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Development Of An Arduino Iot System Solar Cell Electronic Practicum Guide Based On An Automatic Feed Thrower Prototype To Develop Students' Science Process Skills

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ABSTRACT
Science learning, especially in physics, is an abstract concept and difficult for students to understand. In addition, there is also a need for a bridge that can connect physics concepts with life in the student's daily environment. Therefore, technological innovations are needed in learning such as developing an electronic practicum guidebook for solar cells, Arduino IoT systems based on automatic feed thrower prototypes to develop students' science process skills. This study used a 4D model. The subjects of this study were 6th semester S1 Science students totaling 52 students. The data generation instrument uses questionnaires and implementation observation sheets. Data analysis techniques use qualitative and qualitative. Based on the results of the validation that has been carried out, the practicum guide that has been prepared as a whole has eligibility criteria that are very feasible to use, with a percentage of 92.25%, while the students' science process skills in the solar cell electronic practicum guide for the Arduino IoT system based on the prototype of this automatic feed thrower get an average of 92% with a very good category so that it can be considered that students are good at understanding and Work on the basis of practicum guidelines developed.

INTRODUCTION

Indonesia is an archipelagic country with a variety of natural resources that can be utilized in all fields. As in the field of fisheries, the use of aquaculture, especially in the potential of freshwater fish farming, is still not optimal to be utilized so that utilization efforts are needed so that budidaya fisheries production can continue to increase. In general, fish feeding is still done manually and depends on human resources which is done simply by spreading fish feed directly into the pond. Sometimes when the cultivator has other activities in a long time so that feeding becomes delayed.

This has an impact on the ecosystem in the pond, fish growth that becomes less than optimal, not uniform, and experiences economic losses [1].

As time goes by and technological innovation is growing, fish farmers need innovation in the field of technology such as automatic fish feed throwing machines. Where this technology can be integrated into the world of education to support student skills where the skill aspect is one of the objectives emphasized in the applicable curriculum in Indonesia. The main curriculum used in Indonesia today is the 2013 curriculum but there are several driving schools initiated by the Ministry of Education, Culture, Research and Technology that are fostered to implement special curricula, namely the Merdeka Curriculum and the independent curriculum [2]. Both the 2013 curriculum and the independent curriculum all complement each other to support the learning process.

The independent learning curriculum policy aims to increase student creativity, problem solving and learning to be useful in the world of work [3]. In line with the objectives of the 2013 curriculum, namely to prepare Indonesian people to be productive, creative, innovative, and affective and able to contribute to community life [4]. Therefore, efforts to realize the objectives of the curriculum in schools that need to be developed, one of which is through teaching materials.

Teaching materials are materials that are designed, written and arranged systematically with instructional rules to be used by lecturers in assisting and supporting the student learning process in accordance with the applicable curriculum [5]. The form of teaching materials varies greatly such as modules, learning packages, learning units, student worksheets and others. One of the teaching materials used in schools in describing the process is the practicum guidebook. Practicum manuals are books that assist in the implementation of practicum that provides information and can be a learning support that contains instructions on practicum preparation, implementation, and reporting procedures. Supporting this opinion, stated that practicum guidebooks are very important because in addition to being teaching materials, interesting practicum guidebooks can increase student interest in prkaticum and how to make reports correctly. According to Novita [6] using a basic science process skills-based practicum guidebook can increase student motivation, activity, and learning outcomes.

Science process skills are students' ability to observe, group, interpret, predict, ask questions, hypothesize, plan experiments, apply concepts, communicate and carry out experiments. Process skills consist of: Observation, Calculation, Measurement, Classification, Space/time relations, Hypothesis making, Research/experiment planning, Variable control, Data interpretation, Provisional conclusions (Inference), Forecasting, Application, and Communication. Science process skills are needed in school learning, especially physics learning.

Science is a science in which it studies the nature and natural phenomena or natural phenomena and all interactions in it that can be observed by humans. According to Gunawan et al [7] abstract concepts in physics are concepts that are difficult to visualize or display the process directly through real laboratory activities though. In line with Pangestu et al [8] which stated that learning natural sciences, especially in physical materials, most of the material is abstract concepts and difficult for students to understand.

Based on preliminary studies through observations on science learning in the 6th semester Applied Science course of Bengkulu University related to lectured science learning, interviews were conducted with 3 science lecturers using interview guidelines. Meanwhile, the needs analysis questionnaire used a needs questionnaire sheet to 52 students at Bengkulu University directly. The results of observations on Applied Science learning at Bengkulu University, it is known that students are able to do practicum but the use of practicum guides has not been widely used. In addition, there are no specific practical guidelines for Integrated Science learning. The practicum guide used is a printed book and a practicum activity guidesheet that contains a combination of teaching materials and practicum activities. In addition to printed books and practicum guide sheets, there are practicum guides delivered by lecturers obtained via the internet. Practicum guidelines are not all in accordance with the abilities or competencies possessed by students.

Need alternative solutions to learning limitations as expressed above. One way that is believed to be done is to provide teaching materials in the form of practicum manuals that can encourage students to be motivated in learning activities. This practicum guidebook must link between applied science subject matter based on the characteristics of the surrounding environment so that students can be directly involved in learning activities.

METHOD

This research uses a development model, where the research steps are abbreviated as 4D which is an extension of Define, Design, Development and Dissemination. The population in this study is all 6th semester students at Bengkulu University for the 2022/2023 academic year. The subjects in this study were 52 6th semester students at Bengkulu University. Sampling in this study used purposive sampling techniques, which are sampling techniques based on certain considerations. The instrument trial was carried out on 26 6th semester students at Bengkulu University. Data collection techniques to measure students' science process skills using observation sheets are carried out by observers during practicum, and posttest questions are given after learning to determine the ability of science process skills in students. Data analysis uses quantitative and qualitative analysis. The following is the research procedure in the picture below:

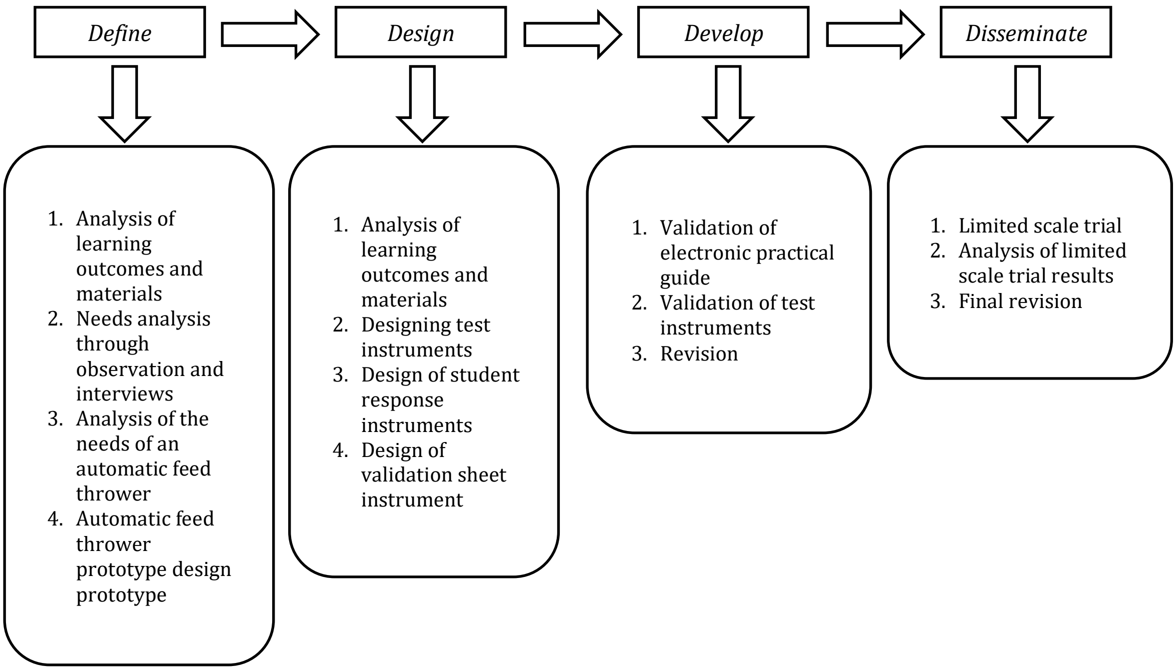

Fig 1. *Research procedure*

RESULTS AND DISCUSSIONS

Results of analysis of learning outcomes and learning materials

At this stage, an analysis is carried out related to the learning outcomes of the course (CPMK) used to achieve learning objectives. Furthermore, an analysis of the relationship between CPMK and solar cells was carried out in Integrated Science learning, through a semester learning plan. Based on the semester learning plan, the course learning outcomes (CMPK) that are considered the most relevant are the simple power plant technology material illustrated in the table below:

Table 1. CPMK and Applied Science Material

Course Learning Outcomes (CPMK)	Material
1. Students are able to analyze applied science studies in the context of Physics, Chemistry, Biology and Environment 2. Students are able to collect and process the phenomenon of science concepts that can be applied in everyday life 3. Students are able to make simple applications and paracticum in integrating applied science in everyday life	Biodiesel, Biogas and simple power generation technology

Results of the analysis of teaching material needs

The results of observations on Applied Science learning at Bengkulu University, it is known that students are able to do practicum but the use of practicum guides has not been widely used. In addition, there are no specific practical guidelines for Integrated Science learning. The practicum guidelines used are printed books and practicum activity guidesheets that contain a combination of teaching materials and practicum activities. In addition to printed books and practicum guidesheets, there are practicum guides delivered by teachers obtained via the internet. Practicum guidelines are not all in accordance with the abilities or competencies possessed by students.

This is in line with student opinions shown from the results of the needs analysis questionnaire based on aspects of interest, it is known that most students still have difficulty in understanding applied science learning, this can be seen from the average percentage of student responses of 53% of 52 students still find it quite difficult, 69% of students feel they need media to understand science lessons, especially applied science. In the convenience aspect, 56% of students stated that the teaching materials used in learning applied science were not easy. Meanwhile, based on the aspect of teaching material needs, it is known that 72% of 52 students still use printed books as the main teaching materials borrowed from the library and 80% of students stated that they still need additional teaching materials other than printed books so as to facilitate the learning process of Applied Science.

Design Results

The results of the analysis of teaching material requirements and the needs analysis of the prototype of the solar cell-based automatic feed thrower of the Arduino IoT system carried out at the define stage were used to design the electronic practicum guide developed. After several analyses were carried out, the product developed in the form of an electronic practicum guide for solar cells, an Arduino Iot system based on an automatic feed thrower prototype, so that an electronic practicum guide was designed as shown below. The results of the electronic practicum guide can be seen at the https://online.flipbuilder.com/usqgy/mwie/link. Here are the parts of each component in the electronic practicum guide:

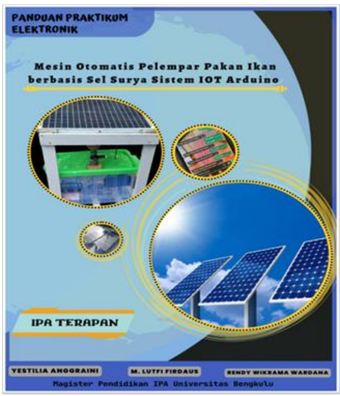

Fig 2. *Electronic Practicum Guide*

Development Results

Validation of the electronic practicum guide was carried out to test the feasibility of the product in the form of an electronic practicum guide for solar cells, an Arduino Iot system based on an automatic feed thrower prototype. Product validation was carried out by 4 lecturers of physics and science education in accordance with the concentration of this research. Validator assessment of products using questionnaires with a likert scale of 4 consisting of 3 aspects, namely content feasibility, language and graphics. The assessment results can be seen in the following table:

Table 2. Results of validation of electronic practicum guide

Assessment Aspect	Percentage	Category
Fill Eligibility	92%	Very Worth It
Language	91%	Very Worth It
Graphics	94%	Very Worth It
Average	92%	Very Worth It

The feasibility aspect of the content consists of 4 assessment aspects that describe the presentation in the electronic practicum guide developed in the form of titles, material content, and questions. Based on the results of the validation test of the feasibility aspect, the content was obtained by 92% with the category of very feasible. This is because this electronic practicum guide has contained indicators of the title, content of material related to feed machines, content of material related to simple power plant technology material and questions about automatic feed thrower prototypes and simple power plant technology materials. Teaching materials that are adapted to learning materials can help in designing and developing a teaching material so that it is systematic and comprehensive in accordance with the content of the material [9]. This is in accordance with Bahtiar [10] that teaching materials that are arranged systematically make every student able to learn effectively

The second aspect assessed, namely the linguistic aspect in the electronic practicum guide, was obtained 91% with a very decent category. This is because the electronic practicum guide is in accordance with Indonesian rules, simple and easy-to-understand sentences, clear image displays and flowcharts and block diagrams that explain how the prototype of the automatic feed thrower works clearly. The sentence structure used must meet grammatical rules and use vocabulary that is rich but easy to understand, and familiar [10].

The graphic aspect in the electronic practicum guide developed received a score of 94% with a very decent category. This is because the electronic practicum guide already contains an attractive cover with the appropriate font size and easy to read, the layout, writing system is appropriate so that it does not interfere with the content of the practicum guide and also the video and audio are clear enough although they still have to be improved so that the sound and display in the video is larger. According to Iqbal et al [11], it is necessary to pay attention to graphic designs such as typography, colors, images, layouts and backgrounds with concepts that are suitable for purpose.

Based on suggestions and input from validators, improvements have been made as shown in the table above, so that the Arduino Iot system solar cell electronic practicum guide product based on the prototype of the automatic feed thrower developed is better. In accordance with the results of the validation that the product is very feasible, the electronic practicum guide can be used in the next stage of the trial.

Results of Dissemination

The dissemination stage is carried out to find out students' knowledge of science process skills. Science process skills are trained with electronic practicum guidance that has been developed by researchers. The results of students' science process skills are determined from observation sheets to see the proficiency of students' science processes after using practicum guides, while student posttest results are used to see students' cognitive abilities after using practicum guides. Therefore, the results of the observation sheet can be supported using questions to develop students' cognitive abilities.

1. Observation Sheet Results

A recapitulation of the data from observations of each indicator of science process skills and their percentages is shown in the table below:

Table 3. Student observations

Indicators KPS	Percentage	Category
Observation	95%	Excellent
Forecast or predict	92%	Excellent
Designing an experiment	90%	Excellent
Using tools and materials	89%	Excellent
Communicate	97%	Excellent
Applying the Concept	88%	Excellent
Interpreting	89%	Excellent
Ask questions in discussion	95%	Excellent
Average	**92%**	**Excellent**

Based on table 3, the results of observation of science process skills using the electronic practicum guide of solar cells, Arduino IoT system based on automatic feed thrower prototypes on observation indicators were obtained by 95% with a very good category. This is because the activities carried out to develop students' science process skills on various indicators make observations in the practicum guide, namely observing phenomena in the context of problems in the practicum guide before students conduct experiments. During the experiment, students also made observations by watching video shows in the practicum guide about assembling prototypes of automatic feed throwers so that it was easier for students to understand the steps of work carried out. This is in line with research conducted by Johan et al [12] which states that animated videos can help to understand science concepts that cannot be observed directly.

The second indicator is hypothesizing or predicting a percentage of 92% with a very good category. This is because the electronic practicum guide leads students to hypothesize after making observations in the context of the problem where students express what might happen in circumstances that have not yet occurred. According to Jayadinata et al [13], through hypothesis submission and hypothesis testing through collected data can draw conclusions from the learning process that has been implemented.

From this activity, the observer can assess whether the student mastered the indicator of predicting or predicting an event. The indicator of designing experiments gets a percentage of 90% with the category very good. Activities are carried out to carry out experiments, students already know well or not the tools, materials and sources used. The second activity is to know the course of practicum by introducing the tools, materials and resources used. The last activity carried out on the indicator of planning an experiment or investigation is that students are asked to determine work steps in accordance with the electronic practicum guidelines provided. Where the tools, materials and steps in designing tools are already contained in the practicum guide making it easier for students to conduct experiments.

KPS indicators using tools and materials get a percentage of 89% with the very good category. The activities assessed on this indicator are first that students are welcome to use existing tools, materials. This assessment looks at how the skills possessed by the student in using the tool components have been provided. Each student is given the opportunity to use the components of the existing tools when practicum activities are in progress in accordance with the functions and instructions in the electronic practicum guide so that students can use tools and materials easily and correctly. This is in line with Frima [14] revealed that tools, materials and other supporting components can help in making it easier for students to conduct experiments.

The KPS communication indicator gets a percentage of 97% with a very good category. This is a very high indicator compared to other KPS indicators because students can already describe and write experimental data using tables they made themselves, which both students discuss about the results of the experiment. According to Faizah et al [15], that students who are active in discussing by responding to their friends' ideas will be more successful in completing their tasks and better understand learning outcomes. Finally, students compile and submit experimental results in accordance with the tamplets in the electronic practicum guide, where each activity on this indicator is contained in the electronic practicum guide used.

The KPS indicator applies the concept of getting a percentage of 88% with a very good category. The assessment carried out on this indicator is the ability of students to apply concepts to ongoing experiments, the observer team looks at the student activities whether students in each group can provide new knowledge from the results of the experiments carried out by analyzing the data produced and linking the problems with the concepts learned in the form of simple power plant technology concepts in the application of feed thrower prototypes Automatic in the practicum guide. The application of concepts can train students to apply concepts that have been mastered to solve certain problems or explain a new event using concepts that have been owned [16].

The KPS interpretation or interpreting indicator gets a percentage of 89% with a very good category. This is because the activities carried out are drawing conclusions based on concepts in the experiments carried out. Where students are good enough to conclude experimental results with concepts based on practicum guidelines. Where the last stage in learning activities is in the form of drawing conclusions which can be in the form of communicating conclusions with students, giving questions to students, and giving quizzes [17].

The KPS indicator of asking and discussing gets a percentage of 95% with a very good category. This is because almost every student has a discussion with fellow groups and asks what they don't understand, making it easier for them to conduct experiments, besides that if they don't understand they also don't hesitate to ask researchers or observers about things they don't understand. According to students' questioning skills, it is seen based on questions asked in small group discussion activities [15]. So that based on the results of observations on the indicators of student science process skills in the solar cell electronic practicum guide, the Arduino Iot system based on the prototype of this automatic feed thrower gets an average of 92% with a very good category so that it can be considered that students are good at understanding and working based on the practicum guidelines developed.

2. Posttest Results

It turns out that with the increasing proficiency of the student science process, it can also indirectly develop students' cognitive abilities after using practicum guidelines so that students' cognitive abilities can be seen on posttest questions that are adjusted to indicators of science process skills and the percentage is shown in the table below:

Table 4. Posttest results

Indicator of KPS	Average Score	Category
Observing	87 %	Very good
Interpret	78 %	Good
Classifying	90 %	Very good
Predict	86 %	Very good
Asking question	82 %	Good
Planning an experiment	80 %	Good
Applying concepts	69 %	Enough
Communicate	75 %	Good
Average	**81 %**	**Good**

Based on the results of the posttest consisting of 8 questions using the science process skill indicator, the highest result lies in the indicator of grouping or calcifying by 90% with the Very Good category because in the grouping problem, students have been able to group the components of the tool used in the experiment to assemble the prototype of the automatic feed thrower so that they can answer well and correctly on question number 3. Activities in grouping can train students to think logically, because the activity of grouping objects in this case is an activity to sort objects based on predetermined criteria or qualifications [18]. Classifying skills are one of the important abilities in scientific work.

The indicator of observing, using tools and materials by 87% with the Very Good category because the observing process involves five sensory activities where in the practicum guide can carry out observing activities such as observing pictures of tool components and materials, videos of how the prototype of automatic feed throwers work directly so that students are able to answer this question well. According to Novianti [19], observation or observing with the five senses can turn on sensitivity and better understanding for students. The indicator predicts 86% with the Very Good category because in the implementation of practicum students have been able to test the correctness of the appropriate prediction results in the experiment and can be accepted as correct.

While the interpreting indicator gets a percentage of 78%, the indicator of asking questions is 82% with a good category because in the learning process many students are active and enthusiastic about asking about things they do not understand so that they can understand well. The indicator of planning an experiment is 80% with the Good category because students have observed the work procedures in the video in the electronic practicum guide, making it easier for students to develop flowcharts or block diagrams into work steps on this automatic feed thrower prototype. This is in line with research conducted by Johan et al [12] which states that animated videos can help to understand science concepts that cannot be observed directly.

While the indicator of applying concepts is 69% with sufficient categories because in terms of steps and content of the electronic practicum guide it directs students to skills rather than knowledge so that students' skills and skills during practicum are more prominent so that the understanding of concepts possessed by students in doing posttest questions is quite good. The application of concepts to students can be in the form of applying something that has been learned both in terms of psychomotor, affection and cognitive so that it can be used in implementing the concept into life [20]. The indicator communicates 75% with the good category, this is because students are good at analyzing data, but when applying it to the form of experimental graphs, they have difficulty getting results in the good category. Where indicators communicate from not only analyzing data but can understand and explain observations with graphs or tables or diagrams [20]. So based on the posttest results, the overall average of these posttest results is obtained in the good category with a percentage of 81%.

3. *Effect Size*

The effectiveness of electronic practicum guides used to see the effectiveness of practicum guides based on postest results to develop students' cognitive abilities in experimental and control classes. The magnitude of the influence of the use of electronic practicum guides developed can be done with an effect size test. Cohend's d effect size analysis was performed using the effect size formula. The results obtained are shown in Table 5.

Tabel 5. Effect Size Test

Posttest	Mean	Standard Deviation	n	Cohend's d
Control	55,5	19,3	26	1,2
Experiment	75,6	14	26	

Based on the table above, it is known that the effect size value of 1.45 according to is in the large category because which means that the electronic practicum guide for solar cells Arduino Iot system based on the prototype of the automatic feed thrower used is effectively used to supply students' science process skills, because the guide developed is practical, that is, the guide can be opened anywhere and anytime through leptop or the handpond and guide developed contain components that are brief, solid, clear to achieve goals in accordance with the goals set at the beginning, namely students are able to analyze studies in context, students are able to collect and process phenomas of science concepts that can be applied in everyday life and students are able to make or assemble prototypes of automatic feed throwers through practicum using electronic practicum guides that have been developed. According to Nofiana et al [21], effectiveness relates to students achieving learning goals set at school with the desired knowledge, skills, and attitudes. In accordance with the results such as the table above, it can be concluded that the electronic practicum guide developed is effectively used in the learning process to support students' science process skills. According to Aini et al [22], the use of learning tools is effectively used in learning if it is proven to improve student learning outcomes.

CONCLUSION AND SUGGESTION

The conclusion in this study is based on the results of the validation that has been produced electronic practicum guidelines that have been developed have eligibility criteria that are very feasible to use, with a percentage of 92.25%. The students' science process skills in the solar cell electronic practicum guide for the Arduino IoT system based on the prototype of this automatic feed thrower get an average of 92% with a very good category so that it can be considered that students are good at understanding and working based on the practicum guidelines developed.

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