Development of Science Teaching Materials Based on STEM: A Needs Analysis

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Abstract. Science learning with the STEM approach aims to prepare students to compete and be ready to work in their respective fields. The science learning process will run more optimally when maximizing all teaching materials that support students. The aim of this research is to analyze the need for the development of Class V science teaching materials. This research is a descriptive study conducted through observation, interviews, and distributing questionnaires to class V teachers and students of the Fatmawati Cluster, Batangan District. The findings of the study show that: 1) students do not understand the benefits of experimental activities they do in their daily life and tomorrow when they are adult 2) teaching materials do not integrate various science supporting disciplines. Based on the research data, it can be concluded that it is necessary to develop teaching materials in the form of STEM-based practicum manuals.

1. Introduction

21st century educational reform has become the most discussed topic in the world. 21st century learning aims to develop 21st century competences. Education is directed at real-world competences. Science education is an inevitable part of modern education. If we are to teach 21st century competence through a disciplinary educational approach, it is important to clarify the goals of education, which in our view should be centered on holistic individual coaching [1]. There are two challenges to learning in the 21st century, first, integrating pedagogy, technology and assessment. Second, the involvement of teachers, students and leaders as stakeholders [2].

Science and technology are inseparable parts of modern life. The development of science and technology can bring convenience and a new way of life, but on the other hand. Mastering science and technology is an important key to facing challenges in the future [3]. Society is needed to have certain abilities in order to be able to compete and live properly in the rapid development of science and technology. In the field of work, a person must have skills in science and mathematics, creativity, mastery of information and communication technology, and be able to solve complex problems [4]. The most important task for teachers is to help their students to build a solid foundation in science content, and gain an understanding of the ethical implications of science and the human context in which science occurs.

Science process skills are scientific knowledge that is used to develop students' abilities in solving learning problems, finding knowledge, understanding the environment with their concepts so that they can build their personality [5]. The relationship between material and its usefulness affects interest and attitudes towards science learning. Students' belief in the benefits of science has an effect on the careers they will live as well as conveying their identity to others [6]. when students' interest has grown, their self-confidence will increase and will ultimately affect the value of their assignments. The
Learning environment affects science learning attitudes. There are still many schools that have not provided space for student practicum activities [7].

Learning science in the right way will lead to student scientific literacy. Scientific literacy is individual scientific knowledge and skills to use knowledge to identify problems, to gain new knowledge, describe scientific phenomena, and make conclusions based on evidence related to science issues, accompanied by attitudes towards science [8]. Professional and pedagogical skills play an important role in science learning [9].

Analysis of teaching materials will significantly stimulate and advance science, and more strongly link it to advances in learning technology. Science learning is more focused on productivity and discovery. With the practical manual book, students will increase their motivation and change their learning method [10]. When the learning media is developed by each teacher, they feel more confident about its content. Teaching material is basically something that contains information and knowledge that users can learn. Broadly speaking, teaching materials consist of knowledge, skills, and attitudes that students must learn in order to achieve predetermined competencies. Teaching materials can be objects or people that can be used to facilitate the learning process [11]. Teaching materials serve to help or make it easier for students to understand the competencies that will be achieved.

Based on the opinions expressed above, teachers should have science teaching materials that can prepare students to face problems faced in everyday life. In addition, the teaching materials used must also be able to stimulate students' interest in creating technology based on the knowledge they already have to solve the problems they face.

The integration of various disciplines such as science, technology, engineering, and mathematics (STEM) cannot be separated in today's life. However, most elementary school teachers are still reluctant to integrate it into learning. This happened in elementary schools in the Fatmawati Cluster, Batangan District, Pati Regency. There are still many grade V teachers who only use guidebooks from the government without any development, let alone integration with other disciplines. Experimental activities carried out by students are only a routine activity in the content of science lessons. Students do not know what use the experimental activities they do in their daily life or tomorrow when they grow up. Teaching is primarily based on theoretical methods, not an activity-based teaching approach.

This results in a lack of student interest and motivation. Students have different levels of learning ability, as a result, they perceive and interpret knowledge differently [12]. There are no teaching materials that support students to learn science using STEM approach. This approach is able to create a cohesive learning system and because the four aspects of active learning are needed simultaneously to solve problems [13].

STEM integrated learning is believed to enable students to gain deeper knowledge through active exploration of challenges in real world problems. In the exploration process, high-level skills, namely creativity, critical thinking, and problem-solving skills will be developed. In an effort to solve problems, students will explore various resources and ask critical questions [14]. Guidelines for advancing science education based on STEM education related to effective information technology in all aspects including the behavior, skills and practices of adopting technology to solve learning management problems [12].

STEM education can help the next generation of students solve real-world problems by applying concepts across disciplines as well as capacities for critical thinking, collaboration, and creativity. Teachers need examples of STEM learning and supporting infrastructure [15]. STEM is a student learning experience that combines multiple disciplines (interdisciplinary, integrated, or trans-disciplinary approaches) and often includes project- or problem-based approaches related to authentic or real-world contexts Inherent in problems- and project-based learning is an opportunity for students growth of twenty-first century skills such as collaboration, critical thinking, creativity, accountability, persistence, and leadership [16].

The purpose of integrated STEM education is to become "a holistic approach that connects scientific disciplines so that learning becomes connected, focused, meaningful, and relevant to students) adding, efforts to combine STEM into one class are based on the linkages between subjects
and real world problems. The focus of STEM education must be to apply knowledge of mathematics, science and engineering, design and conduct experiments, analyze and interpret data, and communicate and collaborate with multidisciplinary teams [17].

Engineering design is the process that engineers use to solve engineering problems and to develop products. It also encapsulates the essence of the engineering profession. Using engineering design as a context for this problem is a natural way for students to learn through STEM integration. engineering in the practical application of scientific knowledge serves to solve everyday problems. The field of engineering in education is very diverse but sometimes not fully understood[18]

Science is a process that involves the skills to formulate problems, make observations, make assumptions, conduct experiments and draw conclusions from phenomena that occur in nature. Technology cannot be separated from computers. Computer assisted learning is very important to facilitate the learning process because it can impose a diversity of learning activities and encourage deep learning among students. Engineering is a science that integrates science, technology and mathematics. Technique-based learning is built on the idea that systematic structures, organized tools, appropriate resources, and real-world projects go hand in hand [19]. Mathematics is the study of patterns and relationships that are used as a language for knowledge, technology and engineering.

The aim of this research is to analyze the need for the development of STEM-based science teaching materials, the effects of heat on changes in temperature and the shape of class V objects. in science learning and its causes, the implementation of learning and the obstacles that occur and the use of teaching materials and their shortcomings. This series of analyzes is expected to provide an overview of the implementation of learning and its problems so that alternative solutions can be formulated and recommendations for the development of teaching materials that help the learning process if needed.

2. Research Method

This needs analysis includes analysis of the perceptions of students, teachers, and existing teaching materials. The subjects in this research is 7 grade V teachers and 110 grade V students of the Fatmawati Cluster, Batangan District, Pati Regency. The research data are collected through observation sheets of the implementation of learning, teacher interviews, documentation and questionnaires. The results of the needs analysis are used as the basis for formulating recommendations for developing STEM-based teaching materials. These recommendations cover at least the aspects of content, presentation, and language.

The stages of this research consisted of two stages. The first stage is to find problems and potentials, so that they can be used as a consideration to develop a product. Problem finding is done by using qualitative method with observation, interview, and documentation technique. Observations were made using an observation sheet which aims to identify curriculum documents, student portfolios, learning resources, practicum equipment, and evaluation of science learning. Interviews are conducted with students and teachers using interview guidelines which aim to identify the methods used in science learning; obstacles encountered in science learning; assessment of the learning resources used; and teacher responses to the development of teaching materials. Documentation is done to identify curriculum documents, student portfolios, science learning resources, practicum equipment, and evaluation. This first stage data analysis technique uses qualitative methods with the Miles and Huberman model, namely data reduction, data display, and conclusions. Data reduction is done by selecting the main things, focusing on the important things, and looking for patterns. Data display is done by presenting tables. Conclusions are stated based on valid evidence.

The second stage is data analysis based on the results of existing research to determine what products need to be developed in order to overcome the problem. Researchers conducted a study of existing research literature as a basis for compiling a questionnaire on student and teacher needs regarding the development of teaching materials. Questionnaires are arranged using the Guttman scale in order to get a firm answer to the problem being asked. The questionnaire was distributed to students and teachers in class V. The second stage of data analysis used quantitative quantitative methods with
descriptive statistical analysis, namely by describing or describing the collected data as it is without making conclusions. Data presentation is done with tables.

3. Result and Discussion

3.1 Observation Results

The 2013 curriculum documentation as the main guideline for determining the direction of learning, has not shown any integration of STEM in it. STEM education has not mastered many of them so there needs to be socialization to the parties concerned, namely teachers and school principals. The portfolio of learning outcomes shows that most of the teachers' students do not have products that have been produced during science learning that can be directly used in their daily lives. The majority of student portfolios contain reports of practicum results as listed in the student books from the government. In addition, most of these practicum reports have not used communication and information literacy. The learning resources used by the teacher came from the government recommended thematic book curriculum 2013. In addition, some teachers still use the 2006 curriculum for material enrichment. Not all schools have complete practicum tools and materials. In integrated practicum, STEM can use tools and materials that are available around students that are easily available. STEM learning will be more acceptable to all parties if it is based on local wisdom. Students will be able to develop their regional potential with STEM education.

3.2 Interview result

Interviews were conducted with 7 grade V teachers and 20 grade V students. Students were taken randomly from 8 elementary schools in the Fatmawati cluster.

| Aspects                      | Results of the interview                                                                 |
|------------------------------|--------------------------------------------------------------------------------------------|
| Learning methods             | Teachers often use demonstration methods in science learning.                                |
| Teaching materials           | The learning resources used by the teacher come from the thematic book curriculum 2013 recommended by the government. In addition, there are some teachers still using the 2006 curriculum science book for material enrichment. |
| Evaluation                   | Evaluation is used in the form of written and practical tests in the form of experimental reports sourced from thematic books. |
| Constraints                  | Teachers have difficulty delivering science material because the material contained in thematic books tends to repeat itself irregularly. |
| Integration with STEM        | Learning has not been integrated with STEM because there are no teaching materials as a guide. |
| Recommendations for science teaching materials | The expected teaching materials are teaching materials that contain material in order and in accordance with current developments. The textbook that will be developed is expected to contain practical guidelines that can be used directly in everyday life. |

From the table above, it is known that the teacher does not have a STEM learning manual. Teachers use the demonstration method more often. The material contained in student thematic books tends to repeat irregularly so that teachers still use the 2006 curriculum science book as additional material. Learning only focuses on activities contained in student thematic books. In terms of implementing the knowledge that has been acquired, students are not able to get the benefits that can be taken for their future work. The focus of the learning objectives is to get the maximum value.
3.3 Questionnaire Analysis Results
To get information about the product specifications desired by the students, researchers distributed questionnaires to 7 fifth grade teachers and 110 grade V students of the Fatmawati cluster. Based on the student assessment questionnaire on the implementation of learning by the teacher, some information was obtained. First, students and teachers want other companion books besides thematic books from the government to increase knowledge. Second, the teacher has not provided sufficient space for students to produce products that can be directly used in everyday life. Third, learning has not been integrated with STEM. The percentage of student needs can be seen in Figure 1.

![Figure 1. Student Needs Analysis Results of Analysis of Existing Teaching Materials](image)

From the figure above, it is known that students feel bored with learning. Saturation occurs because students do not know the benefits of the practicum activities being carried out. Practical activities only leave traces in the form of practicum reports as written in thematic books containing science applications. Students cannot use the results of the practicum for daily needs. Only a small proportion of teachers are able to integrate science, technology, engineering, and mathematics into one integrated unit in practicum activities carried out by students.

3.4 Documentation Result
Documentation is carried out to support the results of interviews, observations, and questionnaires. Documentation is carried out on curriculum documents, student portfolios, science teaching materials, practicum facilities, and evaluation of science learning.

![Figure 2. Curriculum document, portfolios student, and thematic teaching material](image)

The STEM education reform movement is driven by reports from various studies that show a shortage of candidates to fill STEM-oriented jobs. Most of the teachers do not understand STEM-oriented learning [20]. To overcome this problem, training on STEM zeal is necessary. The responsibility for the importance of STEM must involve parents, students, teachers, and business leaders [21].
Natural science practicum activities, which are supported by technical skills, open students' experiences about career life later. Problem-based project completion deepens students' understanding of 21st century skill processes (critical thinking, creative, collaboration, and communication) [22]. The STEM approach has a positive effect on student achievement [23], [24]. STEM-based teaching materials reconstruction supports students' scientific and technological literacy. The development of teaching materials that instill simple concepts is more acceptable to students [25].

STEM integrated education as an integrated learning between science, technology, engineering, and mathematics to develop student creativity through the process of solving problems in everyday life [20]. STEM education is an interdisciplinary approach to learning in which academic concepts are rigorous[16][20]. STEM education encourages students to make connections across STEM disciplines and as a result students acquire life-relevant skills [26]. STEM education also makes students better problem solvers, innovators, collaborative; improve students' self-control abilities, critical thinking skills, communication and self-regulation skills. These skills cannot be separated from the influence of teachers who believe in the importance of STEM in learning [17]. STEM includes strong pedagogical practice centered on student active learning [22]. STEM learning skills and knowledge are used simultaneously by learners.

4. Conclusion
Science education is an inevitable part of modern education. The relationship between material and its usefulness affects interest and attitudes towards science learning. STEM-based teaching materials provide guidelines for students and teachers to do practicum, which results can be immediately used in everyday life. This will raise students' awareness of the world of work they will live in in the future. Teaching materials to be developed need to pay attention to aspects of content, presentation, and language so that they are suitable for use.

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