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The Preliminary Prototype of Learning Material Based on STEM Framework in Renewable Energy Topic

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Abstract.

Renewable energy learning is the first step to create energy security in the future. However, in fact, there are still many students who find it difficult to learn about renewable energy in high school. Learning materials have good role in support students in learning physic. Therefore, this study aims to develop learning materials on the renewable energy topic based on STEM framework. The research method used is development study consisting of 3 stages namely the preliminary stage, the prototyping stage and the assessment stage. However, the discussion on this paper just describes the preliminary prototype of STEM-based learning material on renewable energy topic. The subjects of this study are the 10th grade students in Palembang. Data related to prototyping of learning materials are collected by documents and walkthrough. They are analyzed and described descriptively. The results showed the first prototype of the renewable energy learning materials based on STEM framework containing 8 learning objectives on the renewable energy, the limitation of electrical energy problem, the sources related to renewable energy topic, the series of STEM- based activities, and the evaluation.

INTRODUCTION

Renewable energy is a type of energy that comes from sustainable natural processes, such as water, sun, wind, geothermal and sea wave [1]. Utilization and development of renewable energy is an alternative as well as a solution to protect the environment, save energy from fossil fuels (oil and gas), and minimize negative impacts on the environment such as air pollution, increasing air temperature and depletion of the ozone layer [2]. Indonesia is a country that has a high potential for development and development of renewable energy. This is based on the condition of Indonesia's topography which is mountainous and hilly and is fed by many rivers and certain areas

that have lakes, reservoirs/dams that have the potential to be used as energy generators. The use of renewable energy has now been intensified as an alternative solution to reduce dependence on fossil fuels. Through the Ministry of Energy and Mineral Resources, the government seeks to increase the use of renewable energy in Indonesia [3]. The Ministry of National Education has accommodated this policy by including material on the use of renewable energy in physics subjects in the 2013 Curriculum. At the high school level, the topic of renewable energy is studied in grade 10. It is one of the materials in physics that is very important to study at this time, so that in the 2013 curriculum the material is included in the basic competencies that students must master. Renewable energy learning is the first step to create energy security in the future [4].

But in reality, there are still many students who find it difficult to learn about energy source material in elementary school [5] to material about renewable energy in high school [6]. One of the obstacles faced in learning physics, is that the process of learning physics is often faced with an abstract material. Physics lessons still seem difficult to understand because some of the material has abstract concepts and sometimes it is not easy for students to relate it to everyday events in human life [7]

One of the relevant learning approaches that relate physics learning to human everyday life is STEM (Science, Technology, Engineering, and Mathematics). Through STEM learning, students are better able to solve real-world problems [8]. Students can study the engineering design process in which they define a problem, conduct research, develop some ideas for a solution, and arrive at an idea they work on. Students can then test prototypes, brainstorm and evaluate designs, and redesign to make improvements. Through this process, students can learn a variety of social, collaboration, teamwork, and leadership skills. Students can also learn to explore and most importantly, they can engage in deeper learning that develops critical thinking [9].

In addition to using the right learning approach, the use of teaching materials must also be appropriate to support students in learning physics topics. Teaching materials play an important role in achieving the desired learning objectives. Teaching materials are a collection of information, tools, and texts that are indispensable in the learning process to help teachers plan and study lessons [10]. Teaching materials can be in the form of reading books, student worksheets, shows, newspapers, digital materials, and discussion materials between students [10]. Furthermore, teaching materials can contain appropriate activity designs and technology that can support students learn the physics topic [11].

Previous research on the development of STEM-based teaching materials has been conducted in early childhood education in elementary schools [12] and elementary schools [9]. Even research on stems in the world has been discussed quite a lot [13], [14, 15, 16, 17]. In physics learning, Wandari et al. [18] developed STEM-based teaching materials on light and optics. At the high school level, Hasanah et al. [19] produced a STEM-based biotechnology module equipped with flash animation for learning biology. However, there has been no research on the development of STEM-based teaching materials on the renewable energy topic. Therefore, this study aims to develop learning materials on the renewable energy topic based on STEM framework.

METHOD

This research uses the research method of design research type of development studies. This study aims to develop valid, practical and effective STEM-based materials on the renewable energy. The research was conducted in three stages, the preliminary stage, the prototyping stage and the assessment stage [20]. The evaluation flow used in the development of the prototype is formative evaluation. The phases carried out include self-evaluation, expert review, one-to-one, small group and field tests [21]. However, this article just describes the preliminary prototype of STEM-based teaching materials on renewable energy topic. Data were gathered through walkthrough. Involving the experts that validate the content, the construct, and the display of learning materials developed. The research was carried out in September 2022, the odd semester of the 2022/2023 academic year.

RESULT AND DISCUSSION

At preparation stage, literature studies related to STEM framework and curriculum were conducted. 5-step framework for developing STEM curricula include identifying core competencies, selecting a real-world context or problem, preparing resources and tools, designing a series of activities to engage students, and developing an evaluation rubric for assessing the selected core competencies [22]. The formulation of learning objectives were based on learning outcomes or it is called Capaian Pembelajaran (CP) in the new curriculum in Indonesia that is Kurikulum Merdeka.

At prototyping stage, the preliminary prototype of the learning materials on the renewable energy topic was designed. Teaching materials designed is a textbooks contained science learning materials based on STEM framework. Figure 1 is the preliminary cover of STEM-based learning material.

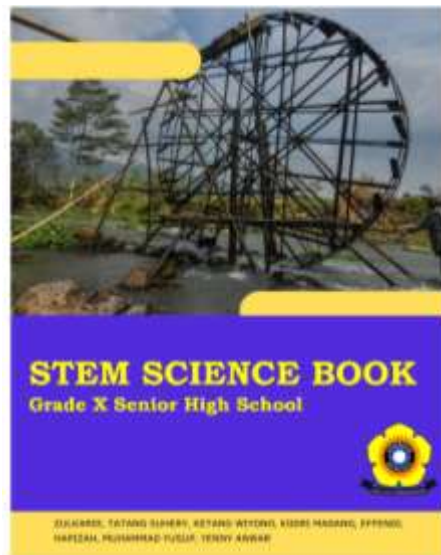


FIGURE 1. The book cover of STEM-based learning material on science

At the identifying core competencies stage, the learning objectives for renewable energy materials are formulated. They also contain abilities that are in accordance with 21st century skills such as problem solving skills, creativity skills, communication skills, and collaboration skills.


Learning competencies

After studying this chapter, you can

1. classify the basic forms of energy,
2. analyze the forms of energy involved in their application in everyday life,
3. analyze the application of the Law of Conservation of Mechanical Energy to events that occur in everyday life,
4. find existing energy availability problems in the environment around where you live
5. find potential energy sources that exist in the environment around where you live,
6. plan a design for making a simple energy producing tool or prototype as a solution to the problem of energy availability,
7. make a simple energy producing tool or prototype, and
8. improve design of a simple energy producing device or prototype that has been tested

(a)

INTRODUCTION



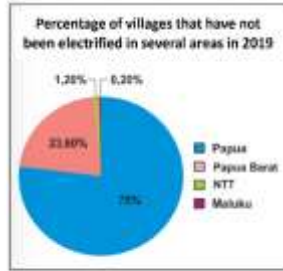
Electrical energy as a resource in human life has become a necessity starting from lighting needs to supporting household equipment and industry. A village cannot yet enjoy the benefits of electrical energy in its environment. Public The village took the initiative to provide electrical energy using waterwheels and river flows heavy in their village. Did you know that electrical energy is one form energy? What is meant by energy? How can a mill produce energy? Come on we learn more

(b)

FIGURE 2. (a) Competencies for the renewable energy topic; (b) a real-world context or problem on renewable energy topic

Figure 2 (a) shows learning objectives on renewable energy topic. There are 8 objectives starting from low order thinking skills to higher order thinking skills. The skills include the ability to classify, to identify, to analyse, to design, and to evaluate. Figure 2 (b) shows the problem posted at the beginning of learning materials. It is a real world problem about limited electrical energy. The problem is given to stimulate students to realize the importance of energy sources. To help students understand the topic of renewable energy, the textbook also contains material explanations about renewable energy.

According to the Minister of Energy and Mineral Resources (ESDM), Ariin Tasrif, and the Main Director of PLN, Zulkili Zaini, the factors that are obstacles to the electrification of these 433 villages are obstacles on the security side, infrastructure problems because they are in remote areas, so that sources energy sources in the village that must be utilized



In full, you can read the information in the link below.

<https://katadata.co.id/happyfajrian/berita/5e9a41f6be793/terkendala-infrastruktur-dan-energi-433-desa-belum-teralirlistrik>

Based on the things discussed above, you can understand that Indonesia still needs to explore its natural potential and riches to meet the need for electrical energy and strive for its availability in areas that do not yet have electricity.

Activity 4

Read and understand the following activity, fill in your answers in the blanks provided.

Science

Is there anything you can use as a simple energy source? The end result does not have to be electrical energy, it can also be other forms of energy can reduce the use of electrical energy.

Technology

In order to answer this question, look for reference sources through books, YouTube, internet and other sources. Look for ideas for possible energy sources used around you. Write the information you get here.

Engineering

Conduct experiments on energy sources. Are there any tools needed for manage these energy sources?

- Make a flat plan of the tools and materials needed to make it (make a prototype).
- Write down the steps on how to make it.
- Describe the design of the tool made.
- How does the tool work principle?
- Does the tool or tool prototype that you use function as intended? expected? Explain.

Mathematics

Include calculations in your test plan! Predict the amount of energy produced by the prototype energy source device

(a)

(b)

FIGURE 3. Supporting resources on renewable energy topic and designing a series of activities to engage students

Figure 3 (a) shows the sources and applications provided in the teaching materials on renewable energy materials. The material contains an explanation of the types of energy, the law of conservation of energy, how to determine the amount of energy, and types of renewable energy. To be able to achieve the learning objectives that have been formulated at the beginning of the teaching materials, the textbooks also contain STEM-based activities. There are 4 activities designed for renewable energy learning. Figure 3 (b) shows one of activities related to designing tools that can produce energy. The sequence of activities is adjusted to the emergence of STEM components which include aspects of science, technology, engineering, and mathematics.

After the textbook was designed, then the textbook was validated by experts in terms of appearance, content, and construction. The experts' comments are presented in the table 1.

TABLE 1. The experts' comments of the first prototype of STEM based material on renewable energy

No.	Experts' Comments
1.	It is necessary to include learning achievements in the book
2.	Provide picture description
3.	Change the image of an example of heat energy conversion from an old iron into a solar panel
4.	Add student answer columns on each activity

Comments from experts are used to revise teaching materials and then the latest prototypes of STEM-based teaching materials on renewable energy topics was produced.

STEM-based science textbooks on the topic of renewable energy are starting with presenting real problems in everyday life related to renewable energy. The use of real problems in everyday life can stimulate students to learn science where students are encouraged to explore information related to the material [23]; [24]. In line with research conducted by Suryawati & Osman [25] that learning that relates material to real situations can increase students' motivation to learn science. STEM-based science textbooks developed provide sources of material and applications that support students to gain an understanding of renewable energy. It is in line with the studies of Hirsh-Pase et al [26] and Robinson et al [27] that sources of information and applications related to the material will help students in learning science. The stem-based science textbooks that were developed also contain learning activities that connect the components of science, technology, engineering, and mathematics. In line with research conducted by Murnawianto et al [28] that integration between components such as science and technology can solve problems in STEM-based science learning.

CONCLUSION

The first prototype of stem-based teaching materials on renewable energy materials is designed with reference to the stem framework which contains: 8 learning objectives to be achieved; The problems raised are the limitations of electrical energy; The book provides a discussion of the material along with other sources of information; there is a series of activities clearly listed for each STEM point; there are evaluation questions.

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