understanding of the theoretical concept of Archimedes' Law.

Design

1. Selection of Tools and Props Materials

The selection of tools and materials is carried out by collecting various reference sources to determine tools and materials, including: (1) Suitability of tools and materials to the research objectives. (2) Safety of tools and materials for researchers and users. (3) Strength and physical resistance of tools and materials from external and internal influences. (4) Function or specifications of the tools and materials used. (5) Ease of procuring materials. (6) Ease of the process of designing props (7) Flexibility or aesthetics of materials. The tools and materials used are presented in table 3.

Table 3. Tools and materials for teaching Archimedes' Law

No	Tool	Material
1	Sandpaper	Arduino Uno R3
2	Drill	12V Power Supply Adapter
3	Cutter	Acrylic, Wood, Resin, Wood paint
4	Hacksaw	Bolts, Nuts, Washers, and Boshes
5	Wood saws	Cable Clips,Spiral Cable Hose
6	Grinding	Fluid (Water), Water Pump
7	Scissors	Heat Shrink Tube
8	Vernier calipers	Cam Holder, Water Pass
9	Putty knife	Hollow Aluminum, Rubber Pad Feet
10	Wrench	Jack Female Power Adapter
11	Key ring	USB TypeA to Type B Data Cable
12	Acrylic Glue	Jumper Cables
13	Burn Glue	Cable Ties, Nylon Ropes
14	Hard Glue	Kew-Kew,Mini hook, Finger Iron
15	Hammer	20 x 4 LCD, 12C Module
16	Planner Machine	Magnets, Bobbins
17	Trimmer Machine	DC Motor, L298N Motor Driver
18	Screwdriver	PCB, Pin Header Male
19	Ruler	Mica Plastic, Nails, Plastic Box
20	Tweezers	Push Button, Toggle Switch
21	Ratcheting Clamps	Water Hose, Water Faucet, KneeT, Knee L
22	Soldering	HC-SR04 Ultrasonic Sensor
23	Pliers	Arduino IDE software
24	Wood Filler	TerminalPCB Block, Switch Roller

2. Physical Design

Archiduino's physical design was carried out in several stages starting from the design of the props which aims to make it easier to determine the size of the props and the shape of the props. and arrange the layout of each component of the props so that they can be arranged in an orderly and neat manner. The initial design of the teaching aids is presented in Figure 1.

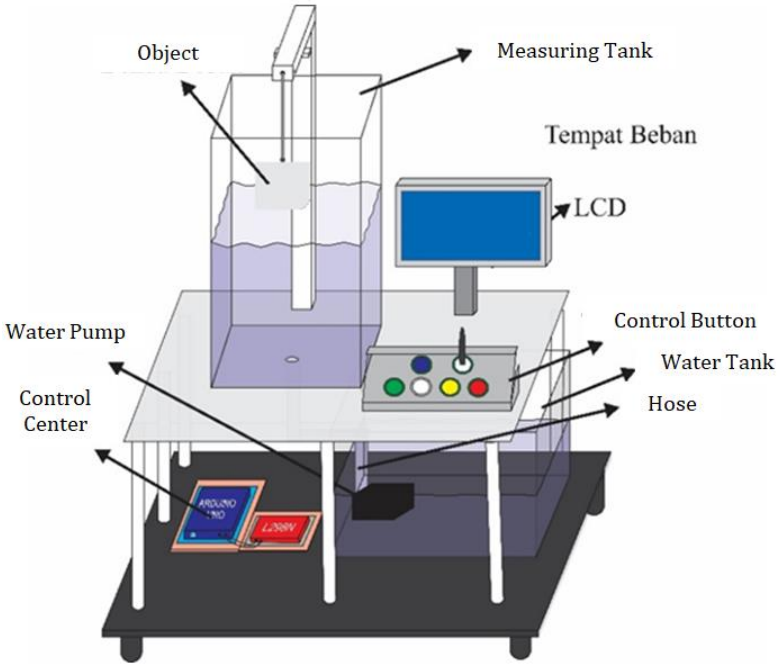

Fig 1. *Archiduino design*

The next stage is designing the hardware design which aims to provide an initial picture of how a series of components from props materials are made. The initial design of the hardware design is presented in Figure 2.

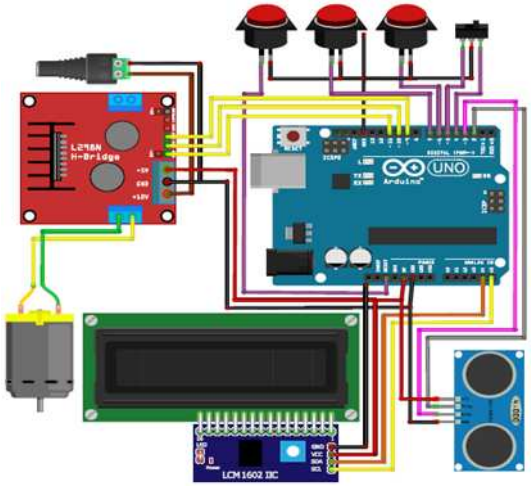

Fig 2. *Archiduino hardware design*

The formulation of a flowchart for teaching aids is carried out as a stage in designing hardware that is adapted to the work function of the teaching aids. The flow diagram of Archimedes' Law teaching aids can be seen in Figure 3.

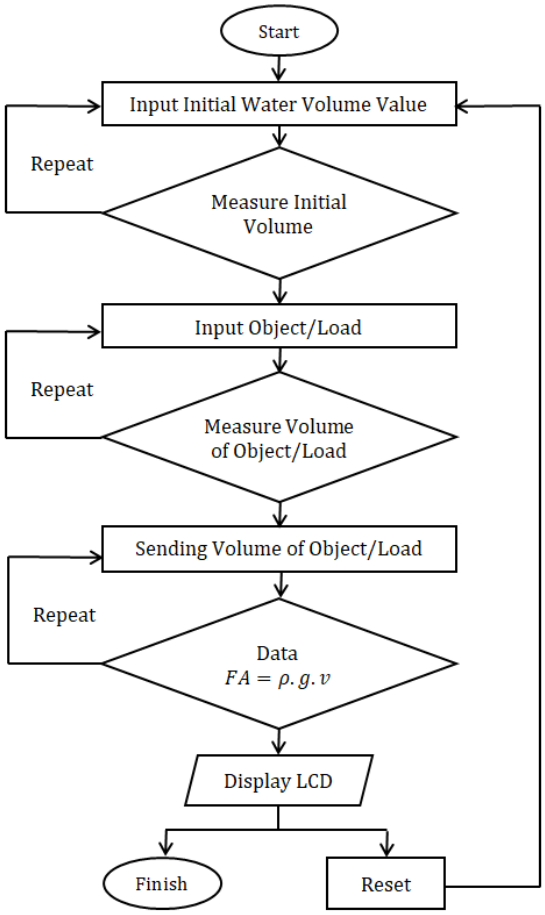

Fig 3. *Props flow chart*

The final stage of design is arranging the components of the propsassemble all the components of the props according to the design that has been made to create a product called Prototype 1. The image of the Arduino-based Archimedes' Law props is presented in Figure 4.

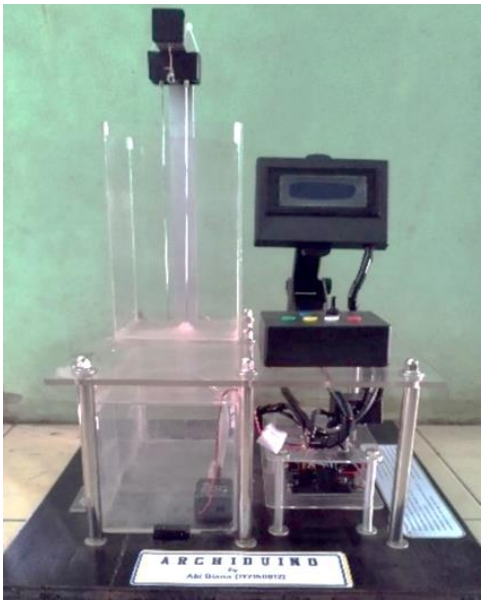

Fig 4. *Archiduino front view*

Development

1. Laboratory Trials

Laboratory trials were carried out by comparing Fa calculations using Archimedes' Law teaching aids with the results of theoretical calculations. Testing this system uses a reference volume of objects, namely variations of objects with a volume of 0.000020 m3.

Table 4. *Fa* value measurement system test results

N	Measurable Fa $(Fa_i)(N)$	$(Fa_i - \overline{Fa})$ (N)	$(Fa_i - \overline{Fa})^2$ (N)
1	1.96	0.00200	0.000004
2	1.98	0.02200	0.000484
3	1.94	-0.01800	0.000324
4	1.95	-0.00800	0.000064
5	1.96	0.00200	0.000004
6	1.95	-0.00800	0.000064
7	1.97	0.01200	0.000144
8	1.95	-0.00800	0.000064
9	1.96	0.00200	0.000004
10	1.96	0.00200	0.000004
Amount	**19.58**	**0.00000**	**0.001160**
Average	**1,958**	**0.00000**	**0.000116**
Error		**(1.958 ± 0.004)**	

2. Validation Test

Product validation tests are carried out to determine the validity of the teaching aids. Product validation is carried out by giving questionnaires to three expert validators. The validators include three media experts and three material experts. Validation results data are presented in Table 5 and Table 6.

Table 5. Media expert assessment results

Assessment Aspects	No. Item	Expert 1	Expert 2	Expert 3	S1	S2	S3	Σs	V	Category
Props										
Equipment Integrity	1	4	3	3	3	2	2	7	0.78	Medium
	2	4	4	3	3	3	2	8	0.89	High
	3	4	4	3	3	3	2	8	0.89	High
Tool Accuracy	4	3	4	3	2	3	2	7	0.78	Medium
	5	4	4	3	3	3	2	8	0.89	High
	6	3	3	3	2	2	2	6	0.67	Medium
	7	3	4	3	2	3	2	7	0.78	Medium
Tool Effectiveness	8	4	4	3	3	3	2	8	0.89	High
	9	4	4	3	3	3	2	8	0.89	High
	10	4	3	4	3	2	3	8	0.89	High
Tool Aesthetics	11	3	4	3	2	3	2	7	0.78	Medium
Security	12	3	3	3	2	2	2	6	0.67	Medium
	13	4	4	3	3	3	2	8	0.89	High
Kit Box	14	4	4	3	3	3	2	8	0.89	High
	15	4	4	3	3	3	2	8	0.89	High

Assessment Aspects	No. Item	Expert 1	Expert 2	Expert 3	S1	S2	S3	Σs	V	Category
Guidebook										
Quality of Compilation and Functionality	16	4	4	3	3	3	2	8	0.89	High
	17	4	4	3	3	3	2	8	0.89	High
	18	4	4	3	3	3	2	8	0.89	High
	19	4	4	3	3	3	2	8	0.89	High
	20	3	4	3	2	3	2	7	0.78	Medium
Communicative	21	3	4	3	2	3	2	7	0.78	Medium
	22	4	4	3	3	3	2	8	0.89	High
Average									**0.84**	**High**

Based on validation tests of teaching aids and guidebooks by three media expert validators, it shows that the average value of the Aiken V index obtained is 0.84 in the high validity category.

Table 6. Material expert assessment results

Assessment Aspects	No. Item	Expert 1	Expert 2	Expert 3	S1	S2	S3	Σs	V	Category
Props										
Linkages with Learning Materials	1	4	4	3	3	3	2	8	0.89	High
	2	4	3	3	3	2	2	7	0.78	Medium
The Value of Education	3	4	4	3	3	3	2	8	0.89	High
	4	4	4	3	3	3	2	8	0.89	High
Tool effectiveness	5	4	4	3	3	3	2	8	0.89	High
Guidebook										
Content Eligibility	6	4	4	3	3	3	2	8	0.89	High
	7	4	4	3	3	3	2	8	0.89	High
	8	3	4	4	2	3	3	8	0.89	High
Feasibility of Presentation	9	3	4	3	2	3	2	7	0.78	Medium
	10	4	4	3	3	3	2	8	0.89	Tall
	11	3	3	3	2	2	2	6	0.67	Medium
	12	4	4	3	3	3	2	8	0.89	Tall
Language Eligibility	13	3	4	3	2	3	2	7	0.78	Medium
	14	4	4	3	3	3	2	8	0.89	Tall
	15	4	3	3	3	2	2	7	0.78	Medium
Average									**0.84**	**High**

Based on validation tests of teaching aids and guidebooks by three material expert validators, it shows that the average Aiken V index value obtained was 0.84 in the high validity category.

3. Limited Test

This stage aims to determine the level of practicality of the teaching aids. The trial was carried out on 10 Physics Education students at Muhammadiyah University, Purworejo. The trial was carried out with practical learning where after the learning was completed, students were asked to fill out a response questionnaire. The practicum is carried out in accordance with the practicum guide that has

been created. Practical learning is carried out in 3 meetings. Where each meeting discusses different material.

At the first meeting, the material discussed was related to the concept of floating objects in Archimedes' Law. Practical learning at the first meeting went well, but there was an obstacle, namely that students were not able to understand the concept of the material to be implemented. The solution to this obstacle is for the researcher to provide a more detailed explanation regarding the material that is the practical topic.

At the second meeting, the material discussed was the concept of floating objects in Archimedes' Law. Practical learning of course begins with an opening stage in the form of greetings and checking attendance. Learning is progressing as it should, but there are obstacles, namely students still don't understand how to use teaching aids, so practical learning takes a long time. As a solution to these obstacles, researchers provided more detailed explanations to students regarding the use of teaching aids.

In the third meeting, the material discussed was the concept of sinking objects in Archimedes' Law. The practicum implementation begins with an opening stage in the form of greetings, checking attendance, and apperception. At the core stage, the researcher explains in detail the parts of the props and how to use them. Then the researcher guided the students to carry out experiments on Archimedes' law using the teaching aids that had been made. In the closing stage, researchers and students together process the practicum data and conclude it. Practical learning was carried out well. However, there is an obstacle in the form of students not being able to connect the results of Archimedes' law practicum with the application of Archimedes' law in everyday life. The solution to this problem is that researchers provide examples related to the application of Archimedes' law in everyday life that can be put into practice. At the end of the activity, students were asked to fill out a response questionnaire to the teaching aids. The results of student responses are presented in Table 7.

Table 7. Results of student responses to Archiduino

No	Aspect	Average Score	(%)	Category
1	Benefit	3.83	95.83	Very good
2	Presentation	3.35	83.75	Good
3	Physical appearance	3.24	81.00	Good
	Average	**3.47**	**86.86**	**Very good**

Based on student responses presented in table 13, the average score was 3.83 with a percentage of 95.83% in the benefits aspect, the average score was 3.35 with a percentage of 83.75% in the presentation aspect, the average score was 3.24 with a percentage of 81.00 % on the physical appearance aspect. From all aspects, an average score of 3.47 was obtained with a percentage of 86.86% and it can be concluded that the Archimedes' Law teaching aids are in the very good category.

Implementation

This stage aims to determine the working function of the teaching aids as practical teaching aids for Archimedes' Law. The trial was carried out to prove that the designed teaching aids could be used to measure the Fa value on the subject of Archimedes' Law by comparing the Fa value obtained from the teaching aids with the theoretical Fa value.(Masyruhan et al., 2020). This test was carried out using three variations of objects as experimental objects, namely objects with Vb = 0.000090 m3, Vb = 0.000150 m3, and Vb = 0.000283 m3 to measure the upward pressure force (Fa) on each object. The experimental results are presented in figure 5.

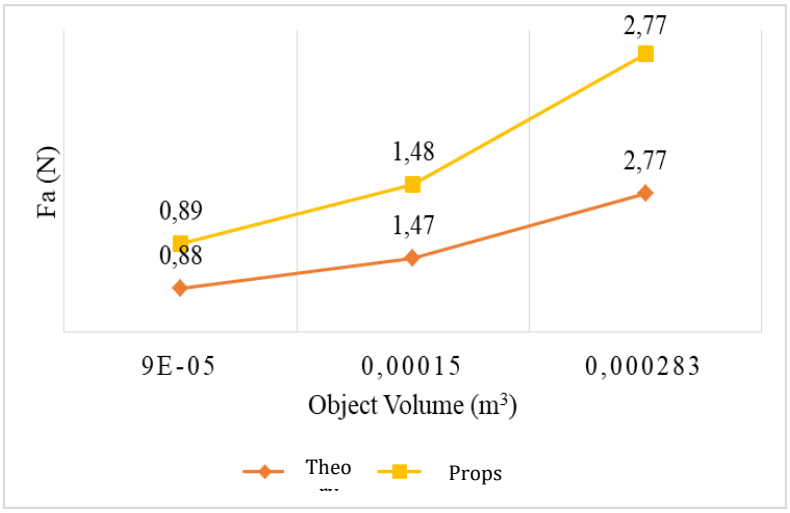

Fig 5. *Graph of the relationship between Archiduino Fa values and theoretical Fa values*

Based on a comparison between the Fa value using props and theoretical calculations, the results obtained were that in the experiment using a variation in the volume of the object of 0.00009 m3, the results of the experiment using props obtained an average Fa value of 0.89 N, while in theory the average Fa value was 0.88 N. In the experiment using variations in object volume of 0.00015 m3, the results of experiments using visual aids obtained an average value of Fa of 1.48 N, whereas in theory the results obtained an average value of Fa of 1.47 N. In the experiment using variations in object volume of 0.000283 m3, the results of experiments using teaching aids obtained an average Fa value of 2.77 N, while in theory the Fa value was 2.77 N. Based on the comparison made between the Fa value when using the props and theoretical calculations, it can be concluded that the results of the props measurements are close to the theoretical results within the limits of error.

Evaluation

The evaluation stage carried out analysis of the results of the laboratory trial stages, validity tests and limited trials of Archiduino. The validity of Archiduino is known through the results of the validation test recapitulation, namely obtaining an average percentage of media expert assessments of 88.02% in the valid category and media experts 87.96% in the valid category. The results of the limited trial were that the average percentage was 86.86% in the good category.

The next evaluation will focus on improving the teaching aids and the accompanying guidebook. Some suggested improvements include adding a waterpass to indicate the level of inclination of the device. Additionally, the researcher will add a cover that can be opened and closed during experiments to reduce the influence of wind. The guidebook table will also be revised and adjusted to align with the Archimedes' Law practical activities. Furthermore, the guidebook will include illustrations that demonstrate Archimedes' Law and explain the variables in the equation.

CONCLUSION

Archiduino, which was designed to meet the valid criteria based on the results of the assessment by media experts, obtained an average percentage of 88.31% in the valid category and the results of the assessment by material experts obtained an average percentage of 87.96% in the valid category. Archiduino met the practical criteria in a limited trial of 10 students, and received student responses to the teaching aids in the aspects of benefits, presentation of the tools and physical appearance with an average percentage of 86.86% in the very good category. Thus Archiduino is valid and practical so it can be used as an alternative teaching aid in learning

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REFERENCES

[1] Suwardi, S. (2021). STEM (Science, Technology, Engineering, and Mathematics) Inovasi Dalam Pembelajaran Vokasi Era Merdeka Belajar Abad 21. *PAEDAGOGY: Jurnal Ilmu Pendidikan dan Psikologi*, *1*(1), 40-48.

[2] Wangge, M. (2020). Implementasi media pembelajaran berbasis ICT dalam proses pembelajaran matematika di sekolah menengah. *Fraktal: Jurnal Matematika Dan Pendidikan Matematika*, *1*(1), 31-38.

[3] Coesamin, M. (2019, October). Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMP Kelas VIII Pada Pembelajaran Dengan Pendekatan Konstruktivis. In *Prosiding Seminar Nasional Pendidikan MIPA FKIP Universitas Lampung* (Vol. 1, No. 2, pp. 76-82). Pendidikan MIPA FKIP Universitas Lampung.

[4] Al Hakim, Y., & Ramadhani, F. N. (2023). Pengukuran Temperatur Berbasis Internet of Things (IoT) dan Implementasinya pada Praktikum untuk mengukur Kemampuan Psikomotorik. *Jurnal Penelitian Pendidikan Fisika*, *8*(1), 52-59.

[5] Husein, W. M. (2022). Upaya guru dalam meningkatkan kualitas pembelajaran melalui penerapan teknologi informasi di MI Miftahul Ulum Bago Pasirian. *Jurnal Petisi*, *3*(1), 20-28.

[6] Pratiwi, E. D., & Linuwih, S. (2017). Pengembangan alat peraga Hukum Archimedes untuk siswa kelas VIII SMP. *Physics Communication*, *1*(1), 43-48.

[7] Palupi, I. A. (2015). Upaya Peningkatan Pemahaman Konsep Hukum Archimedes Melalui-Alat Peraga Katrol Archimedes, pada Pembelajaran Fluida Tak Bergerak di Kelas XI IPA SMA Negeri 3 Salatiga.

[8] Megantari, K. A., Margunayasa, I. G., & Agustiana, I. G. A. T. (2021). Belajar sumber daya alam melalui media komik digital. *Mimbar PGSD Undiksha*, *9*(1), 139-149.

[9] Akhdinirwanto, R. W., Ashari, A., Maftukhin, A., Fatmaryanti, S. D., & Kurniawan, E. S. (2022, January). The validity of the Argumentation-Flipped Learning (AFL) Model to Increase Critical Thinking Skills for Students of Junior High School in the COVID-19 Era. In *2nd International Conference on Education and Technology (ICETECH 2021)* (pp. 351-357). Atlantis Press.

[10] Istiqomah, I., Al Hakim, Y., & Kurniawan, E. S. (2020). Gerak Lurus Berbasis Arduino Uno: Alat Peraga Fisika Alternatif menggunakan Linear Air Track. *Jurnal Inovasi Pendidikan dan Sains*, *1*(3), 85-91.

[11] Situmorang, T. E., & Purba, D. (2019). Perancangan Aplikasi Pengujian Validitas dan Reliabilitas Instrumen Penelitian. *Jurnal Kakifikom*, *1*(02), 54-58.

[12] Wahyuningsih, F. T., Al Hakim, Y., & Ashari, A. (2019). Pengembangan Alat Peraga Pengukur Debit Air Menggunakan Sensor Flow Berbasis Arduino Sebagai Media Pembelajaran Fluida. *RADIASI: Jurnal Berkala Pendidikan Fisika*, *12*(1), 38-45.