Development of Specific Heat Capacity Instrument Based on Arduino As Teaching Media of Temperature and Heat Topic

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The Development of Specific Heat CapacityInstrument based on *Arduino* to measure specific heatcapacity and find out the student's respond actually at heat and temperature topic has done. This refers to the Model ADDIE: analysis, design, development, implementation, and evaluation. The subject of the research is student at grade X (science) IPA 1, MA Syamsul Huda Kedungreja. They are 23 students. The data is collected by literature study, observation, interview and laboratorium test. The result of development is average of specific heat capacity of Aluminum (0,215 ± 0,000) cal/gr ^{0}C, and the average of specific heat capacity of Iron (0,106 ± 0,001) cal/gr ^{0}C, by the Table of standard Alumunium 0,215 cal/g ^{0}C and Iron is 0,107 cal/g. It proves that development of specific heat capacity has been accurate. The validation shows it is 82,85% with good category. The effectiveness of the teaching and learning with this is 85% with very good category, the student's respond increases to 82,98% with very good category. Therefore media of specific heat capacity with *Arduino* is proper to use in class.

Keywords: *specificheat capacity, arduino, teaching media*

I. INTRODUCTION

Education is one of the basic needs that must be fulfilled both within and outside the educational institution. Sinceit is very importance, its should be implemented. The learning process is an implementationto force students achieve the goals.

Kurikulum Tingkat SatuanPendidikan (KTSP) is an educational operational curriculum developed by the government as a complement *KurikulumBerbasisKompetensi (KBK)*. And it is based on the character, needs, potential of schools and regions.

Based on *PeraturanMenteriPendidikanNasional* (*Permendiknas*) No 22 /2006 on Competency Standard and Basic Competencies in SMA / MA for physics study is conducted in scientific inquiry to cultivate the ability to think, work and be scientific and communication as one of the aspect important life skills. Physics as the science of science is not just the mastery of a collection of knowledge in the form of facts, concepts, or principles alone but also a process of discovery. Physical education should emphasize the provision of hands- experience to develop competencies so that students are able to understand what they are learning through the visual aids. Besides that, it will not change the method of teaching to be better, but the aids will help to convey the message and the content of the lesson. The visual aids can provide visualization of actual concepts so that student is able to understand and have similar meaning to the intentions of the delivery of material presented by the teacher in front of the class.Based on observations made in the MA Syamsul Huda and interviews with physics teachers, thatprocess of physics learning is still referring to KTSP. The method is conventional, and text book- oriented. It focus on the book and problem solving. The aid in school is still very limited. Student's Curiosity and motivation to learn are still less, the students prefer playing with others than answering the question or asking the material whether they cannot do.Based on these problems, the authors develop a type of caloric tool as a learning tool. In the development of the tool the researchers conducted an innovation by modifying the calorimeter combined with the use of load cell sensors as digital scales and DS18B20 sensors as a temperature meter with a data processing system using Arduino. Arduino is used because of its low power, so its use is suitable for use as a control system in the manufacture of physics props in high school.

II.THEORETICAL REVIEW

A. Visual Aids

In the process of learning science especially physics, It is needed a visual aids to to explain the concept, so that students obtain ease in understanding the material. Establishes mastery of material that has to do with the material learned and develops skills [1]. The existence of props in the learning process can provide a form of real experience by focusing something that is abstract so that it can be reached with a simple thinking so that the learning process more efficient.

B. Sensor DS18B20

A sensor is a system element that is effectively related to the process by which a variable is being measured and produces an output in a particular form depending on its input variable and can be used by other parts of the measurement system to recognize the value of the variable [2].

DS18B20 is the latest series digital temperature sensor from Maxim IC (formerly the one made is Dallas Semiconductor). The function of this sensor is to change the temperature into a voltage linearly. The sensor is capable of reading temperatures with precision of 9 to 12-bit, range -55 ° C to 125 ° C with precision ($\pm$0,5°C).

C. Load Cell Sensor

Load cells are a major component of the digital scales system. Even the degree of accuracy of a digital scale depends on the type and type of load cell used. Load cell is a sensor that can detect any mass changes caused by force and gravity of objects. Changes caused by the force and gravity of objects will be used as analog signals in the form of voltage that will be forwarded to the transducer. The transducer functions to change the analog signal generated by the load cell to the electrical quantity.

D. Push Button

In general, push button switch is a control device that can only work when pressed. Various push button push button that is, the button NO (normally open) which is a button that in normal circumstances have open contact (open) or in the off condition. NC (normally close) buttons, push buttons in normal circumstances have closed or close, and a combined button between NO and NC in normal state has open and closed [3].

E. Arduino

Arduino is a microcontroller board based on ATmega328 [4]. Arduino has 14 digital input / output pins (6 of which can be used as PWM output), 6 analog inputs, using 16 MHz Crystals, USB connection, power jack, an ICSP header, and reset button. Arduino contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or supply it with an AC adapter to DC or use the battery to start it.

F. Specific Heat Capacity

Specific heatcapacity the amount of heat that takes 1 kg of the object mass to raise its temperature by one unit temperature [5]. The greater the heat of its kind, the harder the substance is increased its temperature because the amount of heat needed more and more.

Type heat can be written in the following equation:

$$Q = m \,.\, c \,.\, \Delta T \rightarrow c = \frac{Q}{m \,.\Delta T} \qquad (1)$$

information :

Q = Many heat (J)

m = Mass of body (kg)

c = Specificcalory(kal / gr ^{0}C)

ΔT = Temperature change (^{0}C)

Each object or substance has a different type of heating value according to its ability to absorb and release the heat.

G. Black's Principle

"If two substances with different temperatures are touched or mixed, a high-temperature object releases heat and a low-temperature object will absorb the heat until thermal equilibrium is reached." Mathematically can be written,

Qrelease = Qaccept (2)

Q (hot water) = Q (cold water)

m1 c (Tp-Tc) = m2 c (Tc-Td) (3)

description:

m1 = hot water mass (kg)

m2 = cold water mass (kg)

c = heat of water type

Tp = hot water temperature (^{0}C)

Tc = mixed water temperature (^{0}C)

Td = cold water temperature (^{0}C)

For example, when we are going to measure the heat of a metal type using a calorimeter, the heated metal will experience a temperature rise of T2, then the calorimeter is filled with water with mass of ma and the initial temperature of T1 equal to the calorimeter temperature and then inserted a molar metal with T2 temperature there will be a heat transfer of the water metal and calorimeter to obtain a T3-will balance temperature, a small environmental heat transfer so that it can be neglected in this case the solid type heat can be expressed in the equation:

$$c_z = \frac{(m_a c + C)(T_3 - T_1)}{m_z\,(T_2 - T_3)} \qquad (4)$$

information:

c = heat of water type (kal / g ^{0}C)

C = heat capacity of calorimeter (kal^{0}C)

cz =specific calorine of substance (kal / g ^{0}C)

III. RESEARCH METHODS

This research is a research of Arduino-based heating tool using ADDIE development model with stages of analysis, design, development, implementation, and evaluation [6], conducted in physics education laboratory of Muhammadiyah University of Purworejo, and its implementation is done in MA Syamsul Huda on students class X-IPA MA which amounted to 23 students. Data collection techniques were obtained by conducting literature studies, observation, interviews, questionnaires, and laboratory tests. The data obtained were then analyzed using descriptive statistical analysis.

IV. RESULTS AND DISCUSSION

A. Hardware Design

The design of the hardware on the props has a control system used to process the Arduino IC data which contains the program to access data from the load cell sensor which functions to calculate the water mass and DS18B20 to measure the temperature degree. In addition, the arduino also receives inputs from the push button that functions to regulate the work of DS18B20 sensors and load cell sensors. The output pin of the load cell is connected to the amplifier (HX711 Module) and DS18B20 sensor connected to 4K7 resistor first to be read by the ADC pin.

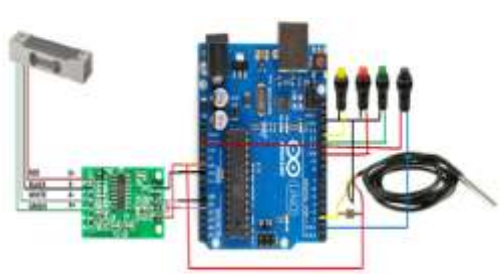


Figure 1. Hardware Design of Heat Type Measurement Tool

B. System Software Design

The design of software in this research is programming on Arduino. Programming is done to set the main function of the props as the type of heat count generated based on the measurement results using the sensor. The software created is used to enable load cell and DS18B20 sensors as automatic mass and temperature measurements, as well as data processors. Software will measure the mass of calorimeter and mass of fluid placed on the scales board in accordance with the commands we provide through the push button.

After the design of software and hardware can be shown the physical form of props made in this

Figure 2 Images of Specific Heat Capacity Instrument

C. Load Cell Calibration

The load cell sensors used are calibrated first with a benchmark. The calibration has been done using a digital balance sheet measuring instrument found in the Physics Education Laboratory of Muhammadiyah University of Purworejo. Measurements performed at each load between 50 grams to 1000 grams of the initial conditions in the measurement is 0 grams. From the test results can be seen that the average weight error rate shown is 0.52%. In terms of hardware, Arduino has certain limits of tolerance to allow the use of components that are not too precise. Based on the data obtained can be made graph of the relationship between the mass of the measurement results using the load cell sensor with the actual mass presented in Figure 3.

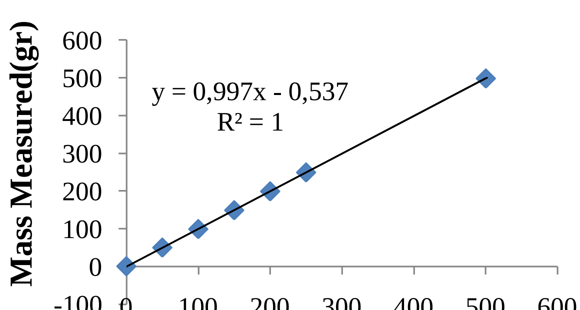


Figure 3. Graph of Relationship toMass(Actual and Measured)

D. Sensor Calibration DS18B20

In the test results of accuracy level DS18B20 sensor by comparing the results read by using alcohol thermometer contained in the laboratory of physics education, obtained difference measurement results with the average error rate (error) of 0.57 0C. Sensor measurement has a maximum error value of 1.72 0C and a minimum error of 0.11 0C, this is due to the offset and noise voltage in the measurement of signal conditioning circuit. From the data then in

accordance with the design that has been determined, to know the value of precision and accuracy of the sensor presented in graphical form as in Figure 4.

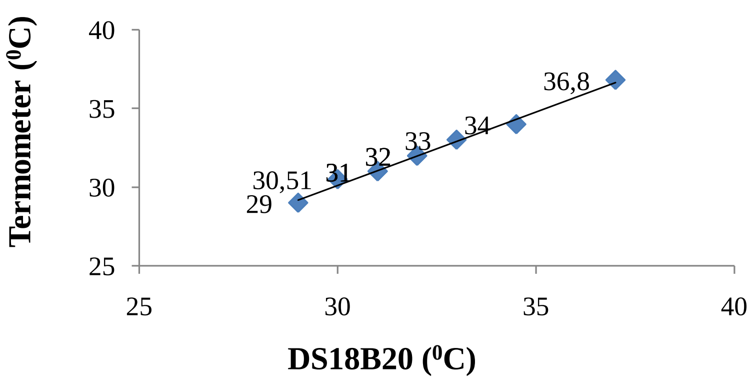


Figure 4 Graph of Relation between Measurable Temperatures in DS18B20 and StandarThermometer

E. Experiment Determining Heat Type of Object

This experiment is only done using two solid materials namely aluminum and iron. In literature, the calorific value of aluminum type is 0.215 cal / g 0C, and iron is 0.107 cal / g 0C. Referring to the calorific value of the reference type of each material, the values of type of heat flats for aluminum (0,217 ± 0,002), (0,215 ± 0,000), (0,213 ± 0,002), and iron type heat (0,108 ± 0,001), (0,106 ± 0.001), and (0,105 ± 0,002) for massive batching of 20 grams, 50 grams and 100 grams as shown in Table 1. Based on the results of the corrected means showing the type of heat tool has a good accuracy value.

F. Specifi Heat Instrument Validation

The data obtained in this research development is the result of the validation of the heating tool of the kind carried out by three experts including media experts, material experts and physics teachers. Based on analysis of reliability test obtained mean score on aspect of relation with teaching materials 67% reliable category, 91% education value with very reliable category, toolability aspects 86% very reliable category, tool resistance 91% very reliable category, aesthetic value 100% category very reliable, 93% of the category is very reliable, the kit is 92%, while for the guidebook on the content feasibility aspect, 80% of the categories are very reliable, the feasibility of 91% of the category is very reliable and the language feasibility is 96% very reliable. The above data is then averaged with the final value of 82.36%. Based on the data obtained can be made diagram as in Figure 5.

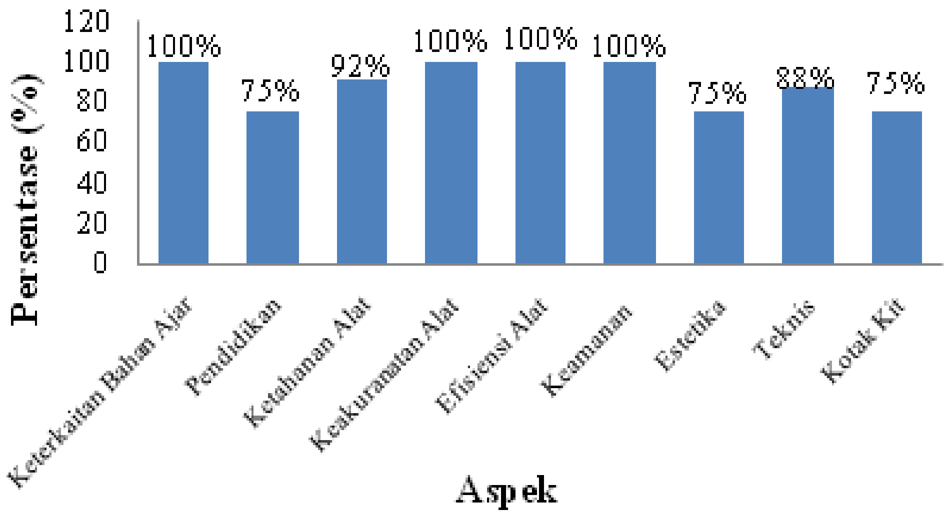


Figure 5. Diagram of Assessment of Display Tool by Lecturer of Expert and Physics Teacher

G. Implementation of Learning

Data on the results of the implementation of assessment learning is given based on three aspects of the implementation ie, preliminary activities, core activities, and cover. Scores obtained on aspects of preliminary activities of 81% included in the category very good, core activities aspects get a percentage of 88% very good category, as well as on cover activities get 88% percentage. Based on the data of the implementation of learning, it can be concluded that the implementation of learning using props very well. The learning implementation diagram is shown in Figure 6.

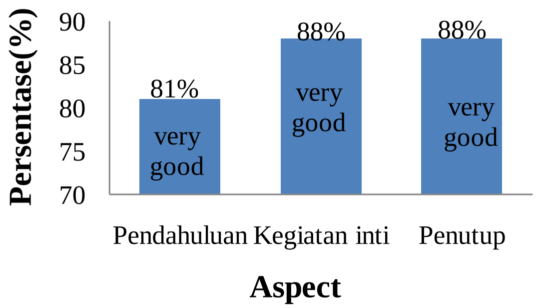
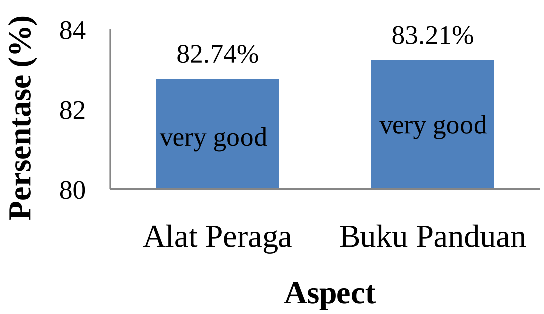


Figure 6. Diagram of Implementation of Learning

H. Student Response

The result data of the students' responses were obtained based on the students' assessment through a response questionnaire that has been filled in accordance with the students' beliefs as presented in Table 21. Scores obtained based on the student ratings for the props get the score of 19.03 so that the average score is 0.83 with the level 82.74% percentage of the category is very good, for the guidebook to get the total score of 19.14 so that the average score obtained 0.83 with the percentage level of 83.21% category is very good. So for the average of all aspects obtained percentage of 82.98% and it can be concluded that the student's response to the props of heat type is very good. Based on the data obtained can be made diagram as in Figure 7.



Based on the results of data analysis can be concluded that the type caloric props have a good accuracy, so it is worthy of use in the learning process. The conclusions were obtained based on experimental test results with aluminum-type heat (0.211 ± 0.004) cal / g 0C, (0,210 ±

0,005) cal / g 0C, (0,208 ± 0,007) cal / g 0C, and heater type iron (0,108 ± 0,001) cal / g 0C, (0,113 ± 0,006) kal / g 0C, and (0,110 ± 0,003) kal / g 0C with standard reference value for aluminum heat 0,215 cal / g 0C and iron 0,107 cal / g 0C for penguran with different mass respectively that is 20 gr, 50 gr and 100 gr, the result of validation of expert lecturer and physics teacher with the percentage 82,23% very good category, result of appraisal of learning implementation using props done by observer obtained by percentage with the average of 85% category is very good, and the student's response to the type heat tool developed by 82,98% very good category.

V.PUSTAKA

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