Development of Digital Archimedes Experiment System Based on Microcontroller for Physics Education

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Abstract. The development of digital Archimedes Experiment System Based on Microcontroller for Physics Education has been done. The use of digital systems makes the tools used more effective and time efficient. The digital system used in this device consists of a microcontroller, digital display, power supply and proximity sensor HC-SR04. A microcontroller receives digital data from the HC-SR04 proximity sensor and processes the digital data into the fluid lifting force and mass density that displayed on the digital display. Based on data measurement, accuracy and system accuracy on average 95.06% and 94.88%. In addition, the development is also done on student work sheets. The work sheets developed contain a scientific approach consisting of observing, questioning, experiments, analyzing, and communicating. Based on the results of the validation of experts obtained data that practicum tool has a validity rate of 83% are in the category is very valid. On the other hand, the student worksheet has a validity level of 89.6% are in very valid category.

Keywords—experiment system; digital; Archimedes; Sensor; Microcontroller.

1. Introduction

The Since 2013, Indonesia has implemented a new curriculum. This curriculum requires students to be active, creative, independent, responsible and able to compete in the global world. Therefore, the learning process should be improved so that students have good competence. Physical learning will be interesting and easy to understand if learning is completed with experimental activities. Experimental activities can improve students' creative thinking skills on all aspects of creative thinking skills consisting of flexibility, fluency, elaboration and originality [1]. Experimental activities also encourage active learning that emphasizes students' independence in the learning process so as to enhance their thinking, emotional and skills [2].

In reality, experimental activities are conducted in a limited way in schools. One of the factors causing the lack of experimentation is the unavailability of experimental equipment in the laboratory. In addition, most existing equipment works manually with a low level of accuracy. Experiments using analog equipment also contribute to errors in experimental data.

In previous work, various experimental systems have been developed such as the measurement of silat kick speed [3], the determination of the gravitational constant by pendulum technique [4], the experimentation of free fall motion [5] and thermo balance [6]. Especially for fluid experiments,
previous system development is only on the topic of viscosity [7]. There has been no system development for the Archimedes experiment. Therefore, in this research will be discussed development of Archimedes experimental system digitally.

This study aims to develop an accurate and precise Archimedes digital experimental system. The system is generally built using microcontroller, LCD display, and ultrasonic sensors. In the next session will be presented development methods, results and discussion and conclusion of this work.

2. Research Method

The Archimedes experimental system was developed based on the laws of archimides in which each object undergoes weight reduction when it is introduced into a liquid. Reduction of the weight of the object is caused by the lifting force given by the liquid to the object. The magnitude of the lifting force given by the liquid in an object is equal to the weight of the displaced fluid [8] as illustrated in Fig. 1.

Based on Figure 1 it can be observed that when a stone is inserted into a container there is water poured into a small container. The amount of water shed is equal to the volume of the inserted object [7]. The magnitude of the lift force experienced by the stone in the liquid can be determined by using the equation

$$F_a = \rho_f \cdot g \cdot V_f$$

Where $F_a$ is liquid lifting force (N), $\rho_f$ is the density of the liquid (kg / m$^3$), $g$ is earth's gravitational acceleration (kg / m$^3$) and $V_f$ is volume of dyed objects (m$^3$).

In general, there are three conditions experienced by objects while in a liquid that is floating, floating and setting. The magnitude of the fluid lifting force and the mass of the object type can be determined by using the equation

$$\rho_b = \frac{m}{V_o}$$

In here, the $\rho_b$ is density of the object (kg / m$^3$), $V_o$ is volume of objects (m$^3$) and $m$ is mass of objects (kg). The design of the experimental system for the law of Archimedes can be seen in Fig. 2.
Accuracy of the system is determined by comparing the results of the measurement system with the results of theoretical calculations. Meanwhile, accuracy is determined by making repeated measurements for one particular density.

3. Results and Discussion

The development carried out resulted in a product of Archimedes digital experimental tool. This experimental system can be used to explain the laws of Archimedes for floating and drowning bodies. Fig. 3 shows the experimental system that has been developed.

![Fig.3. Archimedes Experiment System](image)

The accuracy of measurement on this system is determined by comparing the measurement result of the system with the calculation result. System measurement is done by varying the period and volume of the object in the form of stone. The results of measurements obtained in the form of liquid lifting force and the density of objects. The accuracy of the measurements for lifting force and the period of type are shown in Fig. 4 and 5, respectively.

![Fig.4. Measured data of the system and calculation plotted as a function of object volume](image)
Based on the measurement data shown in Fig. 4 and 5, the accuracy of the system for lift and mass is 97.00 and 93.17, respectively. Accuracy of the system is high and can be used as experimental equipment especially for Archimedes experiments.

The next stage is the validation of instruments that include Accuracy (A), Precision (B), and Effectiveness of the instrument in explaining topics (C), practicality (D) and Clarity of measurement results (E). Fig. 6 presents the percentage of the validation for each indicator.

Based on Figure 6, the average validity of the Archimedes legal practice tool is 83% with very valid criteria. The experimental system of accuracy and precision validation is in valid category whereas in the aspect of effectiveness, ease and clarity are in very valid category. This suggests that in general the developed Archimedes digital experimental system resides on very valid criteria.

4. Conclusions
Based on the results of research and discussion that has been done can be concluded the accuracy and thoroughness of digital practice tools is 95.06% and 94.88%. On the other hand, the validity of digital experiment system for Archimedes law generally has a prevalence rate of 83%. Based on Likert
scale, the practicum tool is at a very valid level but in accuracy and precision points are within valid criteria. These results show that the developed tool can be used for Archimedes experiments.

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