

Designing Material Learning for 5th Grade Elementary School using *Science, Technology, Engineering, and Mathematics (STEM)*

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ABSTRACT

This type of research uses research and development (R&D). This research aims to produce teaching materials based on Science, Technology, Engineering, And Mathematics (STEM) and determine the feasibility of teaching materials. This teaching material is created and developed to improve critical thinking skills on the theme of events in the lives of elementary school students on the material properties nature of things. Research and development in the field of education uses the ADDIE model. Technique data analysis was carried out quantitatively and qualitatively. Data collection instruments in the form of tests and notes. Assessment of teaching materials based on Science, Technology, Engineering, And Mathematics (STEM) according to the assessment of material experts and practitioners is feasible to use. Use of teaching-based materials STEM is feasible to improve critical thinking skills on the theme of events in the participant's life elementary school students on the material properties of objects. STEM- based teaching materials can not only be used in the research subject, but can be used as a source of learning and reference for schools. STEM- based teaching materials present material that is developmentally appropriate science and technology. The use of STEM- based teaching materials encourages educators to utilize technology to achieve understanding of thematic concepts to improve students' critical thinking skills to the maximum according to learning objectives.

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1. INTRODUCTION

The problems of Indonesian education in the 21st century are increasingly complex. First, ranking achievement Indonesia is in the international arena which is always on the bottom board (BPS & SSPKS, 2020; Hewi & Saleh, 2020; S. Utami, 2019). Second, the lack of references to STEM-based thematic learning (Parniati et al., 2021; Susanti, 2021). Third, one of the demands of the 2013 curriculum is giving birth generation who are skilled at critical thinking which is one of the 4c skills in the 21st century [6]. The 21st century 4c skills consist of: Critical Thinking And Problem Solving, Creativity, Communication Skills, and Ability to Work Collaboratively (Aisyah et al., 2021; Mukaromah et al., 2022; Panuntun, 2018; Shantia, 2021; Suwardi, 2021; Elva & Irawati, 2021).

Ritonga & Zulkarnaini (in Fithri et al., 2021) stated that one alternative for improve critical thinking skills is to use STEM-based learning. STEM is a learning approach between two or more STEM components or between one STEM components with other disciplines [14]. STEM according to English, & King (in Nurhidayat & Asikin, 2021) is an approach that helps students solve problems, be motivated in learning, show a more positive attitude, and increase achievement in math and science. Then STEM is a learning approach in education where Science, Technology, Engineering, and Mathematics are integrated in the learning process [16], [17]. Furthermore STEM is learning that integrates 4 components namely science, technology, engineering, and mathematics into the learning process (Bozkurt et al., 2019; Develaki, 2020; Felder, 2021; Hallström & Schönborn, 2019; Leung, 2020; Li et al., 2019,2020; Mcdonald, 2016; Özkul & Özden , 2020; Xie et al., 2015). From the understanding above it can be concluded that STEM is a learning approach by observing and testing (science) by utilizing available means (technology) using mastered science techniques (engineering) to solve a problem systematically (mathematics).

STEM learning will be more meaningful when presented with interesting media (Cape & Faiza in Fitria et al., 2021). One of the obstacles to educators in improving thinking skills critical due to limited teaching materials (Krissandi and Rusmawan in Nuryasana & Desiningrum, 2020). In fact, teaching materials as information providers are needed by educators and participants educated [30]. Canva is a media solution that has a wide variety of graphic designs, animations, templates and so on which can be used in the manufacture of teaching materials [28].

Based on the background of these problems, the author has an idea to develop research entitled “Designing Material Learning for 5th Grade Elementary School Using Science, Technology, Engineering, And Mathematics (STEM)”..

2. RESEARCH METHODS

This type of research uses research and development or Research and Development (R&D). Sugiyono (2018) in his book says R&D is the research method used to produce a product and test its effectiveness [31]. The development model used is ADDIE (Analyze, Design, Develop, Implement, and Evaluate), which can assist teachers in create an effective and systematic learning design [32]. The ADDIE model was developed by Dick and Carry (1996) is used to design learning development systems (Mulyatiningsih in Susanto & Ayuni, 2017). The researcher chose the ADDIE model because the process is simpler and more effective in research and development of teaching materials. In addition, this model was chosen because of its stages described a systematic approach to instructional development [34]. The research subject is 24 students in class Va SDN Petarangan as the experimental class and 26 students in class Vb SDN Petarangan as a control class. Data collection and data analysis were carried out in the research and this development is

a. Test

In this development research, the test was carried out twice, namely trial and error after learning (posttest). Tests are conducted to determine the strengthening of thinking skills critical grade 5 elementary school students after using teaching materials. Researcher first prepare grids, instrument questions, guidelines for scoring and assessment. Prepared test questions validated by experts before being used in the evaluation. Research design developed with the *Desain Control Group Preetest-Posttest* as follows:

Table 1 *Desain Control Group Preetest-Posttest*.

Group	<i>Preetest</i>	Treatment	<i>Posttest</i>
UJ	T		
E		X	P
K		-	P

Keterangan :

UJ : Trial Class

E : Experimental class

K : Control class

T : Pre test in Trial class

X: Treatment in the experimental class with STEM-based teaching materials.

P : Post test in the experimental class and control class

b. Nontes

Researchers used material expert validation questionnaires, educator responses and student responses. Questionnaire used is a closed questionnaire, the respondent can choose a predetermined answer [35]. But in the instrument, respondents have the right to provide comments and suggestions on teaching materials developed. The data that has been collected on the validation sheet will be converted into data quantitative according to the weight of the score with the following formula (Wibowo, 2019; Arikunto, 2013):

$$P = \frac{\text{acquisition scor}}{\text{maksimal scor}} \times 100\%$$

Table 2 Answer Criteria with a Likert Scale

Number	Criteria
5	For answers Strongly Agree (SS)
4	For answer Agree (S)
3	For answers Disagree (KS)
2	For answers Disagree (TS)
1	For answers Strongly Disagree (STS)

Source: Sugiono (2012) (in Puspa & Sudibya, 2016)

Steward & Cash defines an interview or interview as a communication process with predetermined goals, serious in nature, designed to create interactions involving question and answer activities (Hakim, 2013). Interviews with teachers and participants students are used as data collection for better improvement of teaching materials.

3. RESULT AND DISCUSSION

The process of research and development of STEM- based life event themes with material properties of objects that researchers will describe based on the stages of research and development of the ADDIE model, namely:

a. Analysis Stage

At this stage the researcher analyzed various aspects that had an effect on the preparation of the material teaching materials. The analysis was carried out before the development of teaching material products was carried out. Results that obtained from this analysis stage, namely:

- 1) Researchers on December 5, 2022 conducted an interview with Ms. Feti Fatimah, S.Pd as a class 5b teacher and Ms. Rasnawati, S.Pd as a senior teacher at SDN Petarangan for raises basic problems in learning. From the results of interviews with class teachers as an educator obtained data and information as follows: a) Learning design that done by the teacher already using a concept map; b) The learning process carried out by the teacher still centered on the lecture and discussion model; c) The teaching materials taught by the teacher are still centered on a class 5 integrated thematic series book; d) Learning media carried out by the teacher still limited to mathematics and rarely applied in thematic mupels; e) Instruments evaluation more often uses the type of multiple choice questions and short entries. Based on p Based on this, all respondents agreed that class V integrated thematic books were not enough as the only source of learning for pesdik. Educators/teachers must develop more effective teaching materials.
- 2) Interview students to find out their readiness to receive teaching materials STEM-based for strengthening critical thinking skills.

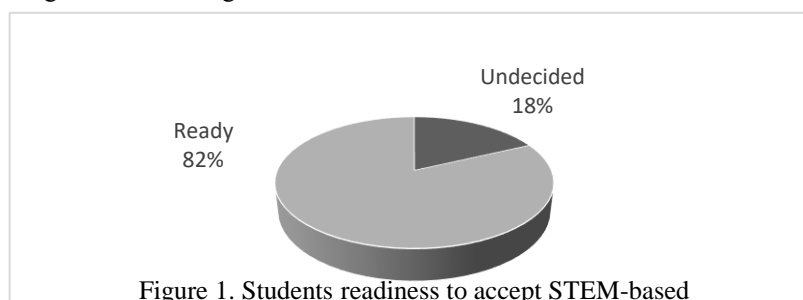


Figure 1. Students readiness to accept STEM-based

Interview activities with 50 students were carried out on December 5, 2022. From the results of the answers to the interview sheets by 5th grade elementary school students at the Dindik Regional Office Kemranjen obtained data and information as follows: 82% of Pedik is ready to receive materials STEM-based teaching materials and 18% of students are hesitant to accept STEM-based teaching materials.

b. Design Stage

At the design stage, the researcher designed the teaching material products to be made. Furthermore the researcher determines the development team that will later contribute to the manufacture of materials teach. The Development Team consists of supervisors, material experts and researchers. Researcher is a developer of teaching materials while supervising lecturers and material experts function as a giver of advice and input on the product of the current teaching material design developed by researchers. The following are some of the activities carried out in this stage:

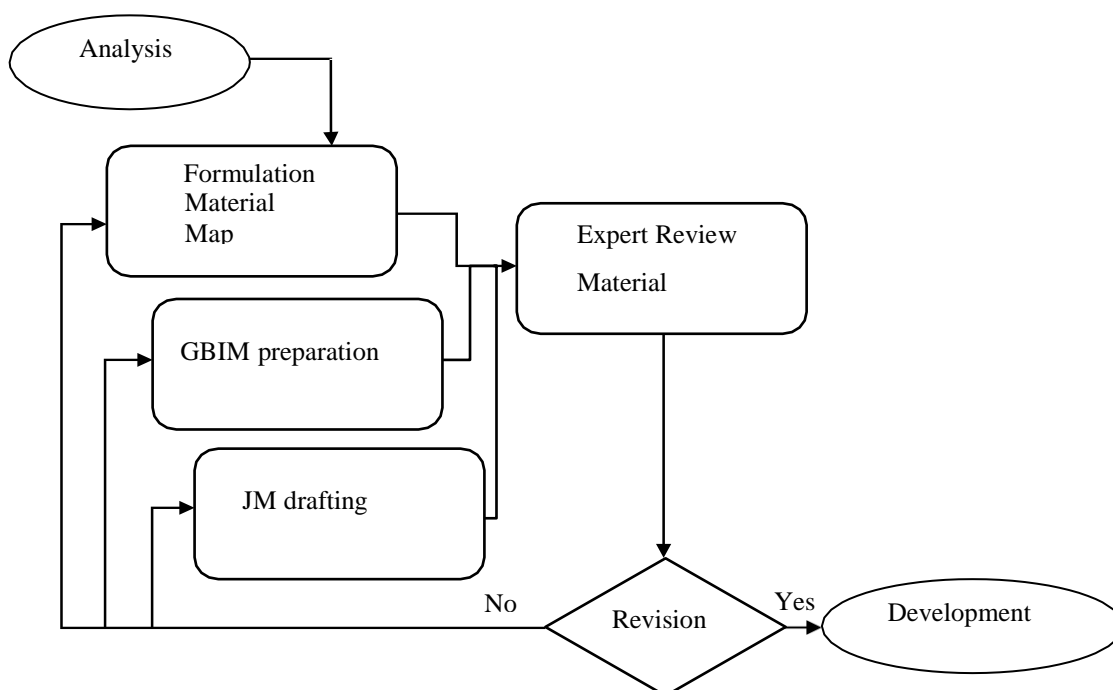


Figure 2. STEM-Based Teaching Material Planning Stage

The following is an explanation of the planning stages of STEM-based teaching materials:

- 1) The analysis stage is the initial stage in determining the teaching materials needed in STEM-based learning.
- 2) Formulation of material maps to map materials and types of learning media based STEM.
- 3) Preparation of an Outline of Media Content as Media Limits that will be applied in STEM-based learning.
- 4) Preparation of the material description as an explanation of the material that will be applied in the media STEM-based thematic.
- 5) Review of material experts as a form of validity of STEM-based learning media.
- 6) Revision of STEM-based learning.
- 7) Development of STEM-based learning.

The development of this research uses the *ADDIE* model which contains realization activities media product design in the form of teaching materials.

c. Development Stage

The draft of STEM- based teaching materials that have been developed is assessed by material experts and practitioners. The validity of these experts and practitioners focuses on the aspect quality components presentation, linguistic aspects and content/material aspects as material for further development.

1) Material Validation Results

Data that has been validated by material experts is presented in table 3 below.

Table 3. Recapitulation of Material Expert Validation Results

No.	Aspect	Number of questions	Amount Score	Average Score	Skor Maximum	Mark	Percentage
1	Content/Material	15	67,33	4,49	75	89,78	90%
	Criteria	Very valid, or usable without revision					
2	Language	3	13,33	4,44	15	88,89	89%
	Criteria	Very valid, or usable without revision					
3	Presentation	7	31,00	4,43	35	88,57	89%
	Criteria	Very valid, or usable without revision					
	Amount	25	111,66	4,45	125	89,33	89%
	Criteria	Very valid, or usable without revision					

Based on this table, it shows that the teaching materials developed by the researcher obtained a value of 89.33 or with a percentage of 89% with very valid criteria, or can be used without revision.

2) Trial 1

Research Trial 1 was conducted in a limited group of class V SD Negeri Manggan on Wednesday 1 March 2023 with 5 students. The results obtained are Test try 1 with an average result of 82.00% it can be said that the teaching material is valid and feasible as well very effective to apply in class. So that the research can proceed to trial 2 with minor repairs.

3) Trial 2

Research Trial 2 was conducted in a wider group in class V of SD Negeri Manggungan with the number of students 19 children. The results obtained are trial 2 with a value of 88.16% with the criteria that teaching materials are valid and feasible and very effective to be applied in class so that research can proceed to the implementation stage.

d. Implementation Stage

The results of the observer's assessment of STEM-based teaching material products with nature material Object properties can be seen in the following table:

Table 4. Recapitulation of Observer Assessment Results

No	Aspect	Observer I					Observer II				
		5	4	3	2	1	5	4	3	2	1
Preliminary Activity (Why So)											
1	Preliminary activities	✓					✓				
Core Activities (Oh I see)											
2	a. <i>Science</i>	✓					✓				
	b. <i>Technologi</i>		✓					✓			
	c. <i>Engineering</i>		✓						✓		
	d. <i>Mathematics</i>	✓						✓			
Closing Activity (So So)											
3	a. <i>Evaluasi</i>	✓					✓				
	b. <i>Refleksi</i>	✓					✓				
Total Scor		33					31				
Total Maximum Score		35					35				
Validity Assessment and Criteria		94,29					88,57				
Average value		91,43									

Based on the assessment made by the observer in table 4 shows that educators can carry out all STEM-based learning syntax very well.

e. Evaluation Stage

1) Teacher Response Questionnaire

The results of the teacher's response questionnaire to the development of teaching materials were obtained using the educator's response questionnaire in the following table:

Table 5. Teacher Response Validation Recapitulation

No	Teacher Response				Assessment and Criteria validity
	Score	Score Maximum	Mark	%	
1	Presentation Aspects				Very valid, or usable without revision
	37	40	92,50	93%	
2	Language Aspect				Very valid, or usable without revision
	38	40	95,00	95%	
3	Content/Material Aspect				Very valid, or usable without revision
	113	120	94,17	94%	
Total	188	200	92,0	94%	Very valid, or usable without revision

Keterangan :

- Presentation Aspects number 1 to number 4
- Language Aspect number 5 to number 8
- Content/Material Aspect number 9 to number 20

From the table it can be concluded that the average value of the teacher's response to the material teaching this STEM-based theme is 94.0% with very assessment and validity criteria valid, or can be used without revision.

2) Student Response Questionnaire

The results of the student response questionnaire on the development of teaching materials were obtained using the student response questionnaire in the following table:

Table 6. Student Response Validation Recapitulation

No	Student Response				Assessment and Criteria validity
	Score	Score Maximum	Mark	%	
1	Presentation Aspects				Very valid, or usable without revision
	184	200	92,00	92%	
2	Language Aspect				Very valid, or usable without revision
	181	200	90,50	91%	
3	Content/Material Aspect				Very valid, or usable without revision
	554	600	92,33	92%	
Total	919	1000	91,90	92%	Very valid, or usable without revision

Keterangan :

- Presentation Aspects number 1 to number 4
- Language Aspect number 5 to number 8
- Content/Material Aspect number 9 to number 20

From the table it can be concluded that the average value of student responses (pesdik) on this STEM-based theme teaching material of 91.9%, which means the value obtained get an assessment and very valid validity criteria, or can be used without revision. The highest value of the results of student responses, namely questions number 1, 4, 6, 7, 8, 11, 12, 13, 15, 17, 18, 19, and 20. While the lowest scores are at numbers 2, 3, 5, 9, 10, 14, and 16. Pg This shows that the use of teaching materials is the theme of events in life STEM-based is very well used to train participants' critical thinking skills educate.

4. CONCLUSIONS

The ADDIE model can be used as a guide in developing *STEM-based teaching materials*. Based on the assessment of material experts, and practitioners of *STEM*- based teaching materials are feasible to use in Learning Activities. This teaching material was created and developed to improve skills critical thinking on the theme of events in the lives of elementary school students on the material properties of objects *STEM*- based teaching materials can not only be used in research subjects, but can be used as a source of learning and reference for other educational units. *STEM*- based teaching materials present material in accordance with the development of science and technology. Use *STEM* based teaching materials encourage educators to utilize technology to achieve understanding of thematic concepts to improve students' critical thinking skills with maximum according to learning objectives.

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