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Article

REELS (Renewable Energy Electrical Circuits) as Innovative and Integrative Learning Media for Environmental Technology Concept

Nuzula Prabandari[1*], Oli Fia[2], Refina Dzurotul Mahmudah[3], Yalika Imanuna[4]

[1]Institut Agama Islam Negeri Ponorogo, Indonesia
[2]Institut Agama Islam Negeri Ponorogo, Indonesia
[3]Institut Agama Islam Negeri Ponorogo, Indonesia
[4]Institut Agama Islam Negeri Ponorogo, Indonesia

**Corresponding Address: nuzulap23@gmail.com*

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ABSTRACT

Conceptual environmentally friendly technology material requires interactive learning media to facilitate students' understanding of the mechanism of the technology. REELS (Renewable Energy Electrical Circuits) is an innovative learning media in the form of an environmentally friendly city replica equipped with solar power plant models and wind power plants as power plants. REELS learning media is different from other media because it is integrated with electrical circuit material. This study aims to determine the feasibility of the REELS learning media that was developed. The method used is Research and Development (RnD) with a modification of the 4D model (to 3D) Thiagarajan with stages including define, design, and develop. Data were collected using validation sheets from three expert validators who are junior high school science teachers. Quantitative data from the validation results were analyzed using descriptive analysis techniques. The results showed that the average feasibility score of REELS media was 3,67 with a good category indicating that this media is suitable for use in learning. Overall, the use of REELS learning media contributes positively to improving students' understanding. Further research is recommended to improve the aesthetic aspects and durability of learning media in order to increase student appeal and the durability of the media.

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INTRODUCTION

This guideline is a template for writing the manuscript for proceeding of in Environmental problems and the energy crisis are global challenges that must be resolved immediately. Dependence on fossil fuels not only pollutes the environment, but also plays a major role in global warming (Rahman, A., & Dewi, N). In this context, the development and implementation of renewable energy technology such as solar power plants and wind power plants is a strategic solution that needs to be introduced from an early age through education.

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An understanding of environmentally friendly technology needs to be instilled in students as the nation's next generation. Effective and interactive learning media is the key to transferring knowledge about solar power plants and wind power plants technology to students (Widodo, S., & Pratiwi, H. 2022). Using appropriate learning media can increase understanding of concepts and raise awareness of the importance of renewable energy in everyday life.

Indonesia, a country on the equator, has large solar energy potential with average daily radiation of 4.8 kWh/m²/day (Ministry of Energy and Mineral Resources). Apart from that, as an archipelagic country, Indonesia also has quite promising wind energy potential in several areas. This potential must be introduced to students through comprehensive learning media to form an understanding of the sustainable use of natural resources.

The development of learning media for solar power plants and wind power plants technology not only aims to increase understanding of concepts, but also to foster students' creativity and innovation in developing environmentally friendly technology (Sutrisno, B., & Hartati, R. 2022). Through interactive learning media, students can understand the working principles, components and practical applications of solar power plants and wind power plants technology in everyday life.

The integration of information technology in solar power plants and wind power plants learning media is a strategic step in the digital era. The use of simulations, animations and interactive models can help students visualize abstract concepts and understand the energy conversion process that occurs in these two technologies (Putra, I. G., & Sari, R. M. 2023). This is in line with the demands of 21st century learning which emphasizes the use of digital technology in the learning process.

Due to the importance of understanding the concept of environmentally friendly technology, researchers have created a learning media called REELS (Renewable Energy Electrical Circuits). This media will provide students with a real picture of the working principles of solar power plants and wind power plants, so that students can easily understand the concept of environmentally friendly technology and learning becomes more meaningful. The difference between REELS learning media and other existing learning media is the integration with the concept of electrical circuits so that this media becomes more efficient.

METHODS

This research method uses the Research and Development (RnD) approach with a modification of the 4D model to 3D Thiagarajan, which consists of three main stages: definition, design, and development. (Germeraad, 2001). At the definition stage, researchers identify problems and needs in the field through observation and discussion to understand the problems faced by users, such as students, teachers, or educational institutions. Furthermore, researchers analyze the needs that must be met to overcome these problems and set clear and specific research objectives. At this stage, researchers conduct early-end analysis, analysis of student needs and analysis of environmentally friendly technology concepts. After the definition stage, researchers proceed to the design stage, where the initial product concept is developed based on the results of the needs analysis. At this stage, researchers create a prototype of the designed product, which is a learning tool. The last stage is development. In the development stage, the researcher conducted a validation test on the REELS learning media by 3 learning media experts who are science teachers at the junior high school level. The assessment consists of several aspects, namely the aspects of durability, accuracy, efficiency, aesthetics and security of the learning media. In the aspect of tool durability, there are 3 criteria, the aspect of tool accuracy consists of 2 criteria, the aspect of tool efficiency consists of 3 criteria, the aspect of aesthetics consists of 1 criterion and the aspect of tool security consists of 3 criteria so that the total criteria are 12. Each criterion is assessed on a Likert scale with a weight of 1 to 5.

As for the calculation of the results of the validation test is done by using formula

Average Rating per Validator =

$$\text{Final score} = \frac{\Sigma\ score\ obtained}{\Sigma\ item\ score}$$

Final Value of Validation Test =

$$\text{Final Value of Validation Test} \frac{\Sigma \ validator \ final \ value}{\Sigma \ \ calidator \ final \ value \ item}$$

Score Interval (Sugiyono, 2013)

Score Interval	Information
1,00 – 1,80	Very bad
1,81 – 2,60	Bad
2,61 – 3,40	Neutral
3,41 – 4,20	Good
4,21 – 5,00	Very good

RESULTS AND DISCUSSION

The development of the REELS learning media has gone through a research process with the expected goals. The research was carried out using a predetermined method, namely by adopting a 3D development model (define, design, and develop).

Define Phase (Definition/Analysis)

At this define phase, the definition and analysis of several things related to learning needs are carried out. The results of the steps of this stage are as follows:

1. Early-End Analysis

The development of current technology demands innovation in various aspects of life, including in the world of education. One of the materials that needs great attention is environmentally friendly technology. Environmentally friendly technology includes various efforts to reduce negative impacts on the environment, such as the use of more efficient and sustainable renewable energy (Mabruri, 2024). Therefore, education about environmentally friendly technology is very important to be introduced to students from an early age, including at the junior high school level.

Learning about environmentally friendly technology for 9th grade junior high school students has its own challenges. Concepts such as renewable energy, solar power plants, wind power plants, and the application of alternative energy are often abstract and difficult for students to understand if only presented through textual materials or lectures (Rahman, et al., 2024). On the other hand, contextual and applicable learning can help students connect theory with the reality around them, so that they can better understand how this technology plays a role in everyday life.

However, in practice, there are still many obstacles in the process of learning environmentally friendly technology in schools. Students' interest in learning this material tends to be low, because they find the concepts difficult to understand and less interesting. In addition, the limited interactive learning media that is able to present visualizations of environmentally friendly technology concepts is one of the factors that causes students to have difficulty understanding the material in depth. Most of the learning still relies on textbooks and lecture methods, which do not provide meaningful learning experiences for students (Meni, 2023).

This condition shows the need for innovation in learning media that can bridge students' understanding of environmentally friendly technology. Then the REELS (Renewable Energy Electrical Circuits) learning media was born. This media is in the form of a replica of an environmentally friendly city consisting of solar power plant models and wind power plants as power plants, which are integrated with electrical circuit material.

With this media, students can learn through direct experience, observe how renewable energy works, and understand the concept of electrical circuits in an applicable manner.

The development of REELS learning media is expected to be an innovative solution in learning environmentally friendly technology in grade 9 of junior high school. Through REELS, students can be actively involved in learning, increase their motivation to understand renewable energy concepts, and at the same time raise awareness of the importance of preserving the environment. Thus, this study aims to develop REELS learning media that can support a more effective and interesting learning process, in accordance with student needs and the demands of today's technological developments.

2. Student Needs Analysis

The Independent Curriculum emphasizes the importance of student-centered learning and encourages more personalized, relevant, and contextual learning (Amalia, et al., 2024). In this learning, 9th grade junior high school students are given the freedom to explore their interests and talents, and are encouraged to develop critical and creative thinking skills. At this stage of development, students have begun to be able to think abstractly but still need visualization and direct experience to understand complex concepts, such as environmentally friendly technology and electrical circuits (Utama, et al., 2024).

Students need media that not only facilitates theoretical understanding but also allows them to explore independently. The REELS (Renewable Energy Electrical Circuits) learning media is designed to meet this need by presenting a replica of an environmentally friendly city that utilizes solar power plants and wind power plants . Through REELS, students can play an active role in learning by seeing firsthand how renewable energy is converted into electricity in a system. This approach is in line with the principles of the Independent Curriculum which encourages students to learn through exploration and find their own understanding.

3. Concept Analysis

In the Independent Curriculum, learning materials are more flexible and adapted to the local context and needs of students. Environmentally friendly technology material in grade 9 of junior high school includes an understanding of renewable energy, such as the use of solar power plants and wind power plants, as well as the application of environmentally friendly technology in everyday life (Haq & Fitriani, 2024). This material is often abstract if only taught theoretically. Therefore, media is needed that can visualize the concept in a real and applicable way. Therefore, the REELS learning media is designed in the form of a city replica, where students can see and practice directly how solar and wind energy can generate electricity. This media supports hands-on learning and allows students to understand these concepts through contextual and relevant activities. Integration in learning media is also deemed necessary to increase the efficiency of the media, so that REELS integrates environmentally friendly technology material with electrical circuit material in the form of a series circuit on a lamp connected to a solar power plant and a parallel circuit connected to a wind power plants.

Design Phase

Building a replica of an environmentally friendly city is an inspiring project that allows to explore sustainability and renewable energy. By incorporating models of wind power plants and solar power plants, it can showcase how these technologies contribute to a greener urban environment. This article guide through creating a miniature city that features both wind and solar energy systems.

Materials that needed for building the city replica there are baseboard like sturdy piece of wood or cardboard for city foundation, craft supplies like wood stick for house infrastructure and wool for grass craft around the city, small solar cells for the solar power plant replica, small

DC motor for the wind power plants replica, wood for the tower, glue, tape, and origami paper for assembly and decoration.

Tools that needed, there are: scissors or craft knife for cutting materials, ruler and pencil for measuring, soldering iron for electrical connections in the solar power plant, drill for assembling the wind power plants. Steps to Build Environmentally Friendly City Replica are:

Step 1: Planning the city layout with a sketch the design with outline different zones such as residential areas, home zones, parks, and renewable energy sites. Include renewable energy Sources and decide where to place wind power plants and solar power plants within the city layout.

Step 2: create the base of outline zones like lightly mark areas for different city components based on the planning.

Step 3: construct the buildings build eco-friendly structures by using cardboard to create buildings and use the stick for buildings the house. Then incorporate Parks and create green spaces with small plants or artificial greenery.

Step 4: create the wind power plants replica. Creating a wind power plants replica is a fantastic project that not only showcases renewable energy principles but also provides a hands-on experience in building and understanding wind energy generation. This article will guide through the steps to create a simple wind power plant replica model that can generate electricity, output the product of renewable energy. Materials that needed for replica of wind power plant there are wood for the tower of replica wind power plant, propeller of plastic sheets for the blades, small DC Motor to generate electricity, LED Light or small battery for demonstrating electricity generation, wires for electrical connections and glue or screws to assemble parts.

Tools that needed for replica of wind power plant there are drilled to make holes for the motor and assembly, saw for cutting wood, screwdriver for screws, scissors for cutting cardboard/plastic, and multimeter to measure voltage output. Steps to make a replica of wind power plant are:

a. Design for wind power plant
   Before starting, make sketch a simple design of wind power plant replica. Decide how tall want the tower to be and how many blades we want. We have design has one blades, which is for capturing wind energy.
b. Construct the tower
   Cut the Base: Cut a piece of wood to serve as the base. It should be stable enough to support the tower and build the Tower: cut a piece of wood for the tower height desire. Drill a hole at the top where the motor will be mounted.
c. Create the blades
   Cut the blades: cut three equal-sized pieces of plastic into a propeller then attach blades: attach the blades to the shaft of the motor using glue or screws. Ensure they are evenly spaced and securely fastened.
d. Install the motor
   Mount the motor: secure the motor to the top of the tower after that ensure the shaft of the motor is exposed for the blades to spin and connect the Wires: Attach wires from the motor terminals to LED light or battery. This will allow to see the electricity generated when the blades spin.
e. Assemble wind power plant replica
   Connect the tower and base: securely attach the tower to the bas then final Adjustments: ensure everything is stable and the blades have room to rotate freely without obstruction.
f. Testing the wind power plant replica by lighting the LED if connected properly, the LED should light up, demonstrating that your wind power plant is generating electricity. Wind power plants work by converting kinetic energy from wind into mechanical energy, which

is then transformed into electrical energy by the motor. The amount of electricity generated depends on the size of the blades, the speed of the wind, and the efficiency of the motor. This project illustrates the fundamentals of renewable energy and its potential for sustainable power generation. Building a wind power plant replica is an engaging and educational project that demonstrates the principles of renewable energy. Not only does it foster creativity and problem-solving skills, but it also deepens understanding of how wind energy can be harnessed to generate electricity. Whether for a school project, a hobby, or just for fun, this wind power plant model will surely inspire interest in renewable energy and sustainability.

Step 5: Create the Solar Power Plants Replica

Creating a solar power plants replica is an excellent way to understand how solar energy is harnessed and converted into electricity. This project is suitable for educational purposes, DIY enthusiasts, or anyone interested in renewable energy. This article will guide through the steps to build a simple solar power plant model that demonstrates the principles of solar power generation. Materials that needed for replica of solar power plant there are solar cells (Monocrystalline or Polycrystalline): These are the core components that convert sunlight into electricity, plexiglass, or clear plastic sheet for covering the solar cells, wood, wire to connect the solar cells, soldering iron and solder for electrical connections, electrical tape or heat shrink tubing for insulating connections, diode to prevent backflow of electricity.

Tools that needed for replica of solar power plants there are soldering KIT for connecting solar cells, drill for making holes in the frame, utility knife for cutting materials. Steps to make a replica of solar power plants are:

a. Design the solar power plant
   Before starting, sketch a design for the solar power plant. Decide on the size and arrangement of the solar cells. A common small panel consists of four to six cells arranged in a grid.
b. Prepare the replica
   Use wood to create a tower electricity replica that will hold the solar cells. Ensure it's slightly larger than the total area of the cells. Then assemble the Frame: secure the corners with screws or glue, creating a sturdy structure.
c. Connect the solar cells
   Arrange the Cells: Place the solar cells on the base of the frame in desired layout. Make sure they are evenly spaced and wiring: Connect the solar cells in series for switch on lamp of the road with series connection: Positive terminal of one cell connects to the negative terminal of the next. This increases voltage. And then solder connections: If necessary, use a soldering iron to secure the connections. Be cautious not to overheat the cells.
d. Secure the solar cells by protect the cells
   Place the Plexiglass or clear plastic sheet over the cells to protect them from the elements while allowing sunlight to pass through. Secure it with screws or tape.
e. Make electrical connections
   Connect Wires: use wire to connect the output terminals of solar power plant replica to a small battery, LED light, or a multimeter for testing and insulate Connections: use electrical tape or heat shrink tubing to cover exposed wire connections, ensuring safety.
f. Testing the solar power plant replica
   Expose to Sunlight: Place solar power plant replica in direct sunlight. Observe the connections with a multimeter to measure voltage output. If connected to an LED, it should light up, demonstrating that the panel is generating electricity. Solar power plants work by utilizing photovoltaic cells, which convert sunlight into direct current (DC) electricity. When sunlight hits the cells, it excites electrons, generating an electric current. The

efficiency of your solar power plant will depend on factors such as the quality of the solar cells, the amount of sunlight received, and the angle at which the panel is positioned.

Building a solar power plant replica is an engaging project that illustrates the principles of renewable energy. It fosters creativity, problem-solving skills, and a deeper understanding of how solar energy can be harnessed for sustainable power generation. Whether for a school project, a hobby, or just for fun, this solar power plant model will inspire an interest in renewable energy and its potential to power our future.

Step 6: Detail and Decorate the replica of city with using origami paper to make a trees craft and markers to add details and color to your buildings and roads.

Creating an environmentally friendly city replica helps illustrate the importance of sustainability, renewable energy, and green urban planning. It encourages discussions about reducing carbon footprints, enhancing energy efficiency, and promoting biodiversity in urban areas. Building a city replica that features renewable energy technologies like wind power plants and solar power plants is a rewarding project that highlights the importance of sustainability. Through this hands-on activity, we can learn about renewable energy sources and their role in creating a greener future.

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Figure 10. Tower

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Figure 10. Tower

Figure 1. Learning Media of Renewable Energy Electrical Circuits

Develop Phase

In the develop phase, a validation test was carried out on the REELS learning media by 3 learning media experts who are junior high school science teachers. The three science teachers came from MTs Darul Huda Mayak, MTs Al-Mukarrom and MTs Muhammadiyah Yanggong. The assessment consisted of several assessment aspects, namely the aspect of media durability, media accuracy in explaining concepts, media efficiency, aesthetics and safety of learning media. Furthermore, at this validation stage, the results were obtained as shown in table 1.

Validator	∑Score Obtained	∑Item Score	Final Score	Category
Validator 1	48	12	4,00	Good
Validator 2	41	12	3,42	Good
Validator 3	43	12	3,58	Good
Avarage Final Result			**3,67**	**Good**

Table 1. Result of validation

Table 1 shows that the results of the validation test carried out by science teachers with an average final result of 3.67 are in the good category so that it can be stated that the REELS learning media is suitable for use for learning activities with revisions according to the suggestions given. The disadvantages of REELS media according to the validator are the use of several small components such as cables or windmills which may be less stable or easily damaged if not used carefully. The suggestion given by the validator is to provide a brief description or explanation of the concept of wind power plants, solar panels and series and parallel circuits on the media so that even though students try independently they can still understand the concept intended by the media maker. Then parts of the entire tool (including miniature houses and the like) can be colored to make it more attractive. In addition, the validator suggests the use of a support cover for storage to minimize damage to the tool.

CONCLUSION

REELS (Renewable Energy Electrical Circuits) is a learning media in the form of an environmentally friendly city replica consisting of solar power plant models and wind power plants as power plants, which are integrated with electrical circuit material. With this media, students can learn through direct experience, observe how renewable energy works, and understand the concept of electrical circuits in an applicable manner. The results of the study showed that the average feasibility score of REELS media was 3.67 with a good category, indicating that this media is suitable for use in learning with revisions according to the suggestions given. Further research is recommended to improve the aesthetic aspects and durability of learning media in order to increase the appeal of students and the durability of the media.

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