Design of Digital-Based Photoelectric Effect Practicum Devices

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Abstract. Some universities provide laboratories and practical units for modern physics, some do not. It only has modern theoretical physics courses which are usually imposed on students in the fifth semester. Based on the analysis of the material and lecture achievements at the predetermined stages, the researcher decided to design a Photoelectric Effect practicum. The research aims to describe the design stages in terms of media selection, format selection, and initial design of digital-based Photoelectric Effect practicum equipment. This research is research and development that refers to the 4D-Thiagarajan development model. Research data is presented descriptively. Based on the research results and description of previous research stages such as media selection, format, and initial design, the Photoelectric Effect practicum will be based on Arduino Uno. The Photoelectric Effect practicum module is presented in digital form. It is hoped that this research can become a learning medium for students, which can be used not only by researchers in the Physics Education Study Program but also in several Physics Education Study Programs that have not yet carried out modern physics experiments.

Keywords: Digital Learning, Experiment, Photoelectric Effect

Introduction

The Modern Physics course is a course that examines the behavior of matter and energy on the atomic scale and subatomic particles or waves. In principle, the same as in classical physics, but the material studied in Modern Physics is on an atomic or subatomic scale and particles move at high speeds [1]. Modern Physics was developed in the early 20th Century when formulations in Classical Physics were no longer able to explain phenomena that occur in very small matter [2]. Abstract concepts in Modern Physics content require practicum to master the concept. Good quality learning (practicum) will be achieved if good learning tools are available. Quality learning requires innovative lecturers, capable of teaching and providing understanding to students, especially in the context of Modern Physics which is abstract in nature [3]. In addition, the quality of

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Modern Physics learning and practicum is also influenced by the availability of facilities such as laboratory rooms and practicum equipment.

Several Physics Education Study Programs, both public and private universities, added Modern Physics practicum as a compulsory subject. However, to add a Modern Physics Practicum to one of the study program courses, the study program needs to have a Modern Physics laboratory, a practicum unit, and resources capable of operating the Modern Physics practicum unit. This is the reason why the Modern Physics Practicum course is not implemented at several private universities, one of which is the Physics Education Study Program at one of the universities in South Sulawesi.

Preliminary observations were made of physics education study programs at two different private universities in South Sulawesi [4]. The results of preliminary observations found that college A had carried out modern physics practicum, but was limited to four manual practicum units and one virtual practicum unit. Manual practicum units in modern physics practicum are magnetic oscillation, michelson-morley interferometer, hydrogen atomic spectrum, and photometry. The unit of modern physics practicum which is a virtual practicum is the photoelectric effect. Meanwhile, College B has not carried out a modern physics practicum. This is because College B does not yet have a laboratory room for modern physics practicum activities. In addition, College B also does not yet have a modern physics practicum unit, and human resources capable of designing a modern physics practicum.

College A has utilized technology in designing virtual modern physics practicums. The currently developing information and communication technology cannot be separated from the learning process, especially in practice. There have been many previous studies that have utilized ICT technology in practical activities, such as the use of sensors or microcontrollers. For example, airspeed measurement using the HC-SR04 ultrasonic sensor as a sound wave transmitter and using Arduino Uno as a control system [5]. Furthermore, there is research that uses an online practicum model supported by Wireless Sensor Network (WSN) to carry out physics practicum after the COVID-19 pandemic. Online practicum is also integrated with video conferencing, chat, evaluation systems, and lab inquiry stages. The sensor measurement process is carried out directly via live streaming video, where the sensor measurement results are sent in real-time to the website via an internet connection [6]. Apart from that, there is also research into the development of microcontroller-based measuring instruments for physics laboratories [7]. The use of sensors can convey information in the form of presenting physics content effectively and efficiently to students. Arduino Uno functions as a processor of analog data into digital data [8].

Based on the results of initial observations and needs analysis, it is deemed necessary to design a digital-based photoelectric effect practicum device (unit) that uses Arduino Uno as a manual data processor for digital data. In developing the Photoelectric Effect practicum device, it is necessary to consider curriculum analysis in the form of curriculum demands of the Indonesian National Qualifications Framework and adjustments for independent learning, demands of the 21st Century on the learning outcomes of study program graduates from the aspects of attitude, general skills, and knowledge. The next aspect to consider is the preliminary-end analysis which finds differences in the weight of course credits at universities A and B. Apart from that, it is also necessary to consider the analysis from the student's point of view, which describes the relationship matrix of the graduate profiles of physics education study program students with the learning outcomes of graduates assigned to courses, which are then derived in the analysis of material and the selection of modern physics content that are considered essential and capable of designing practicum units that represent modern physics phenomena, namely effect practicum photoelectric. The research aims to describe the design stages in terms of media selection, format selection, and initial design of digital-based Photoelectric Effect practicum equipment.

2 Methodology

This research is development research that uses the Thiagarajan development model, namely the 4D model which includes defining, designing, developing, and disseminating [9]. However, this article will examine it in a limited way, namely at the stages of designing a digital-based photoelectric effect practicum device. The design stage consists of selecting the media, selecting the format, and the initial design. The design stages in research into the development of digital-based Photoelectric Effect practical equipment are presented in Fig. 1.

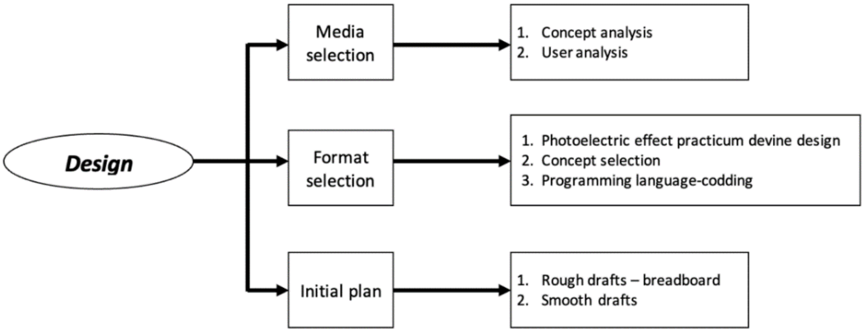


Fig. 1. Design stages of the development of modern physics practical equipment

The data obtained in this research is descriptive data that describes the design stages of the Photoelectric Effect practicum device, which includes the stages of media selection, format selection, and initial design.

In detail, the design stages can be described as follows:

a. Media selection
   Media selection is carried out to identify learning media that are relevant to the characteristics of the material. The selection of media is based on concept analysis and user characteristics. Media selection aims to maximize the use of teaching materials in the process of developing practicum tools in the lecture process.

b. Format selection

The choice of format in designing the Photoelectric Effects practicum device aims to formulate the practicum device design, component selection, and programming language or coding process.

c. Initial draft
Preliminary design is the overall stage in designing practical equipment before trial activities are carried out.

Sampling using an incidental sampling method. Incidental sampling is a sampling method in which the sample is accidentally found by the researcher, and the sample is by the researcher's criteria. The sample criteria the researcher wanted were private tertiary institutions, located in a city in South Sulawesi, which had been established for more than five years, used the Indonesian national qualification framework curriculum, and were oriented towards an independent learning curriculum. From these criteria, the researcher chose College A and College B. The sample is used as a consideration for researchers in developing modern physics practical tools based on Arduino Uno.

3 Result and Discussion

One of the stages of developing a digital-based Photoelectric Effect practicum device with an Arduino Uno device is the design stage of a practicum unit. The product design stage is very important in development. The design stage is the initial stage of development in converting an idea into an initial form of product [10].

a. Media selection
The practicum media chosen is digital-based photoelectric effect content practicum media. The designed Photoelectric Effect practical device will be practiced manually (not in a virtual laboratory), students and lecturers can change the manipulation variables by rotating the potentiometer. Practical measurement results can be read on the screen.

b. Format selection.
After determining the content of the Modern Physics practicum is the Photoelectric Effect and it is planned to be practiced manually (not through a virtual laboratory). So, the next step is to choose the supporting components of the designed practicum unit. The Photoelectric Effect practicum unit will be designed using the Arduino Uno device. Then Arduino Uno will be juxtaposed with several electronic components such as photodiode sensors, diodes, transformers, and Integrated Circuits.

c. Initial draft
First draft:

The initial design of the Photoelectric Effect practicum unit utilized breadboard assistance in its assembly. Figure 1 shows the rough design of the Arduino Uno-based Photoelectric Effect practicum unit. Fig. 2. The design of the Arduino Uno-based Photoelectric Effect Practicum Device is an initial design that is still rough using a breadboard. The initial design of the tool was carried out in the Basic Physics laboratory at the University of Muhammadiyah Makassar.

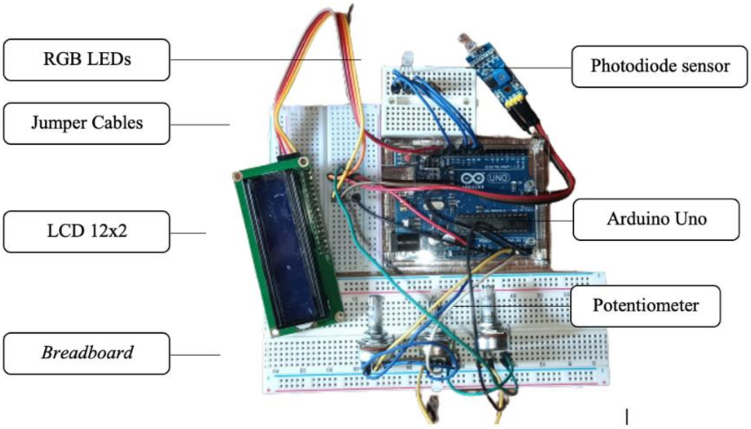
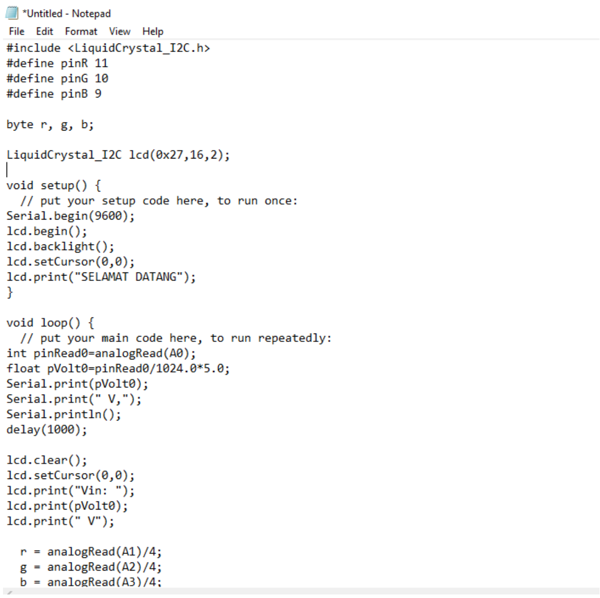


Fig. 2. Design of the Arduino Uno-based photoelectric effect practicum unit

This product design aims to test the tool components and calibrate the tool before making the tool perfectly. The testing of the components of this tool began with making a series of learning media components based on Arduino Uno, with the help of photodiode sensors, RGB LEDs, breadboards, potentiometers, and jumper cables. then proceed with assembling the creation of a programming language in the Arduino IDE application. This programming language is the command given to the Arduino Uno and the components used in this development [11]. This programming language can be seen in Fig. 3.




```
#include <LiquidCrystal_I2C.h>
#define pinR 11
#define pinG 10
#define pinB 9

byte r, g, b;

LiquidCrystal_I2C lcd(0x27,16,2);

void setup() {
  // put your setup code here, to run once:
Serial.begin(9600);
lcd.begin();
lcd.backlight();
lcd.setCursor(0,0);
lcd.print("SELAMAT DATANG");
}

void loop() {
  // put your main code here, to run repeatedly:
int pinRead0=analogRead(A0);
float pVolt0=pinRead0/1024.0*5.0;
Serial.print(pVolt0);
Serial.print(" V,");
Serial.println();
delay(1000);

lcd.clear();
lcd.setCursor(0,0);
lcd.print("Vin: ");
lcd.print(pVolt0);
lcd.print(" V");

  r = analogRead(A1)/4;
  g = analogRead(A2)/4;
  b = analogRead(A3)/4;
```

Fig. 3. Programming Language

After ensuring that the coding process was successful, and being able to measure the response variable that was the target of the practicum, the design of the Photoelectric Effect practicum was continued in the second draft (improvement of the design and construction of the first draft). The design of the second draft can be seen in the following picture.

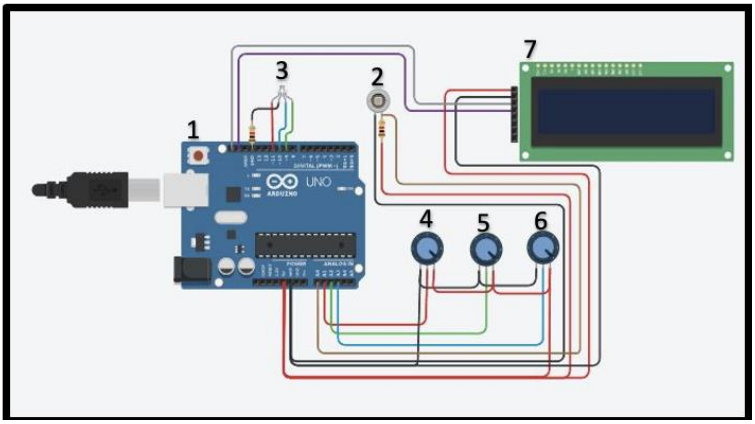


Fig. 4. Design of a series of electronic components in the Photoelectric Effect practicum device

Fig. 4 shows a series of electronic components such as photodiode sensors, RGB LEDs, jumper cables, and potentiometers that are assembled with the Arduino Uno device. After all the components are connected with cables, proceed with making the Arduino Uno box. The Arduino Uno box is made of acrylic material, designed to be opened and closed easily. This is done to anticipate if there are damaged electronic components (for component replacement). The display of the Photoelectric Effect practicum unit which has been covered with an acrylic box can be seen in the Fig. 5.

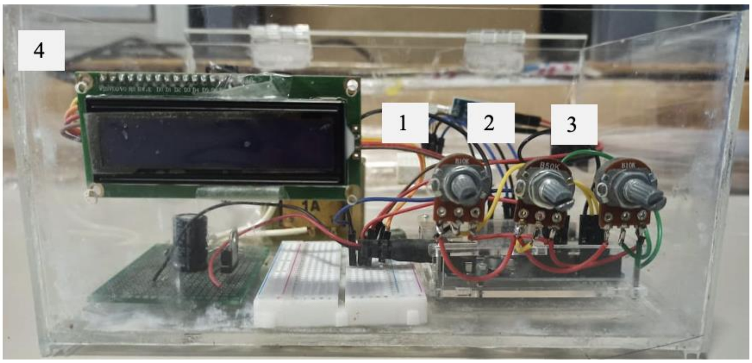


Fig. 5. Design of the Arduino Uno-Based Photoelectric Effect practicum device. Information :1) Potentiometer R; 2) Potentiometer G; 3) Potentiometer B; 4) LCD 12x2 with i2C

The Arduino Uno-based Photoelectric Effect Practical Device is designed in such a way as to facilitate Photoelectric Effect practicum in the laboratory. The advantages of using Arduino devices in designing practicum device prototypes are 1) the microcontroller is easy to use [12], 2) There is a device usage guide that is easy to access [13] and adapted to Physics tools; 3) Arduino Uno devices allow users to experiment innovatively [13]. The Arduino Uno device is a device that answers the need for practical work in the field of Physics, most of the content of which is abstract. The use of the Arduino Uno device in Higher Education can overcome the scarcity of practicum units [14], and increase student attention in lectures [15]. After producing a Photoelectric Effect practicum unit that worked well, the research lecturer team then proceeded to the development stage, namely the validation stage and limited field trials. The research lecturer team plans to carry out product validation through expert validation of several aspects of the test. Apart from that, limited field trials will also be carried out at College A, then after that, it will continue with testing the product at several universities in South Sulawesi that have Physics Education study programs.

4 Conclusion

From the results of the media selection and format selection at the 4D-Thiagarajan design stage, it can be concluded that the Modern Physics content being developed is the Arduino Uno-based Photoelectric Effect practicum unit, which will test two practicum problem formulations, namely the relationship between light intensity and photon energy release, as well as the relationship between frequency and release of photon energy. The design stage has reached draft two, namely testing the fine draft of the Photoelectric Effects practicum unit. The next step in this research is to test the validity, effectiveness, and practicality of the developed Photoelectric Effect practicum unit. With the development of the photoelectric effect practicum device, it is hoped that it will become the forerunner to the development of research on the development of Modern Physics practicum devices for both lecturers and students of Physics education in South Sulawesi.

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