Mini photovoltaic system project: Physics laboratory activities through a technology-rich learning environment

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Abstract. In this paper, we describe how to design the mini photovoltaic system project for physics laboratory activities, in which student can use it to get the various information. This proposed system can record several physical quantities at once, voltage, current, and power for each recording time range. This project uses three types of photovoltaic size, that is 3v, 6v, and 12v. The recording processes using Arduino Uno technology. Each measurement is capable of displaying the recording quantities each time, V-t, I-t, and P-t charts. The time required for recording the data can be adjusted to the design of the laboratory learning. All stored data can be analyzed according to the designed activities by the teacher. This mini photovoltaic system support laboratory activities through technology-rich learning environment.

1. Introduction
Project based learning (PjBL) is a potential solution to increasing collaboration in a team work [1-3] and communication [1, 2] for students. Why we need to increase a collaboration and communication? The answer is because an employer in this century look to hire individuals with that soft skills, collaboration, and communication [2]. Supporting the development of these skills is easily applied in school [4]. PjBL can support by practicum sets and students more interest for learning by using a practicum sets [5], especially in a short projects [6]. One of the applications from practicum sets using record technology, such as data logger to process a lots of data [7, 8]. The use of technology in practicum has proven to produce more effectively learning, even for early childhood [9].

Photovoltaic is a material in physics that processes large amounts of data. The physics instructor must utilize various patterns to instill a deeper understanding of photovoltaic cells [10]. Combining project based learning with STEM can increase effectiveness, produce meaningful learning and influence student attitudes in pursuing a future career. Students have a more positive attitude by combining PjBL with STEM [11]. As teachers, we should integrate this learning style and soft skills with technological development trends by creating a technology-rich learning environment.

2. Methods
We use ADDIE model for research and development method which consists of: analyze, design, develop, implement, and evaluate [12].
2.1. Analyze
Analyzing data from a previously developed practicum set also provides an understanding for researchers to create quality learning media.

2.2. Design
Using CorelDraw software to make a prototype acrylic box to make it easier to use, make a list of tools and materials needed in making the equipment, conduct studies in assembling tools and how to operate the equipment to function properly.

2.3. Develop
Assemble and installation of the practicum set of mini photovoltaic system at box acrylic.

2.4. Implement
Test the practicum set of mini photovoltaic system to student representatives.

2.5. Evaluate
Evaluated from the results of implementation if there are shortcomings to produce quality of practicum set that are quality, attractive, efficient, and useful regarding validity and implementation.

3. Results and discussion
The design form of the practicum set of mini photovoltaic system made in 3D format shown in Figure 1. The software used is Coreldraw. The reason for using Coreldraw, because this program does not require large capacity in computer system and CorelDraw has an easy to use. The top of the practicum set is fitted with a hinge to make it easy to open. Transparent color selection so that the practicum set looks clear and clean.

![Figure 1. Design in 3D format.](image)

The following tools and materials needed for the practicum sets are Arduino Uno, Solar panel 3v, Solar panel 6v, Solar panel 12v, jumper cable, SD card module, and Acrylic box. In general, the stages of making practicum sets are the assemble and install the tools. There are three types of solar panel variations in practicum sets, so the data processed and analyzed by students is more varied. The practicum sets shown in Figure 2.
Figure 2. Practicum set of mini photovoltaic system project.

The measured quantity is voltage and current, while the power value obtained from the calculation results. Relationship between voltage-time, current-time, and power-time shown in Figure 3-5.

Figure 3. Relationship between voltage-time (V-t).
Figure 4. Relationship between current-time (I-t).

Figure 5. Relationship between power-time (P-t).

Figure 3, Figure 4, and Figure 5 shows that the highest peak is at 13.00-13.45 when the intensity sun. Based on data it can be concluded that the more intense the sun will produce a maximum value on potential, current, and power.
This practicum set also equipped with worksheets. The worksheet produced in this study contains instructions for using worksheet, how to work practicum, coding, and a table of practicum observations. Figure 6 shown a front cover of a worksheet, the front cover consists of the title practicum sets, author, affiliation, and grade students, with the solar system as the background. Figure 7 shown an instruction...
of worksheet, this instruction described systematically, so the students easy to be following. Figure 8 shown a table of practicum observations, this table made to facilitate students in observation.

After the process of making practicum sets and worksheet complete, the researchers validate the media and material. The media and material validation results presented in Table 1. The validation results of media experts got suggestions for improvement to change the size of the practicum set to be more proportional. Improvements made by making the size more proportional to be easily moved. The last size of the practicum set has dimensions 30 x 15 x 10 cm. The validation results of materials experts got suggestions to add physics material related to photovoltaic.

Table 1. The validation results of media experts and learning materials.

| No. | Aspects Measured                        | Presentation Scale | Interpretation |
|-----|----------------------------------------|--------------------|----------------|
| 1.  | Can be used as learning media           | 80%                | Very Good      |
| 2.  | The size of the practicum set is       | 84%                | Very Good      |
|     | proportional                           |                    |                |
| 3.  | Practicum set use strong materials     | 80%                | Very Good      |
| 4.  | Practicum set has an attractive design | 87%                | Very Good      |
| 5.  | The measurement tool used has an       | 82%                | Very Good      |
|     | interesting shape                      |                    |                |
| 6.  | Practicum set produces accurate data   | 85%                | Very Good      |
| Average of all aspects                 | 83%                | Very Good       |

Materials Expert Validation

| No. | Aspects Measured | Presentation Scale | Interpretation |
|-----|------------------|--------------------|----------------|
| 1.  | Material theory  | 80%                | Very Good      |
| 2.  | Material concept | 80%                | Very Good      |
| 3.  | Writing explanation | 85%  | Very Good      |
| Average of all aspects                 | 81.44%             | Very Good       |

Based on the validation, media feasibility results obtained 83% and classified as feasible, material feasibility obtained 81.44% and classified as feasible. This book has also been through limited tests of 40 students with a performance value of 85.75% and classified as feasible. It can conclude that the practicum set of mini photovoltaic system is eligible and suitable for use learning. In the future work, this practicum set is expected with the additional use of the internet module so that data recording can be directly uploaded to the cloud site since the cloud system give some promising for provide and support various learning in future [13].

4. Conclusion

Based on the validation results by media experts and material experts, as well as implementation to students, it can be concluded that the practicum set of mini photovoltaic system is worthy of being used for Physics subjects with very good interpretation. The practicum set of mini photovoltaic system that has been developed can be used as a learning resource for students in school. Also, it can be used as a reference for the public regarding alternative energy sources to reduce energy consumption.

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