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Development of PLTS Trainers as Learning Media in the Energy Conversion Laboratory

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Abstract

Enhancing the quality of learning is worthy by the availability of PLTS trainers. This work intends to build and create PLTS trainers as learning material for renewable energy generation. The preparation of this study was divided into two stages: first, a PLTS media trainer kit and a practical training module that functioned as a handbook for using the media trainer were created. The ADDIE method is used as the development model for the practical guiding module and media trainer. Based on the data analysis findings show that the 10Wp solar module can provide a maximum energy of 5.11Wp for 11 hours when charging a 7.5Ah battery. With a 63 Watt total load, the PLTS trainer's Ah battery can run for 37 minutes. With an average percentage of 93% and 92%, respectively, the material expert validator and media expert have deemed the media trainer and practicum instruction module feasible. This places them in the very good category.

Keywords*: PLTS, Trainer, Learning Media.*

Abstrak

Peningkatan kualitas belajar layak sangat terbantu oleh ketersediaan alat PLTS. Penelitian ini bertujuan untuk membangun dan menciptakan trainer PLTS sebagai bahan pembelajaran untuk pembangkit energi terbarukan. Persiapan studi ini dibagi menjadi dua tahap: pertama, kit trainer media PLTS dan modul pelatihan praktis yang berfungsi sebagai buku panduan untuk menggunakan media trainer. Metode ADDIE digunakan sebagai model pengembangan untuk modul panduan praktis dan media trainer. Berdasarkan analisis data, temuan menunjukkan bahwa modul surya 10Wp dapat memberikan energi maksimum 5,11Wp selama 11 jam saat mengisi daya baterai 7,5Ah. Dengan beban total 63 Watt, baterai Ah trainer PLTS dapat berjalan selama 37 menit. Dengan persentase rata-rata 93% dan 92%, masing-masing, validator ahli material dan ahli media telah menganggap modul trainer media dan instruksi praktikum sangat layak dan dikategorikan sangat baik.

Kata kunci*: PLTS, Trainer,Media Pembelajaran.*

Introduction

There is a lot of opportunity for new renewable energy in Indonesia (EBT). Only 0.2 GW of the 2,898 GW of solar energy that may be produced in 2022 will actually be used, according to the Indonesia Energy Transition Outlook report. One of the natural resources that can be utilized as a substitute for conventional energy is sunlight. But very few people are aware of how the sun works and how to use it, particularly when it comes to solar power generation systems (PLTS) and solar modules. Innovative trainer technology can be a helpful tool in the learning process to raise the standard of instruction. The learning process requires creativity in order to produce high-quality learning. When

the educational process was conducted in a traditional manner, students had trouble understanding what they were learning [1]. Student activity levels can be used to gauge the effectiveness of learning. It takes innovation in learning media to raise the standard of instruction.

Based on observations that learning activities are still conducted through lectures, the Electrical Engineering Study Program investigates the use of renewable energy in energy conversion laboratories. This is because the PLTS facilities have not been fully utilized, which has not raised student motivation during the learning process. Based on observations that learning media in the laboratory currently have the major component of the off-grid PV mini-grid system but do not yet have trainers as learning media, students are required to be actively involved in the learning process through the autonomous curriculum. In order for students to become more motivated and achieve the best learning outcomes, it is required to create learning media in the form of trainers based on the findings of tool observations in the energy conversion laboratory.

Literature Review

a. Off-Grid System Solar Power Plant (PLTS)

This generating system simply uses the sun as a power source. Photon energy from sunlight is converted into electrical energy using solar cells [2]. In summary, the off-grid system is a standalone power line transfer system (PLTS) that is not linked to the national electrical grid. Four crucial parts need to be implemented in order for an off-grid PLTS system to operate as best it can solar panels that transform sunlight into electrical energy; (2) a solar charge controller that serves as a supporting component to control the amount of energy that can be charged to the battery following solar panel processing; and (3) a battery that serves as a supporting component to store energy produced by solar panels. (4) An electrical device that can change DC electric current into AC electric current is called an inverter [3].

b. Learning Media

Media is frequently understood in the context of education as a graphic, photographic, or electronic instrument with the ability to record, process, and rearrange verbal or visual information. The term "media" refers to any kind of instrument used to spread or communicate information. Learning media is anything that is used to convey messages and can stimulate thoughts, feelings, attention, and willingness to learn so as to encourage the learning process" based on study citations [4]. By grabbing attention and speeding up the learning process, props, or trainers, are utilized to highlight knowledge [5]. A learning innovation is required since the range of teaching aids is wide, spanning from basic media to sophisticated media in visual or digital form.

c. Trainer kit PLTS

A trainer kit is a collection of educational resources that includes practicum modules and tools or props to assist with practicum exercises. In research explained that the positive impact of using trainers is to increase students' knowledge because learning is not only theoretical but also practical[6]. The use of trainers' functions as a tool or visual aid to convey information in supporting the process of a learning process to help increase knowledge, skills and attitudes [7]. They created a PLTS training kit with a vertically mounted board shape in their earlier research. Five different kinds of testing can be applied in this study to aid in the learning process.

Figure 1. Results of the PLTS Trainer Module Design
(Source : [1])

In 2021 the development of the PLTS module's implementation, which serves as a laboratory learning tool [2]. Basic testing of every component were conducted in this study in order to maximize tool design findings and ensure that the laboratory practicum process was supported appropriately.

Figure 2. Implementation of Off-grid System PLTS Trainers [2]

Method

a. Research Flow

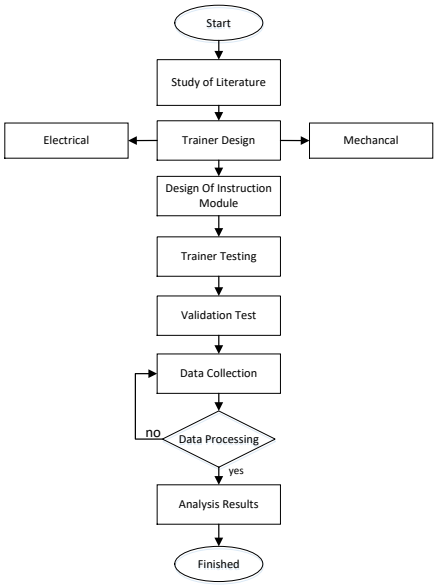

Figure 3. Research Flow

b. Research Type

The ADDIE approach is being used in this research to generate PLTS trainers as learning resources. The five steps of systematic research included in the ADDIE technique are analysis, design, development, implementation, and [8]. This approach is used because the ADDIE model is relatively straightforward and has a methodical application, and it has advantages in every phase when there is an assessment to create valid research.

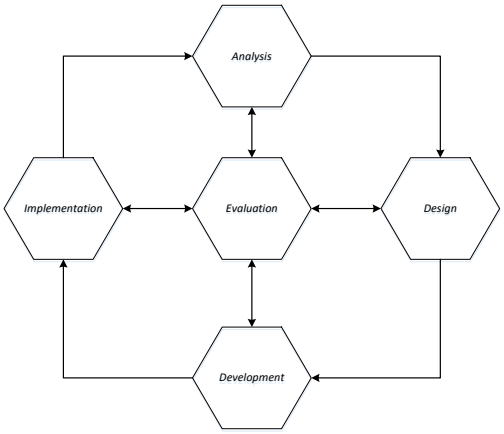

Figure 4. Metode ADDIE

c. Research Location and Time

This research was conducted from March 2023 to May 2023 with data collection in April and May 2023 at the Jambi University FST building Jl. Jambi - Muara Bulian No.KM. 15, Mendalo Darat, Kec. Jambi Luar Kota, Kabupaten Muaro Jambi, Jambi.

d. Research Procedure

A needs analysis in the PLTS trainer creation process was used to conduct the study procedure. The process of developing mechanical and electronic designs for the media trainer development process begins with a size analysis of each component that will be utilized. Making a practical instruction module, which will serve as a manual for utilizing the PLTS media trainer, is the next stage. A validation test including media expert validators and material experts is the next stage after the development of the PLTS media trainer and practicum guide module. Testing the media trainer and simulation as a learning tool with the responders is the last phase.

e. Development Procedure

The creation of a portable PLTS training kit was completed at this point. In this study, a novel development was carried out in a portable form to ease transfer during the learning process. Based on prior research references, the PLTS trainer still has the shape of a trainer board, and it is very difficult to transfer media during the learning process.

f. Data Collection Techniques

Data was gathered between April and May of 2023 by putting the PLTS media trainer through its paces in validation, simulation, and learning media tests. As for the steps of data collection:

1. Testing the PLTS media trainer
   At this point, testing is done on every part of the PLTS trainer to make sure the parts work correctly in the off-grid PLTS system. At this point, the following tests are being conducted: testing inverter modules, testing solar charge controllers, evaluating solar panel characteristics, and testing battery charging.
2. Validation Test
   A validation test with media and material experts was conducted at this point. The purpose of this test was to see whether the practical instruction module and media trainer could be used as instructional tools.
3. Simulation as a learning media.
   The next stage is to run a simulation to get information on the efficacy of using practicum instruction modules and media trainers as learning media after running a validation test.

g. Data Analysis

Descriptive analysis is the method of data analysis employed in this study. A predefined equation will be used to process the obtained data [9]. Tables and percentages are used to present the data. As for the steps of data analysis techniques:

1. Testing the PLTS media trainer
   Data processing is done to test the solar panels' attributes during the testing phase of the PLTS media trainer. It will compute the input power, output power, and efficiency of the solar panel in order to test its features. The following is the equation used to calculate the input power :
   $$Pin = Solar\ Intensity\ X\ Solar\ Module\ Area \quad (1)$$
   Meanwhile, to calculate the output power can use the equation:
   $$Pout = Vmp\ X\ Imp \quad (2)$$
   After knowing the input power and output power, then to calculate the efficiency you can use the formula:
   $$\mu = \frac{Pout}{Pin}\ x\ 100\% \quad (3)$$
2. Validation test
   In determining which media trainers can be utilized in the teaching and learning process the results of the validation test must achieve good criteria (62.51% - 81.25%) and very good (81.26% -100%) [10]. The equation used to process the validation test data for material experts and media experts:
   $$Va = \frac{TSe}{TSh}\ x\ 100\% \quad (4)$$
   Information :
   Va = validity assessment from experts
   Tsh = Maximum score
   Tse = all empirical score (trial results)
3. Simulation as a learning media
   A pre-test and post-test questionnaire will now be presented to responders in order to gauge their level of knowledge both before and after the simulation process is completed. The guttman scale is the data analysis method employed. The Gutmann scale has only two statement boundaries, such as "true, false," "yes, no," and "positive, negative," and it is intended to elicit affirmative action

from responders [11]. A score will be generated from the statement's outcomes. The measurement scale applies the following guttman scale:

a. Measurement scale : Guttman scale
b. Variable : Student knowledge about off-grid PLTS systems
c. Procedure : answer the questionnaire
d. Measuring instrument : questionnaire paper
e. Score value : Yes = 1 , No = 0
f. Measurement results : Level of knowledge (high: 76-100%, medium: 50%-75%, low: 0-55%).

Results and Discussion

a. PLTS Media Trainer Development

At this point, the PLTS media trainer's mechanical design was put into practice and testing was completed. The following figure displays the outcomes of the mechanical design's implementation:

Figure 5. Mechanical Design Implementation

Soldering each component is the following step in the electrical implementation, which comes after the mechanical implementation is finished.

Figure 6. Component Soldering

The next stage is testing the media trainer. This test is carried out within 1 week at 10:00, 11:00, 12:00, 13:00 and 14:00.

1. Results of data collection on the characteristics of solar panels

In testing the characteristics of solar panels, the data obtained will be processed with equations (1), (2) and (3)

Table 1. Recapitulation of the Test Results of Loaded Solar Panels

No	Time	Light intensity	Solar Panel	µ

	(t)	(w/m^2)	Voltage (V)	Current (A)	Pin (W)	Pout (W)	(%)
1	10:00	220,2	11,57	0,32	21,80	4,02	18,72
2	11:00	236,75	13,59	0,36	23,39	5,06	21,72
3	12:00	245,07	12,29	0,33	24,21	4,37	18,42
4	13:00	160,75	10,53	0,29	15,88	3,41	21,49
5	14:00	175,91	9,20	0,25	17,38	2,34	15,34

Table 2. Recap Data from No-load Solar Panel Testing Results

No	Time (t)	Light intensity (w/m^2)	Voltage (V)	Current (A)
1	10:00	247,04	19,56	0,57
2	11:00	336,28	19,66	0,57
3	12:00	293,12	19,39	0,57
4	13:00	173,36	17,20	0,50
5	14:00	153,42	17,97	0,53

2. SCC test results

The following table present the solar charge controlling testing with setting on 11 V to 12 V. The results of the SCC test show that all functions are running with predetermined settings.

Table 3. Solar Charge Controller Testing

Parameter	SCC Setting Value	Test result
Underdischarge voltage	11 V	The lamp used as a load turns off when the battery voltage reaches 11V and the battery is immediately re-charged by the solar panel. Based on the off state of the lamp, it indicates that the SCC is functioning according to the settings when the voltage reaches 11V.
Overcharge voltage	13.4 V	The solar panel stops charging or also known as cut out when the battery voltage reaches 13.8V and SCC works according to predetermined settings.
Load reconnect voltage	12 V	The inverter turns on again and provides an AC voltage output when the battery voltage is 12V. SCC works according to predetermined settings.

3. Battery charging data test results

The battery charging test was carried out at 10:00 to 14:00. At this stage, data collection was carried out for 1 week.

Table 4. Battery Charging Test

No	Time (t)	Solar Panel Voltage (V)	Solar Panel Current (A)	Battery Voltage (V)	Solar Panel Power (W)
1	10:00	13,19	0,37	12,96	4,88
2	11:00	13,21	0,38	13,06	4,96
3	12:00	13,46	0,38	13,21	5,11
4	13:00	13,16	0,38	12,99	4,92
5	14:00	13,09	0,38	13,00	4,92

4. Results of testing inverter module

Based on the test results, an inverter with a capacity of 500 Watt can turn on an AC load with a voltage source from a battery with a capacity of 7.5Ah.

Table 5. Inverter Module Testing

No	Electrical load		Input DC		Output AC			
	Name	Power (W)	Voltage (V)	Current (A)	Volt (V)	Current (A)	Power (W)	Frequency (Hz)
1	No electricity load	0	12,3	0,45	229	0	0	50
2	Hit Elektrik	5W	11,9	1,08	222	0,03	6,66	50
3	Lampu AC	10W	11,6	1,64	218	0,07	15,26	50
4	Charger HP	10W	10,7	3,18	211	0,14	29,54	50

The greater and the total load used will make the battery voltage decrease. During the no-load test the battery voltage is 12.3 V and the current used is 0.45. This is because the inverter has an electronic circuit that requires current to operate. When the inverter is installed with an AC load with a total of 25 Watts, the voltage on the battery decreases to 10.7 V and a total current of 3.18 A. In the Inverter measurement, there is a decrease in current to 211 V with a total current of 0.14 A. Based on the data provided get, the total power used is 29.54 Watt.

b. Creating a Practice Guide Module

Microsoft Excel was used in the building of the practical guide module. This instructional module will serve as a manual for using the media trainer once it is developed.

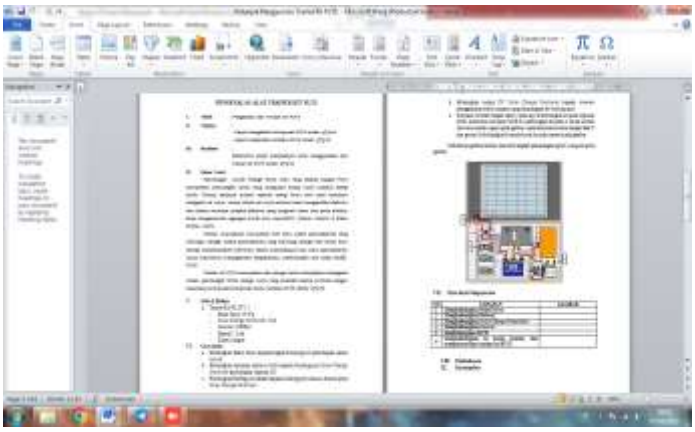

Figure 7. The Process of Making a Practicum Guide Module

c. Validation test

The next stage is to carry out a validation test with material experts and media specialists following the development of the practicum instruction modules and media trainer. The outcomes of the validation test conducted using the validator are listed below.

Table 6. Media Validation Test Results

Assessment Aspect	Validator Score	Max Score	Percentage	Qualification
Physical Criteria	26	28	93%	Very good
Display	22	24	92%	Very good

Average	48	52	92%	Very good

Table 7. Material Expert Validation Test Results

Assessment Aspect	Validator Score	Max Score	Percentage	Qualification
Material Presentation	16	16	100%	Very good
Language	10	12	83%	Very good
Presentation Equipment	15	16	93%	Very good
Average	41	44	93%	Very good

Based on the results of the media validation test and the material validation test, the percentages were 92% and 93% in very good categories and suitable for use.

d. Effectiveness of learning media

The next step is to use a simulation as a learning tool after the PLTS media trainer and practical instruction module are approved for usage.

Figure 8. Respondents in a Simulation Process

A questionnaire was used to gather both basic and end knowledge during the simulation procedure. To gauge the respondents' level of basic knowledge, the first knowledge questionnaire was completed before to the simulation. Additionally, a simulation is run to determine how well media use can raise respondents' level of knowledge before the ultimate knowledge is determined. The outcomes of the simulation's final knowledge and starting knowledge are listed below.

Table 8. Preliminary Information about Responders' Knowledge

Knowledge category	Prior Knowledge	
	N	**%**
High	0	0
Medium	3	10
Low	27	90

Table 9. Final knowledge of respondents

Knowledge category	Final Knowledge	
	N	**%**
High	30	100
Medium	0	0
Low	0	0

e. Discussion

The solar panel's properties were evaluated against a 5 Watt DC load, and the findings showed that its average use efficiency ranged from 15.34% to 21.72%. SCC operates according to preset parameters; to preserve battery life, it will turn off the voltage from the battery to the inverter when the voltage of the 7.5 Ah battery hits 11 V. The PLTS trainer using a 10 Wp solar module can produce an average maximum energy of 4.88 Watt - 5.11 Watt with a charging time of 11 hours 20 minutes for a battery with a capacity of 12 V / 7.5 Ah. With a total installed power of 63 Watts, an inverter with a 500 Watt capacity and a battery with an initial voltage state of 12.3 V can be operated for 37 minutes until the battery voltage drops to 11.1 V. The PLTS trainer that was created receives a very good categorization and validation results from media specialists with an average score of 92.

Student knowledge can be increased by the efficacy of PLTS trainers and practicum instruction modules as learning resources for off-grid PLTS systems. Thirty-seven respondents provided preliminary knowledge data processing, of which 27 showed limited familiarity with off-grid PV mini-grid systems. Following the implementation of the PLTS trainer and instruction module during the learning testing phase, 30 participants reported an improvement in their fundamental understanding of the off-grid PLTS system.

Conclusion

There is an off-grid PLTS system trainer kit with a 10WP solar panel capacity, 7.5Ah battery, 10A solar charge controller and 500W inverter. The results of testing the PLTS trainer kit showed that the testing of solar panel characteristics was carried out using a 5W DC load and had an average usage efficiency of 15.3% - 21.72% and the SCC functions with predetermined settings, when the battery voltage with a capacity of 7.5Ah reaches 11V, SCC will cut off the voltage from the battery to the inverter to protect battery power. Additionally, the 10WP solar panel produces an average maximum energy of 4,88W - 5.11W with a charging time of 11 hours 20 minutes for a battery with a capacity of 12V/7.5 Ah. By using an inverter with a capacity of 500W with a load of 63 watts can last for 37 minutes.

On the other hand, the PLTS training kit, which has been developed, has been evaluated by a material expert with a score of 93 and a very excellent and suitable for use category, and has obtained findings from a media expert validation test with a score of 92. Students' knowledge can be increased by using PLTS trainers as learning resources for off-grid PLTS systems. based on data processing of beginning and finish knowledge through group testing. Twenty-seven of the thirty responders who took the test had inadequate knowledge at the beginning, and three had medium understanding. Thirty respondents tested the trainer as a learning tool, and their knowledge grew as a result, yielding final knowledge results in the high category.

Acknowledgment

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