

Development of Motion-Theme Teaching Materials for Science Learning in Junior High School

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Abstract—This study aims to produce motion theme teaching materials with webbed integration using the 4STMD method (Four-Step Teaching Materials Development). This development research involved 29 students of grade VII at junior high school. Data were collected using tests of validation, text comprehension, feasibility, concept understanding, and student response questionnaire. The data obtained were analysed by descriptive quantitative and inferential. The results show that the developed teaching materials are valid and highly structured. The texts of the teaching materials are easy to understand and have high feasibility. Based on the average N-gain, the students' understanding about the topic is in the middle category. In addition, the teaching materials receives very good responses from students.

Keywords: *teaching materials, science learning, theme of motion, understanding science subject matter*

I. INTRODUCTION

The success of a student in learning science depends on the ability of teachers to compile learning programs, the selection of methods, learning media, and learning resources. The teacher also needs to know the characteristics of students. Student characteristics like personality traits or interpersonal skills of students influence teachers' attitudes towards integration of effective methods [1,2]. The selection of methods, media, and appropriate learning resources will facilitate the teacher in achieving predetermined learning goals and achieving good learning outcomes.

The ability of students to understand science subject matter at the junior high school level is an implementation of the third Core Competency in the national curriculum. The national curriculum requires science learning be carried out in an integrated manner [3]. The implementation of integrated science learning with various learning approaches provides opportunities for students to gain holistic understanding. This is in line with the statement of Ayodele & Adegbite stated that the learning of Integrated Science requires various teaching approaches so that meaningful learning occurs [4]. Another factor that determines the effectiveness of learning is the availability of teaching materials.

Based on the results of an interview with a science teacher in Bogor, it was revealed that students had difficulty mastering

the science subject matter. The results of observations in grades VII, VIII, and IX show that science learning is still fragmented and uses books from several publishers that have not presented teaching materials in an integrated manner. The results of the study by Pursitasari show that the textbooks used in science learning in junior high schools have not presented integrated science subject matter, so it is necessary to develop integrated science teaching materials [5].

The development of science teaching materials has been carried out with the theme of pressure in everyday life [6], air [7], and environmental pollution [8]. In addition, the development of teaching materials based on scientific literacy and Chemirel igiiousa teaching materials has also been carried out [9,10]. The development of teaching materials are able to increase digital literacy [7], scientific literacy [8,9], and character and learning outcomes [10]. However, there was no teaching material on the theme of motion. Therefore, based on the need for a science teaching material, this study focused on development of teaching materials on the theme of motion with the type of integrated webbed to improve student learning outcomes.

II. METHODS

This study is a research and development with the Four Steps Teaching Material Development (4STMD) method. The stages are the selection, structuring, characterization, and didactic reduction (Figure 1). The development of teaching materials begins with the selection of concepts of the motion theme, after that determines the concepts that will be developed in motion teaching materials based on school books, basic physical books, and contextual events in the community. The results obtained at this stage are reviewed by an expert teacher. The next stage is to determine the characteristics of teaching materials and didactic reduction in order to obtain students' understanding of the teaching materials developed. The implementation teaching material carried out in one of the junior high school in Bogor.

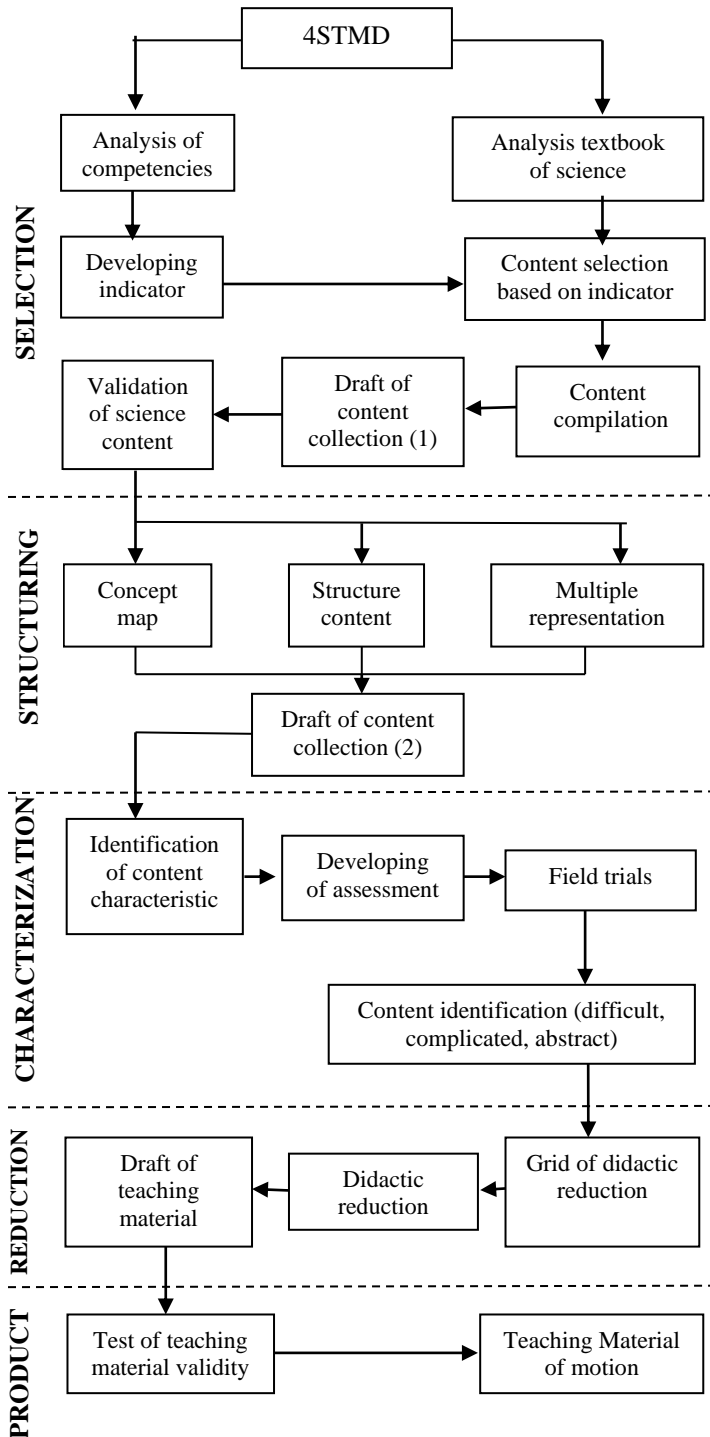


Fig. 1. Flowchart of teaching material development on motion themes [11].

Data were collected using validation sheets of expert and teacher, test of concept mastery, and test of book comprehension. The test of concept mastery consisting of 30 multiple choice questions with a reliability coefficient of 0.92. Data analysis was carried out at the development stage of

teaching materials using CVR. The minimum CVR value for a validator of five people is 0.736 [12]. Data from the implementation step were analyzed using descriptive statistics and data were obtained from the questionnaire was calculated on the percentage of each statement.

III. RESULTS AND DISCUSSION

The teaching materials on motion theme was developed using the 4STMD method. This method consists of several stages that were carried out in processing, compiling, and presenting teaching materials so that they are ready to be studied by students as independent learners [13]. The stages have been carried out in developing book of motion theme with 4STMD method include selection, structuring, characterization, and didactic.

A. Selection Stage

Based on the analysis of basic competencies in the national curriculum that correlate with the motion theme, there was six basic competencies, of which the indicators were derived from (Table 1).

TABLE I. FORMULATION OF BASIC COMPETENCY INDICATORS

Basic Competency	Indicators
3.1 Analysing motion in living things, the motion system in humans, and efforts to maintain the health of the motion system	1. Analysing of motion in living things 2. Understanding the difference between active and passive motion
4.1 Presenting work on various disorders of the motion system, as well as efforts to maintain the health of the human motion system	3. Analysing the effect of force on the motion of living thing 4. Analysing the types of disturbances that can occur in the locomotors 5. Designing a poster about various disorders of the motion system, as well as efforts to maintain the health
3.2 Analysing straight motion, the effect of force on Newton's laws-based motion, and its application to the motion of objects and motion of living things	6. Analysing the difference in regular straight motion and straight changing irregular motion 7. Analysing the effect of force on the motion of objects using Newton's law
4.2. Present the results of the force of motion	8. Doing practicum about the influence of force on the motion of object
3.11 Analysing the solar system, the rotation and revolution of the earth and moon, and their impact on life on earth	9. Analysing the solar system 10. Analyse the application of Kepler's law to the movement of planets in the solar system
4.11 Present work on the effects of the rotation and revolution of the earth and the moon on life on earth, based on observations or searches of various sources of information	11. Make a mind mapping about the impact of the rotation and revolution of the earth and the moon for life on earth

Competencies were taken in the selection phase consist of six basic competencies that are developed into 11 indicators. Concept description is developed based on indicators. Concept descriptions are obtained from several sources such as the Qur'an, textbooks, and newspapers. The results obtained at the selection stage are the suitability of the indicators with the basic competencies (Table 2). Table 2 shows the average CVR for indicators 1 to 11 of 1 (greater than 0.736). It means that all indicators entered the selection stage are get a valid category.

TABLE II. VALIDATION OF CONFORMITY OF INDICATORS WITH BASIC COMPETENCIES

Indicator	CVR	Decision
1. Analysing of motion in living things	1	Valid
2. Understanding the difference between active and passive motion	1	Valid
3. Analysing the effect of force on the motion of living thing	1	Valid
4. Analysing the types of disturbances that can occur in the locomotors	1	Valid
5. Designing a poster about various disorders of the motion system, as well as efforts to maintain the heath	1	Valid
6. Analysing the difference in regular straight motion and straight changing irregular motion	1	Valid
7. Analysing the effect of force on the motion of objects using Newton's law	1	Valid
8. Doing practicum about the influence of force on the motion of object	1	Valid
9. Analysing the solar system	1	Valid
10. Analyse the application of Kepler's law to the movement of planets in the solar system	1	Valid
11. Make a mind mapping about the impact of the rotation and revolution of the earth and the moon for life on earth	1	Valid

B. Structuring Stage

At this stage, the concept description is prepared by scientific aspects-based with considering didactic elements and cognitive aspects. Teaching materials are arranged using multiple representations, namely the macroscopic, sub microscopic and symbolic levels. Representation is a method used to describe, represent or symbolize something in a way [14]. Multiple representations present the same concepts in different forms such as pictures, graphics, and mathematics [15]. The result of expert judgments at the stage of structuring about the suitability of the concept, the macro structure, and multiple representations of matter on the theme of motion shown in Table 3.

TABLE III. EXPERT JUDGMENT ON STRUCTURING

Structuring	Expert judgment (%)	Grade category
Concept maps	100	Very suitable
Macro structure	100	Very suitable
Multiple Representation	100	Very suitable

Table 3 shows the structuring stages of concept maps, macro structures, and multiple representations, of which all

stages have a validation value of 100%. It can be concluded that all three stages have very appropriate value categories. Representation in the form of pictures or text must be included in the developing of textbooks for effective communication [16]. According to Adadan [17] a multiple representation is effective to build students' understanding of the content knowledge.

C. Characterization Stage

The teaching materials should be characterised so that teaching materials that are categorized as difficult can be processed and arranged specifically according to the characteristics of the concept [13]. The teacher can choose the right learning strategy for each learning material. The main focus in the characterization stage is to determine level difficulty of the concepts contained in the draft teaching materials. The stage was tested to 29 students. The characteristic of the concept in question is the difficulty level of the text which is an explanation of the concept. Didactic principles must be used as a guide in delivering material, from simple to complex, from easy to difficult, and from concrete to abstract. The results of the understanding test of the teaching material on the theme of motion are shown in Table 4.

From the results of the characterization test in Table 4, it can be conclude that the text no. 12 and 14 concerning Kepler's law as well as the synodic and Cideric months have a high degree of difficulty. Based on this, it is necessary to reduce the difficulty level of the concepts

TABLE IV. STUDENT DIFFICULTY LEVEL OF CONCEPT IN MOTION THEME

Text No.	Concept	Difficulty level	Decision
1	Components in the human motion system	Easy	Used
2	Active and passive motion in living things	Easy	Used
3	Animal movements on land, water and air	Easy	Used
4	Thrust against motion in swimming sports	Easy	Used
5	Trust against the motion of uterine muscle contractions in normal labour	Easy	Used
6	Disorders of the motion system in humans	Easy	Used
7	Force and motion	Easy	Used
8	GLB and GLBB	Easy	Used
9	Parabolic motion in basketball	Easy	Used
10	Circular motion on the roller coaster	Easy	Used
11	Solar system	Easy	Used
12	Kepler Law	Difficult	Reduced
13	Earth's rotation and revolution	Easy	Used
14	Synodic and cideric month	Difficult	Reduced
15	Calendar system	Easy	Used

D. Reduction Stage

The reduction stage is the final stage of developing teaching materials in the 4STMD method. This stage aims to reduce the level of difficulty of teaching materials. The process of reduction in teaching materials is done by considering

scientific and psychological aspects so that teaching materials that have been developed can be understood by students easily. According to Gusfarina, didactic reduction is carried out in several ways including the use of (1) explanations in the form of drawings, symbols, sketches and experiments, (2) analogies, and (3) levels of historical development, generalizations, and particularization [12].

One of the difficult concepts identified from the characterization process is the Synodic and the Cideric Month. The type of didactic reduction used in the example is the use of explanations in the form of images. The use of explanations in the form of images is needed in studying science. Science subjects often involve languages that are difficult to understand, so the existence of appropriate graphics on teaching materials will greatly help students to understand reading in the text [18].

E. Feasibility of Motion Theme Teaching Materials Using the 4STMD Method

The next stage is the feasibility test of teaching materials conducted by 8 science teachers and 2 science education lecturers. The feasibility test of teaching materials aims to determine the feasibility of teaching materials which include aspects of the feasibility of the content, language, presentation, and graphics. Product development of motion theme teaching materials in the form of this book is given to teachers to see the level of feasibility of teaching materials. According to the National Education Standards Agency, quality textbooks are required to fulfil four elements of eligibility, namely the appropriateness of content, language, presentation, and the graphics. The assessment of the feasibility of teaching materials refers to the instrument worthiness of teaching materials developed by BNSP. Overall (out of ten evaluators) the feasibility of science teaching materials on the theme of motion has an average of 97% with very good criteria (Table 5).

TABLE V. FEASIBILITY OF MOTION THEME TEACHING MATERIALS

Aspect	Percentage (%)
Content eligibility	96
Linguistic	99
Presentation	96
Graphical	97
Mean	97 (Very good)

Based on the Table 5, it can be seen that the science teaching materials on the theme of motion which have been assessed by teachers and lecturers have excellent eligibility. Science teaching materials on the theme of motion meet the standards of eligibility in terms of content, language, presentation, and graphics. Teaching materials that meet the standard of eligibility can achieve four main objectives of making teaching materials, including helping students learn something, providing various types of instructional materials, making it easier for students to learn something, and making learning activities become more interesting [19].

F. Implementation

The developed teaching material was then studied by students of one of junior high school in Bogor. The results show that the understanding of the concept of students has increased after using the developed teaching materials (Table 6) with an N-gain of 47.5%. The relative contribution of visual, auditory and kinaesthetic learning styles to student achievement is 34.8% with the relative contribution of each learning style to learning achievement is visual learning style 26.4%, auditory learning style 24.2%, and style kinaesthetic learning 26.2% [20]. This shows the development of teaching and learning materials must also pay attention to student learning styles [21].

TABLE VI. CONCEPTS UNDERSTANDING OF STUDENTS

Description	Pre-test score	Post test score
Highest	60	86
Lowest	16	45
Mean	41	69
Standard deviation	10.9	9.7
N-gain of mean	47.5 (middle category)	

Teaching material of motion theme also contains basic competencies, indicators, concept maps, learning objectives, material descriptions, student worksheets, discussion sheets, scientist figures, project assignments, sample questions, material summaries, and competency tests, making it easier for students to learn them. Teaching materials also meet technical aspects including user friendly, adaptive, self-instructional, and attractive appearance. The results of student responses to teaching materials are listed in Table 7.

TABLE VII. STUDENT RESPONSES TO TEACHING MATERIALS

No.	Statement Items	Student response (%)
1	The material in teaching materials is clear and easy to understand	92.2
2	Teaching materials have an interesting appearance to be learned	95.7
3	The images contained in teaching materials are in accordance with the theme of motion.	91.4
4	The terms contained in teaching material are easy to understand	86.2
5	The use of the language presented in teaching materials is easy to understand	87.9
6	The teaching material can improve science learning outcomes	81.9
7	The use of writing colors and images contained in interesting teaching materials.	90.5
8	This teaching material can help me to find out insights related to the theme of motion.	84.5
9	made me able to self-directed learning	87.1
10	By using this teaching material I can find out the phenomenon of science in everyday life.	89.7
Mean		88.7

Table 7 shows that students gave very good responses to the teaching materials of the motion-theme with an average of 88.7%. Thus the teaching material developed has been valid

and fulfilled the aspects of material adequacy, linguistic, presentation, and graphics.

IV. CONCLUSION

It can be concluded that developed teaching materials on the subject of motion had valid categories, highly structured, easy to understand and having a very good feasibility. Based on the student's average N-gain, the teaching materials was in the middle category and received a very good response from students.

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