Developing high school physics teaching materials through 7E learning cycle model

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Abstract. Research has been conducted which aims to describe the feasibility of high school physics teaching materials through the 7E learning cycle model. The feasibility of teaching materials is evaluated from the validity of teaching materials, the practicality of teaching materials, the effectiveness of teaching materials, and the achievement of science process skills. This research is a research and development based on the Dick & Carey development model. The subjects of this research are 30 students of science class in one of the high schools in Banjarmasin. The instruments of this study are; the validation sheet of teaching materials, the implementation sheet of the lesson plan, the science process skill observation sheet, and the student learning outcomes test. The results showed that the teaching materials are categorized as good, the practicality of the teaching materials categorized as very practical, the effectiveness of the teaching materials included in the medium category, and the achievement of science process skills categorized as quite good. It was concluded that the high school physics teaching material on straight motion material through the 7E learning cycle model model developed is suitable to use in learning.

1. Introduction
Physics is part of science that is related to natural phenomena, and its learning is a process of discovery. This indicates that physics learning should emphasize student-centered learning and mastery of some information for students [1].

Based on the observation in one of the high schools in Banjarmasin, teachers only use one source of teaching materials, like books from publishers. The learning methods used by teachers listed in the lesson plan are still conventional. Teachers use the lecture method in the learning process, and students rarely do practical activities. When presenting material, the teacher only slightly relates learning to problems in daily life. The unavailability of student worksheets for students cause the for students' science process Skills are not trained.

Teacher's habit of presenting material from one source is considered dangerous because students are forced to understand something from just one point of view [2]. The solution to the problem above is the teacher needs to make improvements to the teaching materials used in the physics learning process. At the development stage of teaching materials, the compatibility of existing problems is needed with the combined learning model. Teaching materials are materials used to assist teachers in carrying out learning activities [3]. Teaching materials are tools and media for students in gaining learning experiences [4]. The types of teaching materials include: (1) visual teaching materials such as...
printed and non-printed teaching materials; (2) audio teaching materials; (3) audiovisual teaching materials; and (4) interactive multimedia teaching materials [5].

In addition to the use of teaching materials, the learning process that is centered on students in the learning process is also very important to be applied in physics learning. One of the learning models centered on students is learning cycle model. Karplus and Thier in 1967 defined the learning cycle as a learning model that centered on learning participant [6]. The learning cycle initially consisted of exploration phases, introduction of concepts, and application of concepts and Lawson modified the terms by expressing phases in the learning cycle, namely exploration, explanation, and elaboration/extension, known as the 3E learning cycle [7]. The 3E learning cycle model was developed into 5E by adding two new phases that add engage before explore and evaluate at the end of the phase [7]. The 7E learning cycle model was then developed by Eisenkraft in 2003 into seven stages of learning, namely: elicit (bringing students initial knowledge), engage (engaging students), explore (conducting investigations), explain (explaining the results of investigations), elaborate (describing/ applying ), evaluate (evaluate learning), and extend (link material in everyday life) [8].

Based the background, teaching materials need to be developed through the learning 7E learning cycle model in physics learning. Therefore, the purpose of this study is to describe the feasibility of teaching materials through the 7E learning cycle model on straight-motion material. Teaching materials used in this research development are printed teaching materials such as lesson plans, teaching materials, students’ worksheets, learning outcomes tests, and observation sheets of science process skills. It is hoped that through this research, teaching materials which are suitable for the high school physics learning process will be obtained through the 7E learning cycle model.

2. Method

The research conducted is research and development. Research and development carried out is the development of teaching materials in straight motion material through the 7E learning cycle model. The stages in this study use the Dick and Carey model with the stages of identifying learning objectives, analyzing learning, identifying student characteristics, formulating learning performance goals, developing criteria reference test items, selecting and developing learning strategies, developing teaching materials, designing and conducting formative evaluations, revising learning, and conducting classroom trials.

Research on the development of these teaching materials was carried out on tenth grade of science class students in one of the state high schools in Banjarmasin with 30 research subjects. The object of this research is the feasibility of teaching materials seen from the validity of teaching materials, the practicality of teaching materials, the effectiveness of teaching materials applying the 7E learning cycle model, and the achievement of students' science process skills.

The validation of teaching materials was carried out by two validators from academics and practitioners. The results of the validity calculation use the average score (X̅) [9]. The mean score is adjusted to the assessment criteria as in Table 1 [9].

| Interval         | Category   |
|------------------|------------|
| x > 3.40         | Very Good  |
| 2.80 < x ≤ 3.40  | Good       |
| 2.20 < x ≤ 2.80  | Quite Good |
| 1.60 < x ≤ 2.20  | Poor       |
| x ≤ 1.60         | Very Poor  |

The reliability of teaching materials was calculated using the Cronbach alpha equation, and the criteria are shown in Table 2 [10].

| Resulted Reliability | Criteria |
|----------------------|----------|
| 0.80 – 1.00          | Very High|
The practicality of teaching materials can be seen from the implementation of lesson plans that were measured using percentage techniques and the practical criteria can be seen in Table 3 [9].

| Implementation Percentage of Lesson Plan (%) | Practicality Category |
|---------------------------------------------|-----------------------|
| 81-100                                      | Very Practical        |
| 61-80                                       | Practical             |
| 41-60                                       | Quite Practical       |
| 21-40                                       | Poorly Practical      |
| 0-20                                        | Not Practical         |

The effectiveness of teaching materials is seen from the test of student learning outcomes. Average pretest and posttest scores were calculated using the N-gain <g> equation and the effectiveness criteria can be seen in Table 4 [11].

| N-gain <g> Interval | Criteria  |
|---------------------|-----------|
| <g> > 0.7           | High      |
| 0.3 < <g> < 0.7     | Intermediate |
| <g> < 0.3           | Low       |

The science process skills observed in this study are identifying variables, conducting experiments, communicating / reporting results, and summarizing the results measured through the average score obtained from the observation sheet of science process skills by two observers. The criteria for achieving science process skills are shown in Table 5 [9].

| Interval | Category  |
|----------|-----------|
| x > 3.40 | Very Good |
| 2.80 < x ≤ 3.40 | Good |
| 2.20 < x ≤ 2.80 | Quite Good |
| 1.60 < x ≤ 2.20 | Bad |
| x ≤ 1.60 | Very Bad |

3. Results and Discussion

3.1. Teaching Material Development

The teaching materials developed can be used to support the process of teaching and learning activities that are by the characteristics of students and the characteristics of the subject of straight motion for high school students in the tenth grade. Teaching material is developed through the 7E Learning Cycle model. The teaching material developed has been designed as whole and systematically to achieve the objectives of the students’ competencies that have been formulated. The teaching material developed is a printed teaching material that consists of a lesson plan, teaching material, student worksheets, and learning outcomes test, and observation sheets of science process skills. The development of teaching materials is carried out based on the criteria of [12] development of teaching materials in general, which includes the component of the feasibility of the content, the linguistic component, the presentation component, and the graphic component.
3.2. Teaching Materials Validation Result

3.2.1. Teaching Materials Validation Result

The validation of teaching materials is carried out according to the aspects of content, presentation methods, completeness, physical, language, illustrations, and accuracy. The results of the validation of the teaching material are shown in Table 6 with a very good category and a very high category of reliability.

| Table 6. Teaching Materials Validation Result |
|-----------------|--------|--------|
| Aspect           | Score  | Category |
| Content          | 3.38   | Good    |
| Presentation Method | 3.25   | Good    |
| Completeness     | 3.33   | Good    |
| Physical         | 3.63   | Very Good |
| Language         | 3.50   | Very Good |
| Illustration     | 3.25   | Good    |
| Accuracy         | 3.50   | Very Good |
| Mean of Validity | 3.41   | Very Good |
| Reliability      | 0.85   | Very High|

The validity of teaching materials, in addition, to containing the principle of suitability of learning materials, must have consistency and adequacy [12]. For the elaboration of the materials to be relevant to the intended purpose, it is necessary to pay attention to the selection criteria like teaching materials must be valid, useful, attractive, consistency, and adequate. A good teaching material consists of titles, learning instructions for students and teachers, competencies to be achieved, supporting information, exercises, student worksheets, and assessments [13].

3.2.2. Lesson Plan Validity

Lesson plan validity based on the criteria of the lesson plan format, language and contents as shown in table 7. The results of the validation of the three lesson plans developed were categorized as very good and the reliability was categorized as very high. Lesson plan validity is in accordance with the characteristics of the lesson plan, namely: (1) there is a learning process activity; (2) learning steps are arranged systematically [14].

| Table 7. Validity Result of Lesson Plan Implementation |
|-----------------|--------|--------|
| Aspect           | Score  | Category |
| Format           | 3.50   | Very Good |
| Language         | 3.50   | Very Good |
| Content          | 3.60   | Very Good |
| Validity Mean    | 3.53   | Very Good |
| Reliability      | 0.98   | Very High |

3.2.3. Learning Outcomes Test Validity

The results of the validation of the Learning Outcomes Test are; there are seven valid questions with minor revisions, one valid question with a revision because it is not in accordance with the learning objectives, and two questions are revised because of picture errors and the addition of phenomena to the questions. The results of learning outcomes test validation on aspects of general construction are in a good category with very high category of reliability.

Learning outcomes test is valid if it can measure the learning outcomes of students after going through the learning process within a certain time. Learning outcomes test can be stated as a good test if it has four characteristics such as; valid, reliable, objective and practical [15]. The most important aspect of validity for learning outcome tests is content validity. Content validity is a measure related to students' mastery in answering the learning outcomes tests. How to find out the level of validity of the test contents, expert judgment is needed [15].
3.2.4. Students Worksheet Validity

Students’ worksheet validation includes format, language, and content. The validation results are shown in Table 8 with good criteria and very high reliability.

| Aspect         | Score | Category |
|----------------|-------|----------|
| Format         | 3.25  | Good     |
| Language       | 3.16  | Good     |
| Content        | 3.36  | Good     |
| Overall Validity| 3.28  | Good     |
| Reliability    | 0.87  | Very High|

Students worksheet that was developed follows the characteristics of students worksheet according to Rustaman [16]: (1) contains all the instructions required by students, (2) instructions are written in short sentences, (3) there are questions that must be filled by students, (4) there is a blank space to write answers, and (5) provide notes for students on what students have done. The developed students worksheet can be used in class trials after minor revisions are made. A good student’s worksheet has didactic requirements, construction requirements, and technical requirements [17].

3.2.5. Observation Sheets Validity

The observation sheet is validated based on format, language and writing, content, and benefits. The results of the validation are shown in Table 9 in the very good category and the reliability of the category is very high.

| General Construction | Score | Category |
|----------------------|-------|----------|
| Format               | 3.50  | Very Good|
| Language and Writing | 3.00  | Good     |
| Content              | 3.90  | Very Good|
| Benefits             | 3.50  | Very Good|
| Validity Mean        | 3.48  | Very Good|
| Reliability          | 0.87  | Very High|

An observation sheet is a measure of students' scientific skills in conducting scientific investigations [18]. The observation sheet developed in this study is the performance evaluation sheet. Considerations in performance appraisal are: (1) there are activities to be undertaken by students, (2) accuracy of aspects of activities undertaken by students, (3) certain abilities possessed by students, (4) only abilities that are observed which is used as an evaluation, (5) capability assessment is carried out sequentially [19].

3.3. Classroom Trial Results

3.3.1. Teaching Materials Practicality

The practicality of teaching materials is measured from the results of class trials by observing the implementation of the learning steps in the lesson plan during the learning process [20]. Observations were carried out at three meetings and the results of observations are shown in Table 10. The results show that teaching materials developed are categorized as practical and can be applied in learning.

The practicality of teaching materials can be seen from whether or not the product can be applied [21]. Teaching materials developed used the 7E learning cycle model. The advantages of the 7E learning cycle are: (1) teachers can choose more effective learning strategies based on the results of students' initial knowledge disclosure; (2) students are moved to recall the subject matter they have
learned previously; (3) students become more active and aroused by their curiosity; (4) students will experience discovery learning processes, so the concepts learned will become more meaningful and durable; (5) higher-level thinking skills (critical thinking and creative thinking) students will be accommodated in the learning process; (6) students will have better scientific communication skills; (7) students' understanding and mastery of concepts will be very strong and the knowledge more useful [22].

Table 10. Observation Result of The Implementation of Teaching Materials from Three Meetings

| Learning Stages | Whole Meeting |
|-----------------|---------------|
| Category        |               |
| Implementation Mean Score (%) | Category |
| I               | 100.00        | Very Practical |
| II              | 95.83         | Very Practical |
| III             | 97.22         | Very Practical |
| IV              | 97.22         | Very Practical |
| V               | 87.50         | Very Practical |
| VI              | 91.67         | Very Practical |
| VII             | 95.34         | Very Practical |
| % mean          |               | Very Practical |

3.3.2. Teaching Materials Effectiveness

Measuring the effectiveness of teaching materials can use learning outcomes tests [23]. The learning outcomes tests results are then tested using the normalized gain test. Before being tested using the normalized gain test, the data is tested for normality. The normality test used is the Kolmogorov-Smirnov test with SPSS. Based on the normality test, the Asymp value is obtained. Sig. (2-tailed) for the pretest is higher than the value of the degree of significance, which is 0.091 > 0.050. Normality test for the posttest value obtained Asymp value. Sig. (2-tailed) for the posttest is higher than the value of the degree of significance, which is 0.901 > 0.050 so that the data are normally distributed. The gain test results are in the intermediate category.

Table 11. The Overall Gain Value of Students

| Mean of Pretest | Mean of Posttest | Gain Value | Category |
|-----------------|------------------|------------|----------|
| 8.10            | 43.10            | 0.31       | Intermediate |

This result indicates that the effectiveness of teaching materials is in the intermediate category, but have not yet reached the Minimum Mastery Criteria value in the School. This is due to the time in practicum activities is longer than the time to deepen the concept, analyze questions from the material being taught, as well as the minimum time for students to work on practice questions. If the teacher introduces new skills or concepts to students, further discussion and guidance are needed [24]. In addition, the Law of Exercise suggests the importance of repetition/ training so that someone has a good understanding of something or becomes skilled [25].

3.3.3. Achievement of Science Process Skills

The students' scientific process skills achievement is shown in table 12. The students' scientific process skills achievement in this study was seen from four aspects of assessment. These four aspects are; identifying the experiment variables, conducting the experiment, communicating/ reporting the results of the experiment, and concluding the results of the experiment. The results showed that the students' scientific process skills achievement was categorized as quite good.

Based on the results of the trial, components of identifying the variables, conducting experiments, and communicating the students were categorized as quite good and good, but the component of concluding the results was categorized as very poor. This should be the attention of the teacher. Science process skill is the ability to carry out an action in learning science [26]. In addition, science
process skill functions as a tool for producing and using information in scientific research and problem solving [27].

Table 12. Students’ Scientific Process Skills Observation Result

| Aspect                                           | Mean | Category       |
|--------------------------------------------------|------|----------------|
| Identifying variables                           | 2.61 | Quite Good     |
| Conducting an Experiment                         | 3.11 | Good           |
| Communicating/ reporting the results of the      | 3.25 | Good           |
| experiment                                      |      |                |
| Concluding the result                            | 0.88 | Very Poor      |
| Average Mean                                     | 2.46 | Quite Good     |

4. Conclusion

Based on the results of the research and development, it can be concluded that the high school physics teaching materials through the 7E learning cycle model that was trialed were appropriate to use. This is supported by the validity of teaching materials developed based on the validation sheet included in the good category, the practicality of teaching materials measured from the implementation of the lesson plans included in the category of very practical, the effectiveness of teaching materials seen from the test results of learning included in the intermediate category, and the achievement of science process skills of students included in the category of quite good.

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