The Effectiveness of Stem-Oriented Project and Mini-Research Teaching Materials in Improving Student Learning Outcomes at SMP 37 Medan

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Abstract. Several STEM-oriented project and mini research teaching materials created by undergraduate students were utilized in schools as a contribution of the campus to the school. This study aims to determine the effectiveness of STEM-oriented projects and mini-research teaching materials in improving the learning outcomes of science students at SMP Negeri 37 Medan. The research approach used in this study is a development research model which refers to Thiagarajan, the 4D model. The validation of the teaching materials was carried out by content-related experts, education experts and the science teacher. The effectiveness of the teaching materials was then explored in Grade 7 students of SMP Negeri 37 Medan by distributing pre-test and post-test as data for the analysis of N-gain calculations. The results showed that the teaching materials were very feasible as accordance to the answer of the content expert; feasible as stated by the education expert; and very feasible as mentioned by the science teacher. Additionally, the students’ responses were very good and the N-gain test result was obtained at 0.5 which is categorized within the “medium” category at the distribution stage. This indicated that the implementation of STEM-oriented project and mini research teaching materials by undergraduate science students is effective in improving the learning outcomes of Grade 7 students in SMP Negeri 37 Medan in the academic year of 2020/2021.

Keywords: Teaching Materials, STEM, Learning Outcomes

1. Introduction

Teaching materials are a set of tools which contain learning materials and methods to be integrated in classrooms in order to achieve the desired learning objectives. The use of teaching materials will be effective if used within the learning process[1]. Teaching material is one of the learning components that can affect learning process [2][3][4]. Science, Technology, Engineering, and Mathematics (STEM) teaching materials are essential in learning and teaching activities as it is an alternative solution for 21st century learning. The skills expected for the current learning objectives are creativity, critical thinking, collaboration, and communication, which can greatly help students in finding
innovative solutions to real problems and elaborate the solutions while also applying them in learning and teaching situations [5][6]. In addition, STEM-oriented teaching materials can improve scientific literacy skills [7][8] proceeded that STEM-oriented teaching materials can also be effectively implemented to cultivate critical thinking skills.

The implementation of the six KKNI tasks is carried out by undergraduate students and reflected by a team of lecturers who teach STEM courses in the Mathematics and Science Education (PIPA) study program at Universitas Negeri Medan. The program has been going well, especially on the project and mini research. The utilization of the project and mini research results as teaching materials can provide additional sources which are deemed useful for schools. Since the materials are produced by the respective campus, the university students who are responsible for carrying out the projects and mini research believe that the courses conducted related to the development of these teaching materials are beneficial.

The development of STEM-oriented teaching materials has not been widely developed in Indonesia. The research carried out is still at the stage of STEM-based learning strategies implementation [9][10]. The STEM-oriented teaching materials developed, which consisted of project and mini-research made by college science students, is expected to contribute in enhancing students’ 21st century skills, especially in Junior High Schools (SMP) [11].

2. Research Method
This research utilizes a development research model; namely the 4D model [12], which consists of several stages: 1) Define; 2) Design; 3) Develop; and 4) Disseminate. In the first stage, which is the Define stage, several analysis are made, such as analyzing the 2013 curriculum, examining student characteristics, analyzing concepts and learning objectives to be achieved. Then, in the Design stage, the basic competencies and indicators of competency achievement is formulated for the Grade 7 students. Then, the strategies which are used to organize the contents of the teaching materials are planned. After that, in the Develop stage, the teaching materials are validated by the content expert, education expert and the science teacher. At the last stage, which is the Disseminate stage, activities using the developed teaching materials are carried out in small groups of Grade 7 students at SMP Negeri 37 Medan.

The validation results are then calculated to find the level of feasibility using the formula adopted from [13].

$$P = \frac{\sum}{N} \times 100\%$$

Note:  
$\sum = \text{The sum of all scores}$  
$N = \text{The number of things}$

| Interval Percentage | Criteria          |
|---------------------|-------------------|
| $85\% \leq X \leq 100\%$ | Very Feasible    |
| $70\% \leq X \leq 85\%$ | Feasible         |
| $55\% \leq X \leq 70\%$ | Quite Feasible   |
| $40\% \leq X \leq 55\%$ | Less Feasible    |
| $25\% \leq X \leq 40\%$ | Very Less Feasible |
The equation to find the effectiveness of the teaching materials is adapted from Hake's theory relating to normalized gain, that is the difference between the posttest and pretest scores. According [14], the normalized gain value is formulated as follows:

\[ G = \frac{\text{post test score} - \text{pre test score}}{\text{Maximum score} - \text{pre test score}} \]

| g Value | Interpretation |
|---------|----------------|
| 0.7 < g < 1 | High |
| 0.3 ≤ g ≤ 0.7 | Low |
| 0 < g < 0.3 | Moderate |

3. Results and Discussion

3.1 The Defining Stage (Define)

The results of the curriculum analysis at SMPN 37 Medan explored that the teaching materials used were not STEM based, and the existing materials were not supported by recent technological innovations. The teaching materials utilized only consisted of a collection of subject materials and exercises which did not require student involvement in the teaching and learning process. Good teaching materials are handy for making learning activities more engaging, providing opportunities for students to learn independently while reducing dependence on the subject teacher, as well as providing convenience in learning competencies that must be mastered by students[15] [16]. The needs analysis showed the weaknesses of students in learning, such as asking, answering, and communication. The results of the Define stage illustrated that the teaching materials at SMPN 37 Medan did not support student-centered teaching and learning process as well as 21st century science learning.

3.2 The Designing Stage (Design)

At the Designing stage, the teaching materials applied the learning steps based on the Science, Technology, Engineering and Mathematics (STEM) approach which can be seen in Figure 1.

![Figure 1](image1.png)

(a) cover; (b) table of content

In the scientific process, students are instructed to carry out experimental activities, then discuss with their classmates to answer questions about static electricity which can be seen in Figure 2.
Figure 2. The scientific process

In the topic of technology and engineering as applications, students are asked to design a simple electroscope which can be seen in the below Figure 3.

Figure 3. Technology and engineering as applications

The mathematical components are carried out in the final step. Students are commanded to work on questions about static electricity. The cognitive and effective assessment sheets, which are in the form of activity rubrics, are included in each STEM component. STEM education, supporting students' scientific literacy. This scientific literacy is the basis of developing students' science process skills [17][18].

3.3 Development Stage (Develop)

STEM-oriented prototypes based on projects and mini-research carried out by college students are in the form of Draft 1 which was resulted from the design stage, then reviewed by subject lecturers, and the teaching materials were validated by content expert, education expert and science teacher at the development stage.
Table 3. Percentage of Content Expert Validation Results

| Rated Aspect                                      | Percentage Average | Criteria     |
|--------------------------------------------------|--------------------|--------------|
| Feasibility of Material Presentation             | 78%                | Feasible     |
| STEM Applied Material                             | 93.7%              | Very Feasible|
| Depth of Material related to Science and Technology | 88%                | Very Feasible|
| Average                                          | 86.5%              | Very Feasible|

The results of the content expert validation stated that the teaching material was very suitable for use in science learning, as it contained materials which were closely associated with students’ daily live activities [19][20]. To add, the materials which raise contextual themes in everyday life can improve students’ science and technology literacy [21].

Table 4. The Results of Education Expert Validation

| Rated Aspect                                      | Percentage Average | Criteria     |
|--------------------------------------------------|--------------------|--------------|
| Relevance of the materials to the 2013 curriculum | 75%                | Feasible     |
| STEM components                                  | 86%                | Very Feasible|
| Learning systematic                              | 84%                | Feasible     |
| Average                                          | 81.6%              | Feasible     |

The results of the education expert validation obtained that the teaching materials developed were feasible. STEM components that are developed systematically and consist of clear steps to make the teaching and learning process practical and ease students to interpret, analyze information, simplify and solve problems, create models, and explain abstract and concrete conceptual problems [22][23].

Table 5. Percentage of Science Teacher Validation Results

| Rated Aspect                  | Percentage Average | Criteria     |
|------------------------------|--------------------|--------------|
| Content Eligibility          | 85%                | Very Feasible|
| STEM Components              | 90%                | Very Feasible|
| The Use of Language          | 85%                | Very Feasible|
| Average                      | 86.6%              | Very Feasible|

The results of the science teacher validation indicated that the developed teaching materials are categorized as very feasible. STEM-based teaching materials which are integrated within science learning can help achieve 21st century competencies, namely creativity, critical thinking, collaboration, dan communication [24] [25].

Table 6. The Results of Student Responses to the Teaching Materials

| Rated Aspect                              | Percentage Average | Criteria     |
|-------------------------------------------|--------------------|--------------|
| Teaching Material Display                 | 96.42%             | Very Feasible|
| Presentation of Teaching Materials        | 89.28%             | Very Feasible|
| Learning Activities                       | 96.42%             | Very Feasible|
| Average                                   | 94.04%             | Very Feasible|
The student responses to the teaching materials used were very good. The students stated that the learning steps were clear, and the learning activities were carried out well. Similarly, a research conducted [26] found that the students were very interested in using STEM learning.

3.4 Disseminating Stage (Disseminate)
Group trials were conducted at SMP Negeri 37 Medan. This trial was done with twenty-seven students from Grade 7. Before conducting the dissemination, students were given a pre-test containing 30 multiple choice by college science student, and then the students were given a post test. The N-gain test result was 0.5 in the medium category. It showed that the implementation of the STEM-oriented project and mini research teaching materials is effective in improving the learning outcomes of science students in VII class of SMP Negeri 37 Medan.[27] [28].

4. Conclusion
The development of teaching materials with STEM-oriented project and mini-research by college science students has resulted that it is very feasible to be implemented as teaching materials by material expert; feasible by learning expert; and very feasible by science teacher. The student response was very good and the N-gain test results obtained were 0.5 with the medium category at the desimate stage, this shows that the implementation of STEM-oriented teaching materials for projects and mini-research by college science students is effective in improving the learning outcomes of science students in VII class of SMP Negeri 37 Medan in 2020/2021 academic year.

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