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THE DEVELOPMENT OF SCIENTIFIC TEACHING MATERIALS BASED ON STEM-PjBL AS A CHANCE TO IMPROVE STUDENT'S CREATIVE THINKING ABILITY ON THE TOPIC OF ANALYZING OF LIGHT AND OPTICS

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Abstract

Teaching material is a learning media that can be employed for independent learning. However, the learning media based on the real problem, assembling STEM aspect, and using independent learning strategy have not much been developed. Based on the observation results in junior high school, students experience the distraction to comprehend the concept of light and optics. The understanding of the concept and language is the principle of creative thinking. Therefore, the purpose of the study is to develop and test the teaching material eligibility based on STEM-PjBL toward light and optics analysis so that it is moderate to improve the students' creative thinking. This study is a research development using the 4-D model by Thiagarajan that includes several stages; define, design, develop, and disseminate. This study solely reached the development stage. The feasibility test was carried out through validation media, material validation, and practical test. The finding of the research indicated that the teaching material developed is valid and eligible to use.

Keywords*: Teaching Material, STEM-PjBL, Creative Thinking, Light and Optic*

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INTRODUCTION

Natural Science is the study of natural phenomena through a scientific method. The results of science learning are in the form of scientific products (Hasbiyati, Sudiarti and Hikmah, 2019). This scientific product can be produced if students are active in the learning process and can recognize their own learning process to solve a problem (Apostol, 2017). By having the ability to recognize the learning process, students are expected to be able to apply and link learning in their lives (Andanawarih, 2019). To achieve this, science learning materials have been regulated in the 2013 education curriculum. One of the materials that needs to be studied is light and optics.

Light and optical matter is one of the materials that are closely related to life, starting from the properties of light, the process of forming images, the process of the eye being able to see (sense of sight) and the application of light concepts in the manufacture of optical instruments (Kemendikbud, 2017). Based on the description above, it is known that light and optics do not only study physics but also biology related to the sense of sight (Oktamagia, 2013). Given the importance of this material, it is necessary to have a lesson that can integrate these concepts. Physics-related problems can be solved if students are able to understand the concept. By understanding the concept, students' creative thinking skills will be stimulated so that it is easier to accept new concepts when faced with a problem (Trianggono, 2017).

The results of observations of field practice activities at SMP Negeri 23 Malang show that learning activities are still emphasized on the method of discussion and lectures, students only have a few opportunities to do practice. Learning is more focused on theory and conceptual understanding. At the time of the exam, the questions are usually not much different from the questions that have been discussed previously, but there are still many students who answer them wrong. From these observations, it means that students still have a lack of ability to understand the questions and concepts in these questions. Understanding the language of the questions is the basis of creative thinking, so that when students are faced with story questions it is hoped that students can read and translate the meaning of these questions (Arini, 2017).

The ability to think creatively is one of the abilities to be able to think higher, namely the ability to think in different ways. This thought process allows generating various possible answers when responding to a problem (Suryandari et al., 2016). The ability to think creatively is needed to keep up with the development of science and technology. The formation of creative individual skills and knowledge is one of the learning objectives in the 21st century (Mathiphatikul, Bongkotphet and Dangudom, 2019). The ability to think creatively is also an ability that is sought during a job interview (Piirto, 2011). Therefore, to keep up with the

development of science and technology, students need to be provided with appropriate learning and teaching materials.

Teaching materials have an important role because they help students in the learning process (Kusumam & Hasan, 2016). Science teaching materials in the 21st century are made by connecting science, environment, technology, and society. The material made should also be actual material about science and technology in society (Yuliati, 2013). To be able to develop students' creative thinking skills, teaching materials are needed to support the learning process. Science teaching materials generally provide principles, concepts, examples of problems and solutions, but they are still lacking in terms of facilitating students to connect with real problems in life (Yuliati, 2013). Activities that can improve creative thinking and suggest the 2013 curriculum are, for example, problem-based and project-based learning models (Meita, et al., 2018).

Project-based learning (PjBL) which is integrated with Science, Technology, Engineering, and Mathematic (STEM) can increase students' interest in learning. In this model, learning becomes more meaningful and can help students solve problems in the real world. By combining various scientific aspects, students become better prepared for a career in the future (Tseng et al., 2013). Project-based learning provides teachers with a road map for integrating the STEM approach. Such learning allows students to transfer their knowledge and skills in real-world problems. In addition, students are also invited to understand and solve problems related to life. This process is carried out through collaboration between students or in groups (Capraro, 2014).

STEM-PjBL learning is learning that aims to improve higher-order thinking skills. Learning is carried out by designing or modifying existing tools. These activities will make a significant contribution to creative thinking skills (Capraro & Corlu, 2013). The stages in PjBL-STEM-based learning help students get used to using mathematical skills, science experiments, utilizing technology and designing a product (Cooney & Bottoms, 2003).

The development of learning resources on the topic of light and optics has previously been carried out, namely through the development of project-based teaching materials. However, in this study, researchers still have difficulty in arranging appropriate learning activities so that they need to be corrected. In addition, the teaching materials are still limited to materials for optical instruments (Oktarinah, et al., 2016). Therefore it is necessary to develop project-based teaching materials that have appropriate learning steps. It would be better if the teaching materials were linked to STEM. Project-based learning with STEM will help students to link several scientific disciplines (Sanchez, 2019)

STEM-PjBL-based teaching materials were developed with the hope of making it easier for students to understand the material, cooperate in groups and improve students' creative thinking skills. Through these teaching materials, students are expected to be more sensitive to surrounding problems related to the material to be studied. Based on this explanation, the research was aimed at developing and testing the feasibility of STEM-PjBL-based science teaching materials as an opportunity to improve creative thinking skills on the topic of analyzing light and optics.

METHOD

This study uses a research and development method that aims to produce a product, test the feasibility and readability of the product. The model used is Thiagarajan's (1974) 4D model which consists of define, design, develop, and disseminate. This research was conducted only up to the development stage. Products developed in the form of teaching materials for teachers and students based on STEM-PjBL, especially on the topic of analyzing light and optics as an opportunity to improve students' creative thinking skills.

The instruments used were a validation questionnaire and a practicality questionnaire. Validation is carried out by material expert validators and media experts. After being declared valid and feasible by the validator, the next step was a practicality test by the teacher and students. The final data obtained is in the form of quantitative data using the Guttman scale and qualitative data in the form of comments and suggestions. The analysis technique uses descriptive analysis by calculating the average answer score for each aspect of the product (Arikunto, 2013). The criteria obtained will be used as a consideration in product development and improvement. The formula for calculating the average value is as follows.

$$P = \frac{f}{N}\ x\ 100\%$$

Description:
P = eligibility of teaching materials
f = Score of teaching materials
N = ideal scores
Sumber: Ridwan (2010)

In interpreting and concluding the data, the percentage of product eligibility can be used. Product eligibility is determined based on the criteria shown in Table 1.

Table 1. Teaching Material Eligibility Criteria

Interval (%)	Criteria
81-100	Very worthy
61-80	Worthy
41-60	Pretty worthy
21-40	Less worthy
0-20	Not worthy

Source: Ridwan (2010)

RESULTS AND DISCUSSION

The products of development research are in the form of STEM-PjBL-based teaching materials consisting of teacher books and student books on the topic of analyzing light and optics as an opportunity to improve the creative thinking skills of grade VIII students. This development research is an effort to produce learning media that can facilitate students to think creatively. The teaching materials developed consecutively consist of the components of the title of the teaching material (containing the cover of the teaching material), a foreword, a table of contents, a guide to using books, concept maps, student activities, bibliography and closings. The cover of the student book contains the title of the book, namely "Cahaya dan Optik berbasis PjBL-STEM untuk siswa kelas VIII semester 2, mengajak berpikir kreatif", the logo of Universitas Negeri Malang along with the identity of teaching materials authors. The cover display of teaching materials can be seen in Figure 1 below.

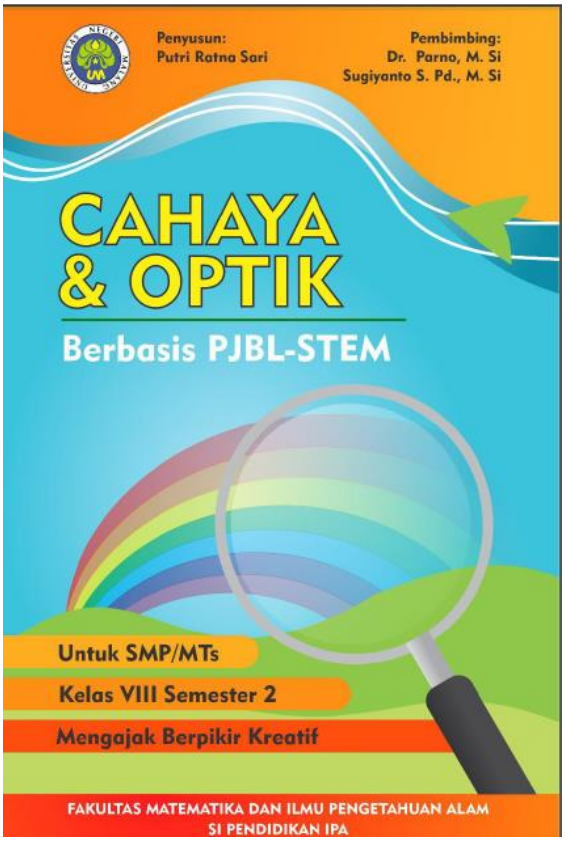

Figure 1. Cover Page of Teaching Materials

The preliminary activity in the form of apperception is displayed at the beginning of each section. In the core activity, 3 sections are presented which include (1) Properties, (2) Mirrors and Lenses, and (3) Eyes and optical instruments. Each section provides problems in daily life in the form of news articles. Through these news articles, students are expected to be able to understand the problems that occur and summarize important information that can be used as a basis for finding solutions. The product or project is a form of solution offered by students. The product is in the manufacturing process using the concepts of light and optics.

Teaching materials developed following the STEM-PjBL learning model with creative thinking abilities can be seen in Table 2.

Table 2. The link between PjBL-STEM and creative thinking skills

Syntax PjBL-STEM	Creative Thinking Indicators
Ayo Cari Tahu (Come on Find Out), represents the syntax of PjBL-STEM Identify Problems and Constraints, and aspects of STEM Science (S)	*Fluency*
Mari Menyelidiki (Let's Investigate), represents the syntax of PjBL-STEM Research, and aspects of STEM Science (S), technology (T), Engineering (E) and Math (M)	*Flexibility*
Mari Mencari Solusi (Let's Find a Solution), represents the Ideate PjBL-STEM syntax, and aspects of STEM Science (S)	*Fluency*
Ayo Menganalisis (Let's Analyze), represents the syntax of PjBL-STEM Analyze Idea, and aspects of STEM Science (S)	*Flexibility*
***Ayo Berkarya* (Come on work)**, represents the PjBL-STEM Build syntax, and aspects of STEM Engineering (E)	*Originality*
Ayo Mencoba Karyamu (Come on, try your work), represents the PjBL-STEM Test and Refine syntax, and aspects of STEM technology (T)	*Elaboration*
Ayo Mengevaluasi (Let's Evaluate), represents the PjBL-STEM Communicate and Reflect syntax, and aspects of STEM Math (M)	*Elaboration*

In addition to class activities, the teaching materials also provide simple practicum activities that can be done at home. This activity aims to make students better understand the concept of the material to be studied. In addition, to fulfill the opportunity to achieve the ability to think creatively, the teaching materials developed are equipped with creative thinking questions. In the teacher's book, there are learning steps and assessment instruments for creative thinking skills based on creative thinking questions.
The product feasibility test consists of a feasibility test for student books and teacher books carried out by a lecturer in the Science Education Study Program, Universitas Negeri Malang, which can be seen in Table 3.

Table 3. The Average Result of the Assessment of Teaching Materials

No.	Assessed aspects	Average	Percentage of Eligibility	Criteria
1.	Material eligibility	1.00	100%	Very worthy
2.	Suitability of PBL-STEM Stages with Creative Thinking Indicators	0.87	87%	Very worthy
3.	Compliance with STEM aspects	1.00	100%	Very worthy
4.	The correctness of the concept	1.00	100%	Very worthy
5.	The suitability of the assessment instrument with the book	1.00	100%	Very worthy
6.	Content eligibility	1.00	100%	Very worthy
7.	Design eligibility	1.00	100%	Very worthy
8.	Language eligibility	1.00	100%	Very worthy
	Average score of eligibility	0.98	98%	Very worthy

The results of the eligibility test of teaching materials showed an average percentage of eligibility of 98% with very worthy criteria. Based on these results, the development of STEM-PjBL-based teaching materials on the topic of analyzing light and optics can be processed at a later stage. The next stage is a readability test by teachers and students. The practicality test of teaching materials was carried out by three junior high schools / Madrasah Tsanawiyah science teachers and 10 junior high school students who had taken light and optics materials. In the practicality test for the teacher's book by the teacher, it was found that the

eligibility percentage was 94% with very worthy criteria. In the student book practicality test by students, the eligiblity percentage was 94% with very worthy criteria. The results of the readability test by the teacher can be seen in Table 4.

Table 4. Recapitulation of Practicality Test Results by the Teacher

No	Product Aspects	Percentage (%)	Eligibility
1.	Ease of use	92	Very worthy
2.	Learning instrument	87	Very worthy
3.	Student Activities	95	Very worthy
4.	The attractiveness of the book display	100	Very worthy
5.	Benefits	94	Very worthy
	Total	468	
	Average	94	

Based on quantitative data from the results of the teacher's book readability by the teacher, an average percentage of 94% was obtained with very feasible criteria, so that student books could be said to be very suitable for use. Learning devices have the lowest percentage because teachers are worried that the time used for learning is not enough. Teachers are also worried if students will find it difficult to make projects. Therefore, in the teaching materials each sub-chapter learning is carried out in two meetings and project development can be continued at home so that it saves more time. Then the highest percentage is obtained in the attractiveness of the presentation because the teaching material is equipped with a teacher's book guide for each meeting which is a simple description of the lesson plan.

Practicality tests were also carried out by students to determine the practicality of teaching materials for student learning. In the practicality test of student books by students, a percentage of 94% was obtained with very decent criteria. The results of the readability test by the teacher and students can be seen in Table 5.

Table 5. Recapitulation of Practicality Test Results by Students

No	Product Aspects	Percentage (%)	Eligibility
1.	Ease of use	99	Very worthy
2.	Student Activities	86	Very worthy
3.	The attractiveness of the book display	100	Very worthy
4.	Benefits	94	Very worthy
	Total	379	Very worthy
	Average	94	Very worthy

Based on quantitative data, the results of student book readability by students, an average percentage of 94% was obtained with very worthy criteria, so that student books can be said to be very suitable for use by students. In student activities, the lowest percentage was obtained because at several stages students did not understand the meaning of the indicators listed. Students can understand after being explained first. The highest percentage was obtained in the aspect of the attractiveness of the book presentation because the teaching materials were presented attractively. The images presented look interesting and are related to the material being discussed. So that in terms of appearance and content, students' books are considered practical, interesting and easy to understand.

CONCLUSION

This research produces STEM-PjBL-based teaching materials on the topic of analyzing light and optics as an opportunity to improve students' creative thinking skills. Based on the results of the feasibility validation, the teaching material received a percentage value of 98% with very feasible criteria. Meanwhile, based on the results of the practicality test, the teaching materials developed obtained a percentage of practicality for both teacher and student books by 94%. So that the teaching materials developed have the opportunity to improve creative thinking skills, practical and suitable for use.

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