The development of electrical energy conversion tools as learning media for the concept of energy sources

Abdul Rohman, I Komang Werdhiana, and Sahrul Saehana
Physics Education Program Study, Faculty of Education, Tadulako University
sahrulsachana@gmail.com

Abstract. The purpose of this research is to produce electrical energy conversion tool as a learning medium. This research process is a research and development research which is commonly referred to as R&D. Sugiyono modified this research model. The instrument used was a questionnaire with a Likert scale which were assessed by media experts, material experts, physics teachers and students of Grade XI IPA Senior High School Lab school, Untad, Palu. The product quality data obtained were analyzed using descriptive analysis. The product quality based on the results of the analysis of the media expert's assessment obtained a percentage value of 84% with the interpretation of "Very Good". The product quality, based on the results of the assessment analysis by material experts, obtained a percentage value of 85% with the interpretation "Very Good". For the results of the physics teacher responses on the perspective of the learning media developed, it obtained a percentage value of 92.2% with the interpretation "Strongly Agree". For the results of the students' responses in Grade XI Science Senior High School Lab school, Untad, Palu, on the limited test, the percentage value obtained was 85.95% which had the interpretation of, "Strongly Agree" regarding the use of the learning media. The results of the tests and questionnaire analysis indicated that the electric energy conversion tool as a learning medium developed is suitable for use in the learning process.

1. Introduction
Physics is one of those subjects which emphasizes not only on the concepts but also the practice. Props are one part that can deliver abstract concepts to become more concrete. Teaching aid is something that can be used to assist the learning process in explaining/realizing a concept [1].

Props are tools (objects) that are used to demonstrate certain facts, concepts, principles or procedures to make them appear more real/concrete. Assistive devices are tools (objects) used by learners to facilitate teaching tasks, and learning aids emphasize helping the learners. All of these terms can be summarized in one general term, namely learning media [2].

Media, which includes learning aids in teaching, also means carrying messages or information from learning sources to learning message recipients. As a presenter and channel of messages, learning media in certain matters can represent teachers in presenting learning materials to learners [3,4].

The use of instructional media in the teaching and learning process can generate new desires and interests, generating motivation and stimulation of teaching activities, and even give psychological effects on students [5].

The difference between this research and previous studies are: (1) the research which has been conducted only uses one energy conversion learning media tool, whereas, in this study, more than one energy conversion tool is utilized; (2) in terms of device components, the researchers of this study utilized
an energy-saving miniature house as a place for energy conversion tools; (3) the resulting media can be made as an example of an energy-saving house model which utilizes renewable energy.

Based on observations which were carried out in the field, especially in MAN 2 Parigi, students only rely on learning facilities provided by the government, which meant that the available learning resources are very limited. Until now, students at MAN 2 Parigi learn only using the available resources. The school lacked teaching aids or learning media, which can be used in the learning process. In particular, in the material for the conversion of electrical energy, there are still no props provided by teachers nor the school which are useful as a medium or as an example, so that students can understand quicker and better regarding the topic of the conversion of energy into electrical energy.

Students at MAN 2 Parigi only learnt using physics books without any other learning media to support their learning and teaching process, such as worksheets. Additionally, no experimental aids which can be found in the school nor BSE books. The presentation of the content in the book available is too general, meaning that both the presentation of the material and the application of examples are presented only in general and very slightly discusses contextual phenomena with the students' environment. It leads to students feeling that the material presented is abstract and difficult to understand directly, except with the teacher's explanation. We know that the learning objectives are several learning outcomes which indicate that students have taken learning actions, which generally include new knowledge, skills and attitudes, which are expected to be achieved by students [6].

Students only receive an explanation of what alternative energy sources can be used as a substitute for energy sources derived from fossil fuels or mining. Besides, the process of converting these alternative energy sources to produce energy which can support our lives are usually elaborated, specifically regarding electrical energy as a support for our daily lives. An intermediary medium for delivering the related material is needed in order to assist students in understanding the material provided to overcome this problem.

The energy conversion teaching aids used as a learning medium for energy conversion alternative material are aimed to engage students to become more interested and enable them to gain direct experience in learning this topic. This teaching aid can be used to study energy conversion materials through demonstration and experimental methods to explain the meaning of energy changes, explain energy forms and examples in everyday life, apply the concept of energy and its changes in everyday life, as well as to explain the benefits, advantages, and disadvantages of energy change phenomenon in everyday life [7].

Energy is a basic human need, which continues to increase in line with the level of life. Oil fuel/fossil energy is one of the non-renewable energy sources which has been the major energy needs in all activity sectors. The wealth of energy resources in Indonesia vary, from hydropower, geothermal, natural gas, coal, peat, biomass, biogas, wind, marine energy, solar and others which can be used as alternative energy [8].

Electrical energy is the energy which is most widely used due to the ease with which it is converted to other energy such as heat or light. Alternative power plants appear along with technological advances in response to increased use of electrical energy in the community. Alternative power plants are considered more environmentally friendly because they use the energy available in nature, which is renewable energy. In its application, alternative power plants require a controller capable of managing the energy produced [9].

Wind, solar and water power are a type of renewable energy with zero pollution level and are quite abundant for the equator. Solar power can be converted directly into electrical energy using solar cells and thermoelectrics. Likewise, the energy of motion in wind and water can be used to move windmills and water to rotate. This rotation will generate electricity in such a way that electrical energy can be stored. The resulting electrical energy is stored in the battery and then used for various purposes, devices to utilize alternative energy [10].

The use of energy conversion tools as a product which can convert natural energy into electrical energy is not a new notion. The Meteorology, Climatology and Geophysics Agency (BMKG) of Palu City during 2013 - 2015 has obtained statistical data regarding weather changes for three years. The data that
has been obtained include both rainfall, sunlight intensity and wind speed. In 2013, the rainfall was 63.33 mm, and sunlight intensity was 27.7 °C to 34.30 °C and a wind speed of 3.60 knots while the sun's irradiation was 57.7. In 2014, the rainfall was 58.76 mm, and sunlight intensity was 26.7 °C to 34.30 °C and a wind speed of 3.90 knots while the sun's radiation was 63.48 [11]. When taught in the classroom, it can give insight to students about the use of natural energy as alternative energy that can be used both in learning media and to fulfill daily life. Based on the problem formulation above, the purpose of this research is to produce learning media with the concept of converting heat, wind, water and sunlight into electrical energy. The energy conversion tools that we often encounter sometimes only use one energy being converted while all around there are many renewable energies that can be converted. More than one conversion tool is being developed so that renewable energy can be utilized. The tool that is wanted to be achieved is to be useful not only as a medium in the school environment but wider so that the society and energy produced is greater. However, due to limited tools and costs, the manufacture of energy conversion tools can only cover learning media in schools.

2. Methods
This research utilizes one of the types of research and development, which is known as Research and Development (R&D). It is a research model used to produce certain products and test the effectiveness of these products [12].

This research was conducted at the Physics Laboratory of the Faculty of Teacher Training and Education. The duration of the research implementation was around six months. The subjects of this study were six students of Grade XI Lab school. Tools that are made or developed must be calibrated in the laboratory before the tools are used.

The technique of analyzing research data was conducted through several stages. First, the questionnaire data is collected; then, they are identified and grouped according to the assessment and answers to the questionnaires. The instrument in the form of a questionnaire used was validated by media experts and material experts so that it was declared fit for use.

Second, the data is processed with the expected amount so that the percentage [12] is obtained as follows:

\[
\%P = \frac{\sum \text{skor perolehan}}{\sum \text{skor maksimum}} \times 100\%
\] (1)

Third, the data is analyzed using a quantitative descriptive technique which is elaborated in the score distribution, and percentages towards the assessment scale category determined [12] as seen in Table 1 below.

| Table 1. Interpretation of Likert scale assessment product |
|---------------------------------|
| Percentage (%) | Score Scale | Interpretation |
| 0 – 20 | 1 | Extremely Poor |
| 21 – 40 | 2 | Very Poor |
| 41 – 60 | 3 | Moderate |
| 61 – 80 | 4 | Good |
| 81 – 100 | 5 | Excellent |

3. Results and Discussion
Energy is a basic human need, which continues to increase in line with the level of life. Oil fuel/fossil energy is one of the non-renewable energy sauces, which has been the mainstay of meeting energy needs in all sectors of activity [13].

Thermoelectric measurements can be concluded that the results of the study, thermoelectric measurements with three thermoelectric modules mounted on an aluminium plate affixed to the
refrigerator compressed produce an average output voltage of 0.174 volts. To produce a high voltage, the Peltier must be arranged in series. The output voltage generated by the TECL-12705 thermoelectric generator is still quite small [14].

The application of DC series-parallel props can improve understanding of the concepts of physics in Ohm's law material in class XI students of mechanical engineering at SMK 1 Comal in the 2014/2015 academic year[15].

The results of the product that the researchers developed were in the form of alternative energy conversion tools as learning media. This tool can generate electrical energy by converting renewable energy, such as wind, rain and sunlight [17]. The results obtained from the use of this tool are the LED which lights up (as an indicator), and the voltage can be seen through the multimeter.

After making improvements, the development of the tool was then continued, with the validation of media experts and material experts. The products produced by the researchers on the design of the electrical energy conversion tool as a learning medium for concepts can be seen in Figure 1 below.

After making improvements, the development of the tool was then continued, with the validation of media experts and material experts. The products produced by the researchers on the design of the Electrical Energy Conversion Tool as a Learning Medium can be seen in Figure 1 below.

![Figure 1. Electrical Energy Conversion Tool as a Learning Medium](image)

3.1. The Result of the Analysis Evaluation of Electrical Energy Conversion Tool as a Learning Medium

3.1.1. Evaluation by Media Experts
The results of the analysis evaluation by the media experts penilaian oleh ahli media disajikan dalam Tabel 2.

| Aspect | Average |
|---|---|
| | 84% |

Conversion tools and learning media that have been tested are then repaired so that they are suitable for use in the school environment so that students will more easily understand the learning material provided by the teacher. However, the energy conversion tool still does not work as desired. Learning has the meaning of acquiring knowledge or mastering knowledge through experience, remembering, mastering experience, and obtaining information or discovering. Thus, learning has a basic meaning of activity or activity and mastery of something[17].
Table 2. The results of the evaluation by media experts

| NO | Assessment Aspects                              | Evaluation Criteria                                                                 | Result   |
|----|-------------------------------------------------|--------------------------------------------------------------------------------------|----------|
| 1  | The quality of the tool and its effectivity     | 1. The interesting shape of tools                                                   | Good     |
|    |                                                | 2. Convenience in operating the tools, following the tool principles                | Excellent|
|    |                                                | 3. Convenience in managing the tools                                                | Good     |
|    |                                                | 4. The durability of the tools (long-lasting)                                       | Good     |
|    |                                                | 5. The tool works properly                                                          | Good     |
| 2  | The Appropriateness of the Tools with the Physics Concept | 6. Physics concept integrated within the tools                                       | Excellent|
|    |                                                | 7. Convenience level towards physics concept which is still abstract is more concrete through the use of tools | Good     |
|    |                                                | 8. Factual knowledge as shown by the tools                                          | Good     |
|    |                                                | 9. Conceptual knowledge as shown by the tools                                       | Excellent|
|    |                                                | 10. Procedural knowledge as shown by the tools                                      | Excellent|
| 3  | The Durability of the Tools Used                | 11. Not easy to break, fall off, or destroyed when operated                          | Good     |
|    |                                                | 12. The appropriateness of the component when built                                 | Good     |
|    |                                                | 13. The durability of the component on its basis                                     | Moderate |
| 4  | Safety Hazards for Learners                    | 14. Safe construction for learners (will not easily fall apart)                     | Good     |
|    |                                                | 15. The usage of the tools do not require any specific types of equipment (wearing masks or gloves) | Excellent|
|    |                                                | 16. No dangerous chemical effects (does not easily combust, does not cause irritation) | Good     |

The aspects of quality evaluation of the teaching tools are presented in the diagram in Figure 2 below.

Figure 2. Diagram of quality evaluation by the media expert
3.1.2. Evaluation by Material Expert
The results of the evaluation carried out by the material expert, as presented in Table 3 below.

| NO | Evaluation Aspects                                      | Evaluation Criteria                                      | Results  |
|----|---------------------------------------------------------|---------------------------------------------------------|----------|
| 1  | Suitability of the tools with the learning materials   | 1. Able to indicate physics phenomenon                   | Good     |
|    |                                                         | 2. Required in the topic of renewable energy resources   | Excellent|
|    |                                                         | learning and teaching process                            |          |
|    |                                                         | 3. Able to actualize physics concepts from the            |          |
|    |                                                         | demonstration of the tools                               |          |
|    |                                                         | 4. Able to assist in explaining the concept of renewable |          |
|    |                                                         | energy resources                                          |          |
| 2  | Education values                                        | 5. The appropriateness of the tools with the students'   | Good     |
|    |                                                         | intellectual development                                 |          |
|    |                                                         | 6. Easy for students to understand the concept           | Good     |
|    |                                                         | 7. The appropriateness of the tool with the learning and | Excellent|
|    |                                                         | teaching needs                                           |          |
|    |                                                         | 8. Gives ease for students to increase their skills      | Good     |
|    |                                                         | (thinking, speaking, and moving)                         |          |
|    |                                                         | 9. Enhances students' motivation to study harder         | Good     |

The aspects of the quality evaluation of the teaching tools are presented in the diagram in Figure 3 below.

Figure 3. Diagram on the evaluation of the material expert

3.1.3. Evaluation by the Physics Teacher
The results of the evaluation performed by the physics teacher are displayed in Table 4 below.

| NO | Evaluation Aspects                                      | Evaluation Criteria                                      | Results |
|----|---------------------------------------------------------|---------------------------------------------------------|---------|
| 1  | Suitability of the tools with the learning materials   | 1. Able to indicate physics phenomenon                   | Strongly|
|    |                                                         | 2. Required in the materials of the renewable energy    | Agree   |
|    |                                                         | resources learning and teaching process                  |         |


| NO | Evaluation Aspects | Evaluation Criteria | Results |
|----|--------------------|---------------------|---------|
|    |                    | Able to actualize the physics concept from the demonstration of the learning media | Strongly Agree |
| 2. | Education values   | 3. Able to assist in explaining the concept of renewable energy resources | Strongly Agree |
|    |                    | 4. The appropriateness of the tools with the students' intellectual development | Strongly Agree |
|    |                    | 5. Easy for students to understand the concept | Agree |
|    |                    | 6. The appropriateness of the tool with the learning and teaching needs | Agree |
|    |                    | 7. Gives ease for students to increase their skills (thinking, speaking, and moving) | Strongly Agree |
|    |                    | 8. Enhances students' motivation to study harder | Strongly Agree |
| 3. | The Quality and the Effectivity of the Tools | 9. Interesting shape of tools | Agree |
|    |                    | 10. Convenience in operating the tools, following the tool principles | Strongly Agree |
|    |                    | 11. Convenience in managing the tools | Strongly Agree |
|    |                    | 12. Durability of the tools (long-lasting) | Agree |
|    |                    | 13. The tool works properly | Agree |
| 4. | The Appropriateness of the Tools with the Physics Concept | 14. Physics concept integrated within the tools | Agree |
|    |                    | 15. Convenience level towards physics concept which is still abstract is more concrete through the use of tools | Strongly Agree |
|    |                    | 16. Factual knowledge as shown by the tools | Agree |
| 5. | The Durability of the Tools | 17. Not easy to break, fall off, or destroyed when operated | Strongly Agree |
|    |                    | 18. The appropriateness of the component when built | Agree |
|    |                    | 19. The durability of the component on its basis | Agree |
| 6. | Safety Hazards for Learners | 20. Safe construction for learners (will not easily fall apart) | Strongly Agree |
|    |                    | 21. The usage of the tools does not require any specific equipment (wearing masks or gloves) | Agree |
|    |                    | 22. No dangerous chemical effects (does not easily combust, does not cause irritation) | Strongly Agree |
|    |                    | 23. The construction is safe for the learners (does not easily fall) | Strongly Agree |
The aspects of the quality evaluation of the teaching tools are presented in the diagram in Figure 4 below.

**Figure 4.** A diagram on the evaluation carried out by the physics teacher

### 3.1.4. The evaluation carried out by students

The results of the evaluation performed by the physics teacher are displayed in Table 5 below.

**Table 5.** The results of the evaluation by the physics teacher by grade xi science students of *lab school* untad

| No | Response Aspects                                      | Response Criteria                                                                 | Results     |
|----|--------------------------------------------------------|-----------------------------------------------------------------------------------|-------------|
| 1. | Learning motivation and conceptual understanding of the topic of renewable energy resources with the use of the learning media | 1. I can understand the physics concept on the materials of renewable energy resources easier with the help of the learning media | Agree       |
|    |                                                        | 2. My motivation in learning physics increase since the implementation of the learning media in the classroom | Strongly Agree |
|    |                                                        | 3. I enjoy learning physics due to the learning media used                        | Strongly Agree |
|    |                                                        | 4. I am more active during the learning activities due to the learning media used | Strongly Agree |
|    |                                                        | 5. I cooperate with my classmates during the learning activities using the tool as the learning media | Strongly Agree |
|    |                                                        | 6. The media developed increased my knowledge of physics application               | Strongly Agree |
|    |                                                        | 7. The availability of the learning media makes me feel more interested in trying and creating the tools as given examples before | Agree       |
| 2. | The operation and the performance of the media         | 8. The media is easy to operate                                                   | Agree       |
|    |                                                        | 9. The media function well when operated                                           | Agree       |
|    |                                                        | 10. The learning media is suitable to be used for                                 | Agree       |
3. Learning media quality

| Question                                                                 | Rating     |
|------------------------------------------------------------------------|------------|
| 11. The learning media assist me in obtaining knowledge regarding     | Strongly    |
|   renewable energy resources                                           | Agree      |
| 12. The learning media can present the physics concept being taught   | Agree      |
| 13. The learning media is simple and practical                          | Strongly    |
| 14. The learning media is durable, does not easily break down when     | Agree      |
|   used                                                                  |            |

The aspects of the quality evaluation of the teaching tools are presented in the diagram in Figure 5 below.

![Figure 5](image)

**Figure 5.** A diagram on the evaluation carried out by the senior high school students of *Lab school* UNTAD

3.2. Discussion

The results of the data analysis are obtained from the development of energy conversion tools into electrical energy as a learning medium for the concept of energy sources based on the results of validation and limited trials.

This research begins with the design process, or a temporary description, of the tool. Then, the tools and materials which will be used are prepared. Next, a tool design is made by consulting to the supervisor in order to obtain input on the design of the tool to be made. Based on the results of the consultation and guidance, the design of the tool then becomes a complete product.

Experts then validate the tools which have been designed. The expert in this study was a lecturer in Physics Education of the Faculty of Teacher Training and Education in UNTAD. The assessment by experts utilizes an assessment instrument to get responses. The expert's response is used as a reference for improving the product. After the revision stage was carried out, it was continued with a limited trial conducted by the physics teacher with six students of Grade XI Science Senior High School *Lab school* Untad Palu by filling in the response questionnaires.

The results of the media expert's assessment conducted by physics lecturers of the Faculty of Teacher Training and Education in UNTAD was based on several aspects which could be seen in Table 2. The results of the assessment on the aspects of the quality of the tools as well as the
effectiveness of the tools and the suitability of the tools with the physics concept were categorized in very good category (VG). Meanwhile, the durability aspect of the props obtained a good category (G). The average of these three aspects obtained a score which belonged in the very good category (VG).

The material assessment was carried out by another physics lecturer of Faculty of Teacher Training and Education in UNTAD, as shown in Table 3. The results of the assessment on the aspect of the relationship between the tools and teaching materials and the value of education were categorized in the very good category (VG). The average of these two aspects is included in the very good category (VG).

Meanwhile, the results of the assessment conducted by the physics teacher indicated that the category obtained was of the "strongly agree" (SA). The results of the assessment of each aspect is an assessment of the relationship between the teaching tools and learning materials, the education values, the quality of the tools as well the effectiveness of the tools, the appropriateness of the tools with the physics concept, the durability of the tools and the safety for students; all of these results were categorized "strongly agree" (SA) category. The average of these aspects also belonged in the "strongly agree" category (SA).

The advantage of the electric energy conversion tool as a learning medium for the concept of energy sources is that the teacher can show directly to students on how the tools can convert energy into electrical energy and it makes it easier for teachers to deliver the materials during the learning and teaching activities in the classroom [18-20]. Additionally, it helps increase students' interest in learning physics [4] and eases them in understanding the concepts directly from the media used. Nevertheless, the media created by the researchers also had several weaknesses, such as the large space it needed and that there are still some tools which could not function optimally.

From the research results, energy conversion tools as learning media are deemed suitable for use in schools to assist teachers in learning and teaching activities.

4. Conclusion
This research can be concluded with several statements: An electrical energy conversion tool as a learning medium is developed through the concept of energy resources. The steps taken to carry out this research began from collecting the tools and materials needed, and then assembling the tools and materials. The results of the assessment given by the media expert, the material expert and the physics teachers along with six students of Grade XI Science Senior High School Lab school Untad, Palu, on the feasibility of the product, indicated that the tool met the criteria very well and was suitable for use.

Based on the current research and development, the researcher suggested for future researchers to Develop this product, namely the energy conversion tool which is done by utilizing renewable energy resources, to try and make it more attractive and more sophisticated in order to attract students' interest in the learning process. In the future, further research is needed with wider trials following the steps of Sugiyono's model. For future researchers, to experiment with the effectiveness of this tool on students.

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