

Development of Light Polarization Learning Tool Based on Arduino and Scientific Performance

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Abstract: *The study and research has been done to develop a polarization learning tool based on Arduino and science performance. Method used in this research is research and development through four steps: initial study, design, develop, and examination. Products have designed in this research are polarization tool based on Arduino, teaching materials, and student work sheet. Instrument used in this research are science performance questions test and questionnaire. This research aims to find the effectiveness and the feasibility of light polarization learning tool in enhancing physics students science performance. The instrument evaluated both quantitative and qualitative. The evaluation of testing data and questionnaire confirms the effectiveness and the feasibility of light polarization learning tool.*

Keywords: Arduino, light, polarization, science performance.

1. Introduction

Comprehension of physics concept achieved by students is an important thing in learning physics. The use of learning methods is very important to achieve that comprehension. Students fail to understand physics concepts generally caused by learning process that not allowing students to find the concept by him or hers self. Therefore the concept gathered from learning process would lose from cognitive structure [1]. In order to understand physics concepts, learning process must allowing students to find concept directly by their self through learning activities.

One of learning models that can be used to solve the problem above is implementing inquiry learning model [2]. There are several activities in inquiry learning model as observing, measuring, classify, asking, defining hypothesis, planning experiment, processing data, and communicating information by learner under guidance of teacher [3]. Through those activities, students allowed to find concept directly and to train their science process and science performance skills. Science performance and science process are the important thing have to be owned by students especially physics teacher candidate [4][5]. Because these skills would be implemented in learning process by student (teacher candidate) when they graduate and work as physics teacher. This is in line with Badan Nasional Standar Pendidikan (BNSP) Indonesia that emphasized implementation of inquiry learning in learning process [6]. Therefore the college that produce physics teachers like STKIP Soe have to trains students skills in science process and science performance.

Several studies have been done in training and enhancing students science performance skills [1][7][8][9]. These studies or research reported that there are increasing on students science performance skills after conducting inquiry learning process. These research also reported the important of using of learning tools or material design in inquiry learning to develop students skills on science performance.

Light polarization is an abstract concept in physics. This concept would be difficult to understand by student if learned without using tools or media [10]. Light polarization can be demonstrated using polarizer and light detector. Those apparatus can be found in our laboratory, but not equipped with light detector. So student only do demonstration without getting quantitative data. The solution to that problem is to make a learning tool that equipped with light detector using electronic devices that easily and cheap to found. Those electronic devices are Arduino and photodiode. Arduino is a microcontroller that can be used as microprocessor to read analog data. Photodiode is a light sensor that can be used to detect intensity of light. The two devices can be used to design a learning tool of light polarization that can measure and display the data of light intensity digitally.

Based on background stated above, the problem statement in this research is:

- 1) How to design and develop a light polarization learning tool based on Arduino and science performance?
- 2) How to validate the light polarization learning tool?
- 3) Is the light polarization learning tool effective to raise student science performance?
- 4) Is the light polarization learning tool feasible to use in learning process?

2. Literature Review

2.1 Science Performance

Science performance is an activity conducted according to scientific rules. The steps of science performance are defining problems, defining hypothesis, examining hypothesis, interpreting data, and draw conclusion [11]. Suparno (2006) stated that science performance in physics is observing, questioning, defining hypothesis, planning experiment to evaluate the hypothesis, drawing conclusion based on experiment results. In this research, subject of science performance of students observed are defining hypothesis, identifying variable, planning experiment, getting data, drawing conclusion and communicating data or

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information [12].

2.2 Light Polarization

Light is a wave form. Light wave that half of its vibration plane absorbed called polarized light. Light that has only one polarized direction called linear polarized light. Polarized light wave produced by using polarizer or polaroid. Polaroid is optic material that can transmit wave that its direction of vibration in line with its transmission axis and absorb wave that its direction of vibration perpendicular to its transmission axis. Polarization explained by Malus law. Malus law stated that intensity of light that propagate through two polaroid equal to function \cos^2 of angle between polarization axis of the two polaroid or $I = I_0 \cos^2\theta$ [13].

2.3 Arduino

A microcontroller (sometimes abbreviated μC , uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input or output peripherals. Arduino is a board contains AVR microcontroller. Arduino board consist of hardware and software IDE that can be used to design program. The advantage of Arduino is that we are not bothered with the minimum circuit of the system and the programmer because it has been built in on a board. Therefore we can focus on system development. Arduino can be used to design cheap and affordable learning tools [14].

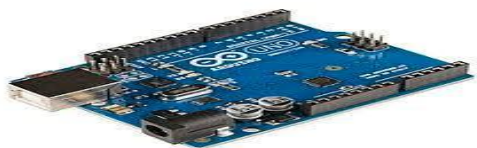


Figure 1: Board Arduino

2.4 Photodiode Sensor

Photodiode sensor is diode that sensitive toward light. Resistance of photodiode will change if it illuminated by light and it will flowing forward current as common diode. Photodiode drained electric current linearly with light intensity [15]. Photodiode more stable than light dependent resistor. Photodiode used as light detector on learning polarization tool designed in this research.



Figure 2: Photodiode sensor

3. Methods

3.1 Research Model

This research is research and development (R&D) model [16]. This research conducted in four steps i.e. 1) initial study; 2) design; 3) development and 4) examination. Initial study covers literature review, variable identification, and

preparing all thing necessary. Design is to design light polarization tool based on Arduino and its equipment like student worksheet and polarization material. Development is how to validate the products through expert validation and laboratory experiment. Examination is implementation of light polarization learning tool in learning process. Examination aims to measure effectiveness and feasibility of light polarization learning tool based on Arduino to increase student science performance.

3.2 Population

This research involved 34 students of teacher candidate and 3 expert on physics. The students and expert is from physics department of STKIP Soe. Instrument test used to measure science performance early tested on 30 students before used in examination. The instrument test, students work sheet, polarization material, student questionnaire are also validated by 3 physics expert before used in field examination.

3.3 Data Collecting

Technique collecting data in this research is test, questionnaire and laboratory experiment. Test using question test based on science performance. Questionnaire is used to validate products and to get opinion from students after learning using light polarization learning tools.

3.4 Data Analysis

Data of this research is evaluated both quantitative and qualitative. Laboratory examination data evaluated quantitatively through comparing the data of experiment with theoretic data of polarization. Whereas data of expert validation and student questionnaire evaluated by descriptive percentage. Pretest and posttest data evaluated using t test. The t test also used to evaluate the hypothesis of this research.

4. Results and Discussion

4.1 Products

Products designed in this research are a) Polarization learning tool; b) Learning material; c) test questions; d) student work sheet; e) lesson plan; f) student response questionnaire.

a) Light Polarization Learning Tool Based on Arduino

Light polarization learning tool consist of two parts namely hardware and software. Hardware consists of polarizer and analyzer, light detector, servo motor to rotate the analyzer, green laser pointer and Arduino as controller or processor [17][18]. The result of hardware as shown in Figure 3.



Figure 3: Hardware of light polarization tool based on Arduino

Software is program to operate Arduino. Program designed in Arduino IDE as shown in Figure 4. Program designed according to C program. Program designed to rotated servo motor when push button pressed and stops the servo at a certain angle. Besides that, program designed to read analog data of photodiode sensor and convert them to digital data then display them on screen. Program also designed to send data via serial monitor of Arduino IDE when the button pressed. Program uploaded to Arduino after successfully designed. Hardware and software work well.

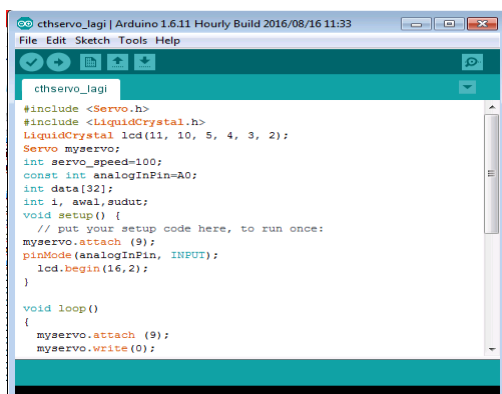


Figure 4: Arduino IDE

b) Polarization Material

Polarization material designed to support polarization learning tool based on Arduino. Polarization material contains explanation of light especially light as wave and light as particle. This material also contains questions and its explanation, exercise questions and experiment instructions.

c) Question Test

The purpose of designing question tests is to measure scientific performance of students or physics teacher candidate in STKIP Soe. Therefore the questions describe scientific performance measurement. As mentioned above that aspects of scientific performance measured through question test are defining hypothesis, identifying variable, planning experiment, getting data, drawing conclusion and communicating data or information. There are 8 questions based on scientific performance designed in this research.

d) Student Work Sheet

Student work sheet designed to guide student conducting experiment using light polarizer learning tool based on Arduino. Student work sheet designed to help student conducting experiment according to scientific performance steps. The product also designed to train student scientific performance skills.

e) Lesson Plan

Lesson plan designed to guide teacher for teaching light polarization. Learning process designed in lesson plan according to inquiry model learning.

f) Student Response Questionnaire

Student response questionnaire designed to measure the feasibility of light polarization learning tool based on Arduino. Questionnaire contains question about learning tool based on Arduino, learning process using the learning tool and student work sheet. Student fill the questionnaire by choose options in Likert scale from 4 to 1 (very agree, agree, less agree and do not agree).

4.2 Laboratory Examination

Laboratory examination is conducted toward light polarization learning tool based on Arduino. The examination was conducted through measuring ADC (analog to digital converter) values. The values of ADC are read from photodiode sensor by Arduino. Photodiode output depends on the intensity of light. When the angle of polarization axis of analyzer and polarizer change, the intensity of light propagate through polarizer and analyzer will change too. The change of light intensity observed trough the values of ADC. Therefore the data of ADC sent to serial monitor of Arduino IDE and the angle of polarization axis changed by servo motor at the same time. The data of ADC versus angle of polarization axis displayed on Figure 5.

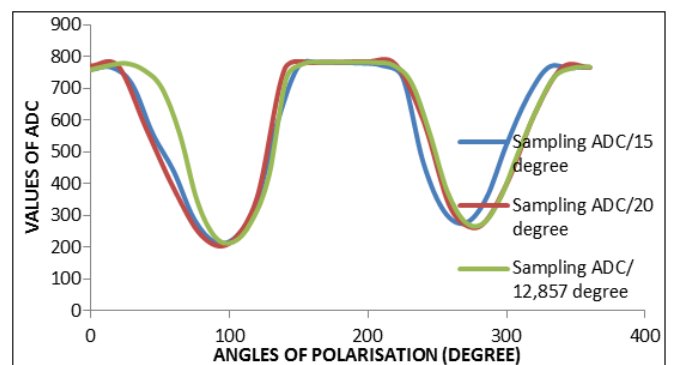


Figure 5: Curve of ADC values toward polarization angle

The curve on Figure 5 shown that the values of ADC vary with the angles of axis polarization between polarizer and analyzer. The curve pattern seems to suitable with curve of \cos^2 functions. This is proved that the learning tool based on Arduino work well as explanation of polarization by Malus law [13]. Although the curve doesn't smooth as curve of \cos^2 , the learning tool can be used as light polarization learning tool.

4.3 Expert Examination

Expert examination involved 3 physics lecturer in physic department of STKIP Soe. The three expert involved to validate products designed in designing step. The results of expert validation as shown on **Table 1**.

Table 1: Results of expert examination

No	Learning tool	Validator				Criteria
		I	II	II	Average	
1.	Material	3.5	3.37	4	3.62	Very good and used without revision
2.	Question test	3.38	3.63	3.75	3.58	Good and used with small revision
3.	Student work sheet	3.37	3.6	3.83	3.60	Very good and used without revision
4.	Questionnaire	3.63	3.63	4	3.76	Very good and used without revision
6.	Lesson plan	3.78	3.57	3.77	3.71	Very good and used without revision

Experts who validate the products suggest small revision to the products. But generally the results of experts validation shown that all products valid and then can be used in learning process. Besides experts validation, the questions test tested statistically. The results shown one question test is not valid. The question is to measure aspect of defining variable.

4.4 Field Examination

Field examination conducted to measure effectiveness of light polarization learning tool to raising student scientific performance skills. Field examination conducted through one group pretest-posttest design. Pretest given before treatment whereas posttest given after treatment. Treatment is conducting inquiry in learning process. The students are guided to learn light polarization through experiment using light polarization tool based on Arduino. They did experiment by the instructions in student work sheet. The instruction in student work sheet designed according to steps of scientific performance. Pretest and posttest evaluated with t test [19]. It is found that $|t_{count}| = 6,05791 > t_{table} = 2,0452$. It means that H_0 rejected and H_a received, that there are enhancement of student scientific performance after learn light polarization using polarization tool based on Arduino. Therefore we can conclude that the light polarization learning tool is effective to raise student scientific performance skills.



Figure 6: Students conducting experiment using light polarization tool based on arduino

It is shown that there are enhancement of all aspect of student scientific performance skills. The highest enhancement is on communicating information aspect, whereas the least

enhancement is on defininghypothesis aspect. Although there are enhancement at all aspects of scientific performance.

Students who have learned using light polarization tool based on arduino filled out the questionnaire. The result of evaluation to the questionnaire by descriptive percentage are shown on **Figure 7**.

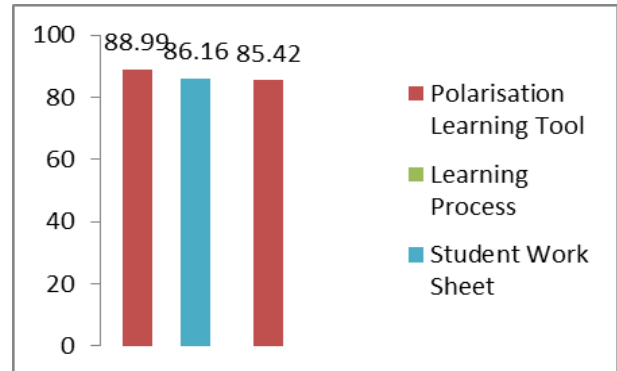


Figure 7: Student responses

Figure 7 shown that percentage of student responses toward light polarization learning tool, learning process using polarization learning tool based on arduino, and student work sheet respectively are 88.99 %, 86.16% and 85.42%. It means that students gave good response to the products. Therefore we can conclude that the learning tool based on Arduino and scientific performance are feasible to use in learning process. This conclusion supported by students testimony that the learning tool easy to use in learning process then help them to clearly understand the topic of light polarization.

The result obtained from evaluation shown that light polarization learning tool is effective and feasible to use in learning process because using the learning tool allowed students to: 1) demonstrate light polarization; 2) collecting data quantitative through experiment; 3) prove Malus law through experiment; 4) train their scientific performance ans science process skills.

5. Conclusion

A light polarization learning tool based on Arduino and scientific performance have been developed. The conclusion of this research are: 1) Light polarization tool based on Arduino and scientific performance is valid to used in learning process. It is confirmed by the results of expert examination and laboratory examination; 2) Light polarization learning tool based on Arduino and scientific performance is effective to raise student scientific performance. It is confirmed by evaluation to pretest and posttest; 3) Light polarization learning tool is feasible to use in learning process. It is confirmed by evaluation to student response questionnaire. The suggestion to the next experiment is to conduct experiment using the learning tool in the dark room so the source of light not bothered.

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