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Development Solar Cell Trainer (SCT) as Learning Media on Renewable Energy

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ABSTRACT

Starting from the limitations of learning media on renewable energy material, the idea of developing a Solar Cell Trainer (SCT) was sparked. The purpose of this research is to develop a SCT as a learning media on renewable energy material that can help the learning process become easy and fun. This research is a Research and Development (R&D) which aims to produce a SCT and test its effectiveness. The effectiveness of the SCT trainer is seen from the aspects of Content, Learning Communication Media, Implementation Power and User Response. The R&D procedure is divided into 3 stages, namely: preliminary studies, product development, and evaluation and revision. The object of research involved 1 media expert lecturer and 35 students as users. The data collection technique used a questionnaire which then the results were analyzed descriptively. The results showed that the content and media aspects of learning communication were in the good category with a score of 82.5; while the implementation power and user response to the SCT media were in the good category with a score of 80.9. The conclusion of this research shows that SCT media is suitable for use in learning.

Keywords: Solar Cell Trainer, Learning Media, Renewable Energy

INTRODUCTION

Renewable energy material is one of the materials in scientific courses for students of the Mechanical Engineering Education Study Program. The topic of discussion is about the components, workings and applications of renewable electrical energy which is currently a growing trend. One of the renewable electrical energy sources discussed is the Solar Cell (SC), solar cells are a device for capturing electrical energy in SC by util sunlight which is also discussed in the material.

Solar cells are semiconductor devices that can convert sunlight directly into direct current (DC) using thin silicon (Si) crystals. Si cells are mounted in series in a panel made of stainless steel and protected by glass. Solar cells produce a voltage of 0.5 to 1 volt depending on the intensity of light and the type of semiconductor used [1]. Research related to solar cells, for example [2][3][4] focuses on optimized the performance of solar cells and their development, while this research focuses on developing solar cells as learning media in the classroom. In other words, solar cells are developed in the form of learning media.

The idea of developing a SCT is motivated by the existence of various limitations and problems that occur in the learning process, especially in renewable energy material for the 2021/2022 and 2022/2023 academic years. The problem is that renewable energy material is considered quite difficult by 80% of students, because the material discusses strong current electricity where 90% of the problem solving is done without opening the toolbox and 10% making repairs [5]. In other words, that problem solving in the electrical field requires high-level thinking. Students are required to think at a high level to be able to find the right solution.

In addition to these problems, there is no real learning trainer that can be seen and simulated by students related to renewable energy material. Whereas the role of media greatly determines the success of learning [6]. Research has provided empirical data that media can attract attention, motivate and make it easier for students to understand the material [7]. Therefore, learning media needs to be well developed.

Several developments of solar cells used as learning media have provided significant evidence for learning [8][9]. The development of solar cells as learning media is one of the innovations that can facilitate and bring students closer to the real application of the learning process, so that students do not consider the material difficult and confusing.

The development of SCT is very important to do, considering the condition of the Laboratory has not provided SCT as a practical for renewable energy material. The results of a preliminary study of 35 students showed that 53.3% agreed with the development of the SCT, and 46.7% strongly agreed with the development of the SCT. There was no response (0%) that stated less or disagreed.

Studying previous development results [9][10][11][12] that they focused on solar cell media with one solar cell panel. This is

considered to cover less teaching material about electricity. There needs to be additional panels or series and parallel circuits, so as to provide understanding to students related to series and parallel circuit. In addition, the SCT design is minimalist and portable so that it can be moved according to the needs of the place and does not require a large space. The trainer made is also equipped with a circuit scheme, so that students can easily understand the material.

Based on the urgency of the problem, the purpose of this research is to develop a SCT as a learning media for renewable energy material in order to help make learning easy and fun.

RESEARCH METHOD

This research uses the type of research and development that aims to produce SCT products and test the effectiveness of the product. The development procedure in this research refers to the development procedure of Dick [13]. Dick's development model is adapted to the research context because the development design can provide opportunities for researchers to collaborate with experts related to the product so that good quality development results are obtained.

The procedure is divided into 3 stages, namely preliminary study, development, and evaluation-revision. The data collection technique used a questionnaire with a Linkert scale to measure the effectiveness of the product. The object of research involved 1 expert lecturer and 35 students as users.

The questionnaire grids adapted from [14], can be seen in the table 1.

Table 1. The questionnaire grids

Aspect	Indicator
Content	The coverage and adequacy of the media, the media is free from conceptual errors, and the currentity of the media.
Learning media and communication	The level of interactivity and convenience, attractiveness of the overall media packaging, the quality of media utilization with the objectives, characteristics of students, the media designed can provide illustrations that match the actual situation, and all components function.
Implementability and user response	Ease of use, the level of possibility of student interest when used in the classroom, the possibility of being used for individual learning, the level of encouraging students' ability to think critically and solve problems, the level of contextuality, the level of providing ease and speed of mastery of materials, concepts and skills in accordance with related topics.

The research data were analyzed by descriptive statistics which is outlined in the form of a research diagram.

To be able to give meaning to the data, provisions are used as in table 2.

Table 2. Data meaning fixity

Score	Category	Decision
90 - 100	Very good	No improvement needed
75 - 89	Good	No improvement needed
65 - 74	Enough	Minor Improvements
55 - 64	Less	Major Improvements
≥ 54	Very poor	Not suitable for use

(adapted from [15])

RESULT AND DISCUSSION

The results of the research are outlined in 3 sections, namely: results of the preliminary study, SCT design development results, and effectiveness of SCT media.

1. Results of the Preliminary Study

Data from the preliminary study on the needs analysis of 35 students, obtained 46.7% stated that it was very important and 53.3% stated that it was important with the development of SCT. In addition, no one stated quite important, less important and not so important with the development of SCT. The percentage of student responses related to the development of SCT is presented in Figure 1.

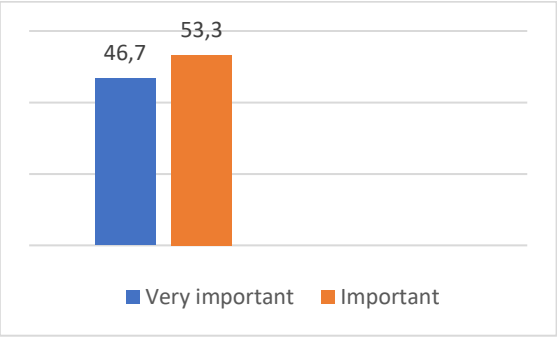

Figure 1: Respondents' opinions

Students in the preliminary study argued that the SCT needs to be developed because it can help students in understanding the material because students can practice seeing what components and how SCT works. Thus, the SCT is very important to be well developed. According to [16] that systematic and tested development must be done before the media is used in the classroom. This is to ensure that the quality and needs of the media are suitable for use as learning media.

2. SCT Design Development Results

Before making the SCT media in the form of a real product, the development team first developed a 3D drawing design. This work is done to ensure that each component, size or dimension is appropriate and functions properly on the panel. The results of the 3D design drawing of the SCT are presented in figure 2 and table 3.

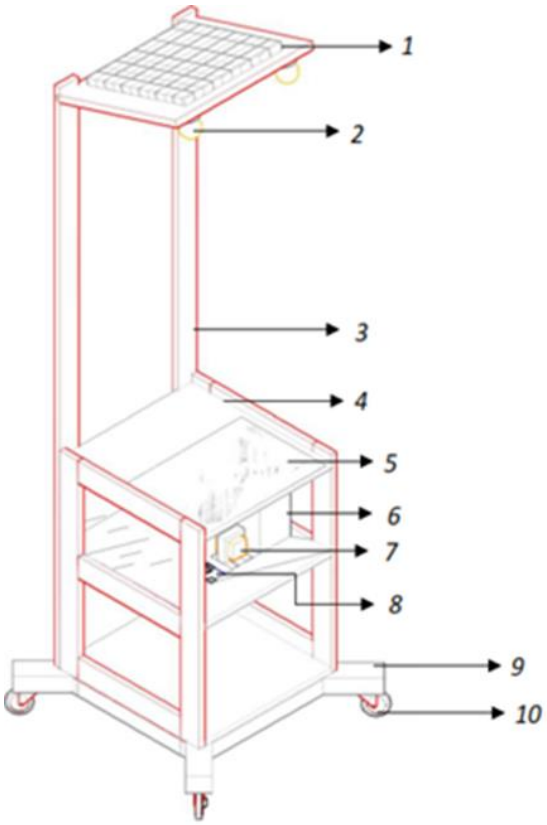

Figure 2. Design of SCT media

Table 3. 3D design of SCT

No	Part	Spesifications
1	Solar Panel	10WP, 17.5V
2	Light Bulb	5W
3	Mounting Structure	Wood
4	Trainer Desk	Wood
5	Solar Cell Circuit Diagram	Stickers
6	Battery	12V, 3.5Ah
7	Inverter	CT-3A, 30V
8	Solar Charge Controller	6-60V, 10-30A
9	Frame Leg	Hollow steel 4x4
10	Wheels	2 Inch

The 3D design of the SCT shows the layout of the SCT components. The solar cell component (no. 1) is mounted on the top of the panel which allows the solar cell to be exposed to direct sunlight, the light bulb (no. 2) is mounted on the ceiling of the panel, the wiring diagram (no. 5) is mounted on the panel table, other components such as the battery (no. 6), inverter (no. 7), and charger controller (no. 8) are mounted in the middle of the panel. Meanwhile, the bottom of the SCT is equipped with wheels (no. 10). The advantage of this SCT is that the panel table is equipped with a wiring diagram which is useful to facilitate students in understanding the SCT circuit. In addition, the wheels at the bottom of the trainer function so that the trainer is easily moved according to the place of study, thus enabling learning outside the classroom, this attracts student motivation in learning. Figure 3 shows the enthusiasm of students learning outside the classroom using the SCT media.

Figure 3. Enthusiastic students learning outside the classroom using the SCT

3. Effectiveness of SCT Media

The effectiveness of the SCT media is seen from the aspects of content, media and learning communication and user response.

Data from the content aspect is presented in Figure 4. q1 is the coverage and adequacy of media content, scored 80; q2 is the correctness of media content free from conceptual errors, scored 100; q3 is the current content, scored 80.

Data from the media and learning communication aspects are presented in Figure 4. q4 is the level of interactivity and ease, scored 80; q5 is the attractiveness of the overall media packaging including colour, component illustrations, images, component layout, scored 60; q6 is the suitability and quality of media utilization with the objectives and material, scored 80; q7 is the media can provide illustrations in accordance with the actual situation,

scored 80; and q8 is all components function properly, scored 100.

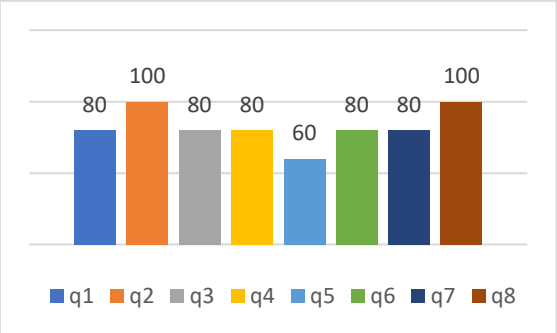

Figure 4. Content aspect data

q1 The coverage and adequacy of media content
q2 The correctness of content free from conceptual errors
q3 The current content
q4 Level of interactivity and ease
q5 The attractiveness of the overall media packaging
q6 The suitability and quality of media utilization
q7 The media can provide illustrations in accordance with the actual situation
q8 Component function

Based on the data in Figure 4, it is concluded that the content, media and learning communication of the SCT media are in the "good" category (see table 1) with the decision not to need improvement with an average score of 82.5.

Q1 is the ease of use, scored 81.7; Q2 is the level of possibility of student motivation when used in learning, scored 81.1; Q3 is the possibility of being used for individual learning by students, scored 82.9; Q4 is the level of possibility of encouraging students' ability to think critically and solve problems, scored 78.9; Q5 is the level of contextuality, scored 80.6; and Q6 is the level of possibility of providing easy mastery of the material, scored 80.6.

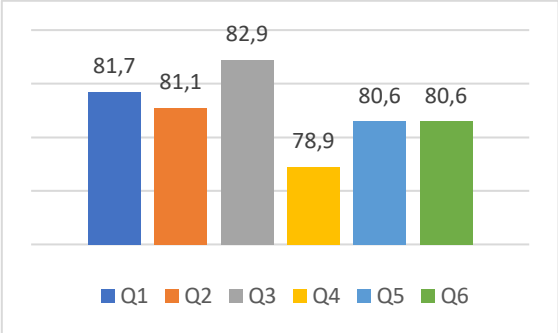

Figure 5. Implementation power and user response

Q1 The ease of use
Q2 The level of possibility of student motivation when used in learning
Q3 The possibility of being used for individual learning by students
Q4 The level of possibility of encouraging students' ability to think critically and solve problems
Q5 The level of contextuality
Q6 The level of possibility of providing easy mastery of the material

Based on the data in Figure 5, it is concluded that the implementation power and user response to the SCT media are in the "good" category (see table 1) with the decision not to need improvement with an average score of 80.9. In other words, the SCT can or is suitable for use in the classroom.

There is something interesting to discuss related to the results of this research. Looking at the data in Figure 4, it is known that q5 is related to the attractiveness of the colour and layout of the components, scoring 60. It is considered necessary to rearrange the colour and layout of the SCT components. This is important, given that the media

attractiveness factor is an attraction for students in learning. Therefore, future research needs to consider the suitability of media colours with user characteristics and the layout of components, for example from ergonomic and occupational safety and health aspects.

The development of this SCT media is the first time done, so it still needs further development, including, the output voltage of the SCT media produced is still low, it is necessary to increase the voltage by adding a solar cell panel that has a higher output voltage. This certainly increases the amount of budget required. Budget limitations are the main factor in choosing the size of solar cell panels.

The voltage output of the SCT in this study is 12 volts DC, which is converted to 220 volts AC. With a maximum power of 10 WP solar cells, it can do a full charge for 4 hours under the hot sun of 32 degrees centigrade. Meanwhile, the discharge time when used with a 10watt load is 1.5 hours. The data shows that the low output voltage of the solar cell causes the charging time to be longer and the discharge time to be shorter when an electrical load is used.

In addition to increasing the power of the solar cell panel, it is necessary to increase the capacity of the battery to 24 volts DC. The battery capacity needs to be increased as a place to store a larger voltage so that the time to use electric power can be longer.

Looking at the development results [17][18] it is very interesting to be adapted to this solar power trainer in the future. The PLTS trainer needs to add a sunlight intensity reader so that the solar cell can follow the movement of brighter sunlight, with variations in the angle of the sensor. This can certainly add to the mastery of material for students who study solar cells.

Looking at the data in Figure 5, it is known that Q4 is the level of possibility to encourage critical thinking and problems solving skills, getting a score of 78.9. The score on Q4 is considered the lowest compared to other Q scores. If we look at the real conditions in the field, students may assume that they only practice understanding the components and functions of SCT components. They did not troubleshoot the SCT, because the SCT was designed for simulation. All the components are new and the circuit is already installed on the panel, so there is no trouble shooting on the trainer. Therefore, there is a need for future development so that the SCT can train critical thinking and problems solving skills.

Some research focuses on problem-solving-based media development such as (Made et al., 2013; Sari & Sugiyarto, 2015; Delfianti, 2019), where they combine

trainer media with multimedia in a problem-solving pattern. This concept can be adopted in future SCT.

The SCT needs to be conceptualize with a problem-solving pattern such as forming component parts that have not been identified then students are asked to identify components and compile a SCT circuit on the trainer. It can also be by conceptualize the SCT with a problem such as the charger controller light not turning on, then students are asked to find the cause and provide alternative solutions. This concept needs to be tried in future research.

CONCLUSION

The results showed that the content and learning communication media were in the good category, while the implementation power aspect of the SCT was in the good category. This means that the SCT fulfils the feasibility aspects and can be used in the learning classroom.

Based on the results of this study, the aspects of the attractiveness of media packaging and the level of possibility to encourage problem-solving skills still need to be improved in the future. Some future suggestions have been presented in the discussion.

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