The development of the pictorial stories about solar panels for elementary schools

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The development of the pictorial stories about solar panels for elementary schools

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Abstract. The main objective of this research was to produce a prototype of a pictorial story with the topic "Processing Solar Thermal Energy into Electric Energy". This product could be used as a supplementary book for Grade IV of Elementary Schools. This product was made based on the limitations of the material in the 2013 Curriculum student book and the needs in the classroom. Research & Development (R & D) method was applied in this research, with six stages: (1) Potential and problem analysis, (2) Data collection, (3) Product Design, (4) Product validation, (5) Product Design Improvement, (6) Product Design Testing. The data gathering technique applied interviews, observations, and questionnaires. The product was approved by two validators with the average score of 3.16 (from a range of values 1-4); and was included in "good" category; so, it was worth testing in a student learning activity, after being revised. After implementing in 4th grade elementary school students, the product obtained an average score of 3.58 which was included in "*very good*" category. As the result, the prototype was worth to be implemented as a learning medium which was also a means of literacy in supporting the "Gerakan Literasi Sekolah" (school literacy movement).

1. Introduction

Alternative energy is a renewable energy source that will not be exhausted [1]. This energy source is created because there is a threat that one day the energy source would run out. There are several alternative energy sources that can be utilized in human life, namely: the energy derived from water, wind, sun, and geothermal [2]. The material about alternative energy is one of the contents of Science courses taught in thematic learning of grade IV applying the 2013 Curriculum of Elementary Schools in Indonesia.

Humans become very dependent on fossil fuels as energy source, but it is finite, so it is necessary to find alternative energy sources in which the sun is one potential energy source [3]. Based on this, students need to explore the use of the sun as a potential energy source for the earth. One tool that utilizes energy from the sun is solar panel. Solar panel is a tool for converting solar thermal energy into electrical energy [4]. The application of solar panel technology to utilize the available solar energy potential is the right solution [5]. This is because Indonesia is a tropical country where there is continuous solar thermal energy throughout the year. Solar panels will be more desirable because they can be used for various purposes as well as in various places [5]. Usually solar panels are installed in places which easily absorb solar thermal energy.

Topics on alternative energy (including solar panels) are an essential topic for elementary schools. Grade IV of elementary school students specifically need to understand various energy sources, changes in energy forms, and alternative energy sources. Material on alternative energy needs to be taught to students so that they know various energy sources which are more environmentally friendly.

It is important for the students to develop a caring attitude towards the environment and have a wise awareness of energy use. The introduction of alternative energy can be done through various techniques and media, for example: using concrete objects [3], learning to use websites [6], demonstration and project creation [7]. The introduction of the science concept can be done using interesting literature. Children can learn more easily when using e-books [8] and illustrated storybooks [9]. Nevertheless, based on the results of the questionnaire filled out by 36 grade IV students, the obtained data show that as many as 68% of students stated that they had never read literature including illustrated stories about the use of alternative energy. On the other hand, the results of interviews with teachers convey that they found difficulties in obtaining media which introduced alternative energy and were matched with the student characteristics. In addition, the results of the document study show that the topic "Alternative Energy" has been alluded to in the Teacher's Book and Student's Book of the 2013 Curriculum. In those books, there is an introduction to various alternative energy sources, even about solar panels. Even so, the books do not provide information on the process of processing energy from the sun into ready-to-use energy.

Pictorial stories are children's story texts written on the basis of a particular activity or event in accordance with the children's point of view so that they can attract reading interest composed of texts and images that complement each other [10]. In Children's pictorial stories, there are various interesting illustrations, and are generally full of colors so that they can attract the attention of children and readers in general [11]. There are six types of pictorial stories according to [10], namely: fiction, history, information, biography, folklore, and true stories. Informative pictorial stories contain facts and data which are useful to add insight, skills, and also theoretical provisions for readers. Based on the results of interviews with fourth grade elementary school teachers, they agreed that pictorial stories can be used as media of learning about alternative energy. Pictorial stories can make students more interested in learning because there are pictures and comics which can give conceptual ideas of the material to be taught.

Pictorial stories can serve as a means of literacy in supporting Gerakan Literasi Sekolah (the School Literacy Movement/ GLS). GLS is a comprehensive effort to make schools as learning organizations in which the citizens are lifelong learners [12]. Through GLS, students 'interest in reading can be developed, so that they further develop their ability to comprehend reading, relating it to their personal experience, thinking critically, and processing communication skills creatively. Based on these reasons, Pictorial stories are developed with the main topic of solar panels. The main purpose of these pictorial stories is to introduce the functions, parts, and how solar panels work. Pictorial stories can be used as an assessment book for elementary students in general, as well as specifically to explore the concept of alternative energy in Grade IV of elementary school.

2. Research Method

This research is a Research & Development (R & D) which aims to produce products and test the effectiveness of the products. The Research & Development stages are carried out based on the formulation of Borg and Gall [13] with steps: (1) Potential Analysis and Problems, (2) Data Collection, (3) Product Design, (4) Product Design Validation, (5) Improvement of Product Design, (6) Product Trial, (7) Product Improvement, (8) Use Test, (9) Product Improvement, (10) Mass Product Making. In this research, the process is limited to the 6th step. Researchers have not made product repairs until mass production. The steps are generally described as follows:

2.1. Potential and problem analysis

Potential analysis is carried out by reviewing documents, namely: reviewing government documents related to Basic Competencies that need to be achieved by students as well as Teacher's Books and Student's Book and the 2013 Curriculum. While investigating the problem is done through interviewing teachers and distributing questionnaires to students. Based on the results of the questionnaire, obtained data show that as many as 68% of students stated that they had never read literature including illustrated stories about the use of alternative energy. On the other hand, the results

of interviews with teachers convey that they found difficulties in obtaining media which introduced alternative energy and were matched with the student characteristics. In addition, the results of the document study show that the topic "Alternative Energy" has been alluded to in the Teacher's Book and Student's Book of the 2013 Curriculum. In those books, there is an introduction to various alternative energy sources, even about solar panels. Even so, the books do not provide information on the process of processing energy from the sun into ready-to-use energy.

2.2. Data collection

The collected data are related to students' understanding of alternative energy. The purpose of this data collection is to obtain a general description of the content of the pictorial stories that students need. Data are collected using a closed questionnaire. Students' understanding of alternative energy shown in Table 2.

2.3. Product design

Products are developed starting from the design process in general (grid) to giving details of the contents. The grid is developed according to the data about the students' understanding of alternative energy. The content of the pictorial stories is developed by deepening the story and giving pictures based on the grid. Images are made manually and then edited using the Adobe Photoshop program.

2.4. Product validation

Validation aims to assess the product design so that weaknesses and strengths are known. The aspects of the pictorial story design which are assessed are language, writing format, and content. Validation is carried out by 2 validators consisting of elementary school teachers and science experts. The results of the validation are 2 types of data, quantitative and qualitative. The quantitative data are in the form of scores, while qualitative data are in the form of criticism, suggestions / input from the validator. The quantitative scores are converted into qualitative criteria using the Likert scale scoring guidelines 1-4 [13], with the criteria as shown in Table 1.

Table 1. Scale scoring 1-4 using Likert scale

Interval Score	Criteria
3,26 - 4,00	Very good
2,51 – 3,25	Good
1,76 – 2,50	Poor
1,00–1,75	Very poor

2.5. Product design improvement

The design improvement is based on the qualitative input in the form of validators' criticism / suggestions.

2.6. Product design testing

The purpose of the product testing is to know the quality and effectiveness of the pictorial stories. The product trial was conducted among 22 students of fourth grade, elementary school. The trial process was integrated with the learning activities carried out by the students in the class. After reading the pictorial stories, the students then worked on reflection. Students' answers to the questions served as the indicator of pictorial story understanding.

3. Finding and Discussion

3.1. The content of the pictorial stories

The main objective of this research was to produce a prototype of a pictorial story with the topic “Processing Solar Thermal Energy into Electric Energy”. This pictorial stories has a specific title,

named "Benefits of Solar Panels: Turning Solar Thermal Energy into Electrical Energy" . This product was designed on the basis of preliminary data on students' understanding of alternative energy. The students' initial understanding is described in Table 2.

Table 2. Student's initial understanding on alternative energy

No	Statement	Student's response percentage					Follow-up plan
		SA	A	I	D	SD	
1	Alternative energy can be used to replace fossil and petroleum energy.	**55%**	27%	9%	9%	0%	Most students have understood the definition of alternative energy, the pictorial story does not discuss in depth the definition of alternative energy.
2	Various types of alternative energy sources are wind, hydro, and solar.	**55%**	41%	4%	0%	0%	Most students have understood various alternative energy sources, the pictorial story does not discuss in depth the types of alternative energy.
3	The benefits of learning alternative energy to explore the use of environmentally friendly energy sources.	41%	41%	**10%**	**4%**	**4%**	The percentage of 'strongly agree' answers is lower than previous items. The percentage of students who are inconsiderate - strongly disagree is greater than the previous item. The implication is that in the pictorial story the emphasis would be on the use of alternative energy sources and their relation to environmental sustainability.

Based on the data in Table 2, the content of the pictorial story is emphasized on the use of alternative energy sources, as well as their relation to the environmental sustainability. Specifically, the energy source discussed is solar and its processing into electrical energy using solar panels. The pictorial story grid contains the parts as shown in Figure 1 until Figure 8. It was start with the difinition of energi, how the solar panel was work, and the last part was the question about the content of the pictorial story. For the begining, there was a simple definition about alternative energy (Figure 1). It is start from definition and examples of energy, then followed by the definition of the alternative energy. Alternative energy is energy that is not derived from fossils and petroleum. The various alternative energy sources were mentioned in the next page, for examples water, sun, geo-thermal, and nuclear (Figure 2). After that, the contents of the book focus on solar energy. In the book written various benefits of the sun, for example, is useful in the process of photosynthesis, drying clothes, and helping the process of making dried fish (Figure 3).

Figure 1. The page which show the definition of alternative energy

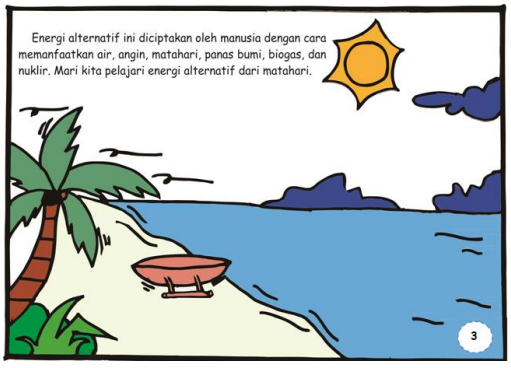

Figure 2. The various alternative energy sources is mentioned

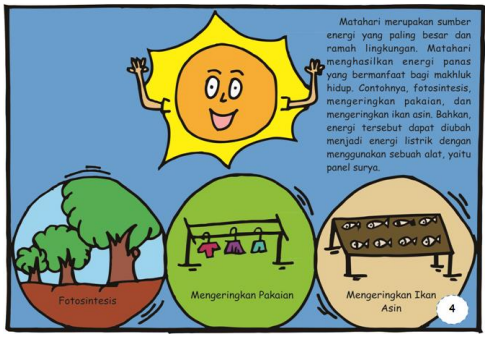

Figure 3. The page which show the benefits of solar thermal energy

The next part of the pictorial story was related to solar panels. First, the introduction of the function of solar panels, then described the general components of solar panels consisting of glass, silicon, and metal (Figure 4). This section also introduced the differences of two types of silicon, type N and type P silicon. Before there was an explanation of how solar panels work, it was first explained about the strategic place to install this tool, namely a place with strong sun exposure (Figure 5). Furthermore, it was explained the process of processing solar thermal energy into electricity by solar panels. The process started from the entry of heat energy through the glass and interacting with silicon, to the storage of energy in the battery (Figure 6).

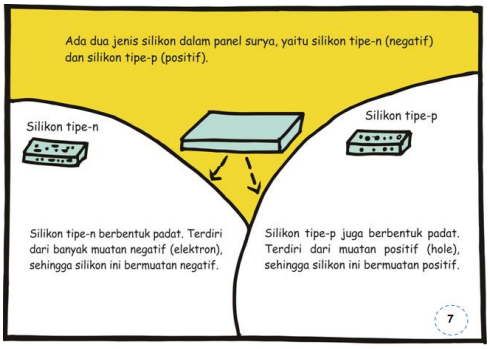

Figure 4. The page which show general functions and components of solar panels

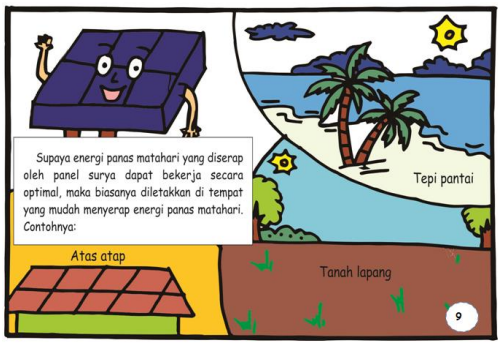

Figure 5. The page which show places to put solar panels

Figure 6. The page which show how solar panel works

After there was an explanation of how solar panels work, then there was a section that confirms that Indonesia as a tropical country will have a lot of solar heat so that solar panels can work optimally (Figure 7). At the end of the pictorial story, there were evaluation questions to review the reader's understanding of the contents of the pictorial story (Figure 8).

Figure 7. The page which show that solar panel potential in Indonesia

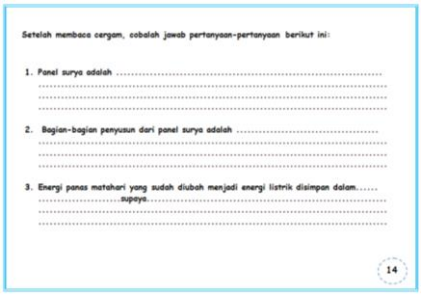

Figure 8. The page which contain some questions about the concept of solar panels

In making the pictorial stories, the researchers apply illustrated images that match the story line previously made. The pictorial stories are intended for elementary students who are experiencing the stage of concrete operational development [14], in which the students have the ability to think based on reality. The researchers develop the pictorial stories using illustrated images which are designed based on concrete things in everyday life. The Illustration and text images in the pictorial stories, can stimulate students' imagination and provide information about processing solar thermal energy into electrical energy using solar panels. In addition, the pictorial stories are colorful so the students are interested in reading and understanding the contents of the pictorial stories..

The illustrated images tell about solar panels that can convert solar thermal energy into electrical energy. The first part of the story content briefly explains that energy is an ability that can be used to do things, kinds of energy, and the alternative energy which is energy that is not resulted from fossils and petroleum. Various types of alternative energy are wind, water, sun, geothermal, biogas, and nuclear. The sun is the biggest source of energy. The energy from the sun is beneficial for living things for photosynthesis, drying clothes, and drying salted fish. In addition, energy from the sun can be converted into electrical energy using solar panels.

Solar panels are tools for converting solar thermal energy into electrical energy [4]. The solar panel consists of three parts, namely glass, silicon and metal. Glass can be easily penetrated by solar thermal energy which then moves towards silicon. There are two types of silicon, namely: negatively charged n-type silicon and positively charged p-type silicon. Metals have many electrons so they can conduct electricity. Solar panels are usually placed in a place that easily absorbs solar thermal energy, such as on roof, terrain, and beach [15]. The way solar panels convert solar thermal energy into electrical energy is by absorbing the heat energy of the sun entering through glass by silicon. The negative charge in silicon moves freely and when silicon n and silicon p touch each other it forms a positive pole on silicon n and negative pole on silicon p. Due to the flow of negative and positive charges, an electric field is formed. When solar thermal energy touches silicon p and silicon n, the negative charge moves from silicon to the metal. This negative flow is called electrical energy which then stores in a battery. The electrical energy that is stored in the battery is then connected to electronic equipment through cables [16]. At the end of the story, there are suggestions for using solar panels and reflection questions to find out students' understanding of the contents of the pictorial book prototype.

3.2.Quality of the pictorial story

Based on the average value of the validation results, the general score of 3.16 is included in the good category (Table 1). If viewed from the aspects of language, writing format, and content, the quality is obtained as shown in Table 3. The presentation of the quality of each aspect is presented in Figure 9.

Table 3. Product validation result

Aspect	Score	Criteria
Writing Format	3,50	Very good
Language	2,83	Good
Content quality	3,15	Good
Average	**3,16**	**Good**

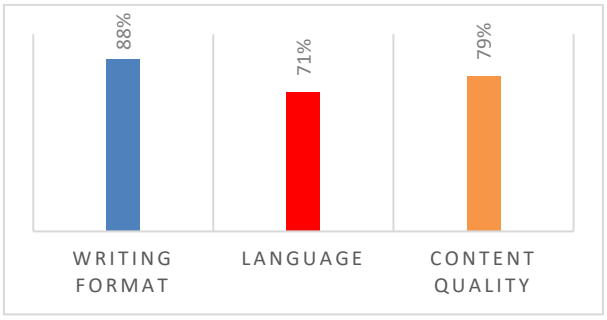

Figure 9. Quality percentage of each aspect in the pictorial story

The quality of writing format aspects in the pictorial stories shows the suitability of the format used by the rules of Indonesian writing system. In this case, the pictorial stories are written in very good spelling. Even so, the language used needs to be adapted to the characteristics of elementary school students as the readers. The aspect of the language highlights this. One item in the aspect of language is the use of language which is easily understood by students. This item got a low score (one of the validators gave score 2) and got a comment from the validator; so the improvements made are word replacement and removal to simplify the meaning. The examples of improvements are included in Figure 10 and Figure 11. Before revision, there was a specific word, “atom” (Figure 10). The language was simplified, and the term “atom” was deleted (Figure 11). Other example, many words were replaced with other word (make to simplify the meaning). In Figure 12, there was uncommon word for children, “electron”, it was replace with “muatan negatif” in Figure 13.

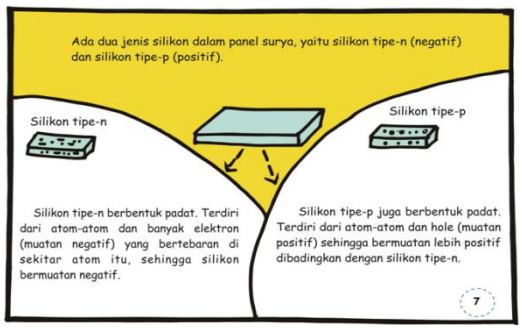

Figure 10. Before revision, there was a specific word, “atom”

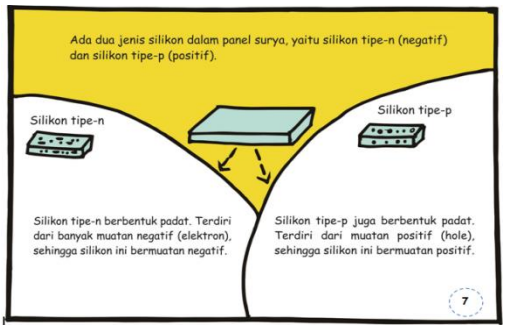

Figure 11. After revision, the term “atom” was deleted

Figure 12. Bevore revision, there was uncommon word for children, “electron”

Figure 13. After revision, some words were deleted to simplify the meaning

The product quality is also known based on the results of the product use trial on respondents. The product is used as assessment book as when the students study the concept of alternative energy. Next, the students answer the questions related to the content of the pictorial stories. The student answers represent the quality of the reader's understanding. Student answers to the questions about the content of the pictorial stories are shown in the following Table 4.

Table 4. Students' understanding of the pictorial story contents

Concept	**Number of students properly answers the contents of the pictorial stories**	**Student's answer score (max 4)**
Functions of solar panels	21 (95%)	3,90
Main components of solar panels	22 (100%)	3,99
Energy storage process	13 (59%)	2,81
Variety of information obtained	19 (86%)	3,61
Average	**18,75 (85%)**	**3,58**

Deriving from Table 4, it is concluded that the content of the pictorial stories is easily understood by the students. The number of the students who answered questions corresponded to the content of the pictorial stories is 85%. Furthermore, when reviewing the quality of the student answers to the questions at the end of the comic, the average score is 3.58 (maximum score 4) with a very good category based on the scale in Table 1. This score is obtained based on the scores of the student answers. Complete answers corresponding to the content of the pictorial stories get a maximum score of 4. Reviewing in more detail, the lowest percentage (59%) and the lowest score (2.81) appear in the concept of "Storage of electrical energy in batteries". This question is understood by students in various perspectives. Student answers lead to the concept of energy storage occurring in solar panels (9 students), not batteries. This question is specific and is not the main concept of the pictorial stories. This fact is useful as a product improvement material, namely: improving the clarity of battery function and its position in solar panels.

Besides functioning to help students understand the general concepts of solar panels, these pictorial stories serve as means to develop creativity and imagination. The pictorial stories for children need to contain fresh information and new ideas for children so that they can stimulate imagination [11]. In this pictorial stories, information is presented differently from the Teacher and Student Books of the2013 Curriculum which are refered by students on a daily basis. There is additional information related to specific things in Science, such as electrons, holes, silicon, to the influence of energy from the sun on the charge. These concepts are not specifically introduced in their daily books so that they

can obtain new information. In addition, the pictorial stories also try to describe the actual process that students cannot see with their eyes directly; for example: the flow of electron movements from solar panel components. This abstract concept is tried to be concreted through a series of images so that they can help students imagine the processes that occur.

The pictorial stories are also developed with regard to the literacy rules. Literacy is the ability to access, understand, and use things intelligently through various activities, including: reading, seeing, listening, writing, and or speaking. Through literacy, students can improve their reading and understanding information in an analytical, critical, and reflective manner [12]. In addition, through literacy students can develop the ability to understand text, critical thinking, and process the communication skills creatively through activities responding to assessment textbooks. The growth of reading interest is important for the development of student literacy skills [17]. The pictorial stories developed by the researchers can foster students' interest in reading because they are colorful and accompanied by interesting illustrated images. Through illustrated images and story texts contained in the pictorial story prototype, students can develop the ability to comprehend reading. In the reflection section, students can develop the ability to process the information which has been creatively obtained. Therefore, the pictorial story prototype can be used as a means of literacy in supporting the School Literacy Movement

4. Conclusion

The research results in a pictorial story prototype focusing on the concept of processing solar thermal energy into electrical energy through solar panels. The general part of these pictorial stories is the introduction of the alternative energy meaning; functions, parts, and ways of how solar panels work; also, an invitation to use alternative energy. The pictorial stories obtain good quality (score 3.16 with a maximum score of 4) from the aspects of language, writing format, and concepts. The pictorial story improvement is carried out mainly on the aspect of the language by replacing and deleting words to simplify sentences. Based on the trial results, 85% of the students are able to understand the content of the pictorial stories with an average score for all answers is 3.58 (very good quality). This means that the content of the pictorial stories can be easily understood by students. Further improvements need to be made to the quality aspects of the content, including the clarity of energy storage which has been produced through solar panels.

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