

Inquiry-Oriented Learning Material to Increased General Physics Competence Achievement

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Abstract

This study aims to produce inquiry-oriented general physics learning material to improve student learning outcome. Development steps of learning materials were adapted from the design model of Dick and Carey. Stages of development consists of three phases: planning, development, and formative evaluation and revision. Implementation of formative evaluation involves three expert reviewers, they are subject matter experts, general physics lecturer, and media experts; one-to-one evaluation involved three students, evaluation of small groups involve 15 students, and a field test (effectiveness test) involve 30 students. The structure of the contents of the learning material refers to the concept of scientific investigations which generally consists of: stating the problem in a question form, formulating the hypothesis, literature, testing the hypothesis, analyzing the result and writing the conclusion. The result obtained from subject experts, general physics lecturer and media expert are in a good categories with their respective ideals for each are 80.2%, 82.7% and 84.5%, an increase competency achievement of pretest and posttest on field tests in the medium category $\langle g = 0.67 \rangle$, and the results of student responses to the instructional materials belonging to the positive response with a score of 73.5%. These results illustrate that the inquiry-oriented general physics learning material has a good criteria and suitable used as learning materials.

Keywords: *learning materials, inquiry, general physics and dynamics*

1. Introduction

The purpose of learning physics in high school curriculum/MA in 2013 include: "Students are expected to master the knowledge, concepts, and principles of physics, as well as having the skills to develop the knowledge, skills and attitude of confidence that can be applied in everyday life and as a provision for continuing higher education. The objectives formulation of curriculum 2013 is in line with the objective of the formulation of general physics competency that stated are physic education syllabus that are: "able to apply the scientific method to investigate the natural phenomena, as well as apply the concepts, principles, and laws within the range of general physics material in solving the problems of simple physics. From both objective formulation mentioned above illustrates that aspects of learning provided and trained by lecturers to students include three aspects: cognitive, skills, and attitudes.

To achieve these three aspects optimally, learning activities at the State University of Medan do curriculum improvement. For instance, in 2008, there is KBK curriculum improvements with block system with students learning approach (student centered learning / SCL), in 2009 SCL approach enhanced by strengthening soft skills, and in 2016 curriculum of KKNI was applied. The learning approach of KKNI is oriented in concept of scientific method or scientific inquiry. The purpose of the curriculum changes and improvements is to increase student achievement of competence for all subjects including general physics course. The fact in the field shows the results of these improvements have not been able to produce the optimum competence of General Physics. The average score of basic Mathematics and Science tests (competency test) general physics I in 2009, 2010, 2011, and 2012 is between 40-60 [1].

The low scores of the competency test is related to general physics learning materials that commonly used by students for this long is the printed material form, which content is tends be oriented to the improvement of students' "cognitive", yet equipped with materials for upgrading the skills and attitudes of students. One strategy to improve the knowledge, skills and attitudes of students in the study of General Physics is a way to complement the content of learning materials oriented scientific investigations. Scientific investigation includes several components, namely: (a) the questions to be answered by student, (b) to formulate hypotheses, (c) test the hypothesis, (d) to analyze the result of hypothesis testing (e) to write the conclusion, and (f) to communicate the results [2].

Investigation strategy is a series of learning activities that emphasizes the process of thinking critically and analytically to seek and find their own answer to the problem in question [3] investigation activities can improve students' ability to learn [4]. Several advantages of investigation strategies are: (a) more emphasis on the development of cognitive, affective and psychomotor aspects in a balanced manner, (b) provide space for students to study according to their learning styles, (c) can serve the needs that have the ability above average, (d) can develop the thinking skills of students, and (e) criteria for the success of the process refers to the extent to which students search for and find something move through the process of thinking [5]. Investigation strategy may involve maximally all the abilities of students to search and investigate in a systematic, critical, analysis, and using the techniques of approach to the problem can formulate his own discovery [6]. The purpose of this development is to generate inquiry-oriented general physics learning material to improve competence performance of general physics I.

1.1 Development of Learning Materials

The development of learning materials is one of the stages in developing learning models. Some models of learning development that can be used in the development of learning model are: (1) class room-oriented models, (2) product-oriented models, and (3) system-oriented models [7]. Classroom-oriented models, are models related to the learning process that takes place in the classroom both faculty and students. It is closely related to learning materials, learning strategy planning, the selection of instructional media, delivery and evaluation system.

Product-oriented models is a learning model that was developed based on four assumptions, namely: (a) learning products required (b) development which is necessary and essential in an existing product (c) the emphasis on testing and revision (d) the product must be used. System-oriented models is a learning model with the characteristic (a) carried out by a team that is a big number and expertise, (b) developed linearly with the precision step and (c) oriented problem solving. Inquiry-based learning materials are printed learning materials which content is laid out based on the concept and strategy of the investigation, so that the presence of these learning materials students can learn and are trained to use the skills of Science and the scientific method. Skills and scientific methods meant is the abilities: observing, classifying, measuring, inferring, predicting, communicating, making models, defining operationally, collecting data, interpreting data, organizing, analyzing, synthesizing, identifying and controlling variables, formulating hypotheses, and experimenting. The function of learning material is not only as a material representative lecturers, but learning materials have function as a means to achieve their learning competencies, and to optimize the service in learning activities of students. Another term of learning materials called as contents areas, namely: (1) the facts, (2) the concepts, (3) the principle, and (4) the procedure [8]. To develop learning materials there are three basic principles that should be considered are: (1) the suitability (relevance), (2) the constancy (consistency), and (3) adequacy [9].

1.2 General Physics

Physics is a part of Science. Laws and theories in science is the product of a series of human activities, known as scientific inquiry. The emergence of scientific investigations initiated from a curiosity to a natural phenomenon, then developed into questions issues to look for the answer or solution through observation and experiment until it is concluded.

To conduct scientific investigations, one must possess a number of skills called science process skills. Methods to conduct scientific investigations using process skills of science is known as the scientific method, but these two terms, Science process skills and the scientific method, are often used in the same sense, as well as between scientific inquiry and the scientific method, despite the fact that scientific inquiry is more flexible than the scientific method. Based on the explanation above, the nature of science is a process, product, and scientific attitude. The process, is to practice to gain the ability to observe, to collect data, to process the data, to interpret the data, to conclude, to communicate, and others; 2) The products, is a process to produce a concept, proposition, laws, theories, and principles; and 3) attitudes, is the emergence of an open nature, objective, fact-oriented, responsible, cooperative, oriented to reality, and others as the effects of already implemented the processes and products of Science [10].

Currently the scientific investigation (scientific inquiry) has to be excellent in science and other science. Experiments or lab work is an important part of the Science / Physics. This is because science is a science that is based on the discovery by physical phenomena in everyday life. Science learning should be more emphasizing

on the process, students are active during the learning to build knowledge through a series of activities so that learning becomes meaningful for students. In the Science study, the student acts as if as scientists, using scientific methods to find answers to a problem that is being studied. The role of students as if they were scientists in science learning implies that learning science using a "science process skills". Science process skills / physics can be classified into two parts: (1) basic skills, namely: (a) observing, (b) classifying, (c) measuring, (d) inferring, (e) predicting, and (f) communicating; and (2) integrated skills consist of: (a) making models, (b) defining operationally, (c) collecting data, (d) interpreting data, (e) identifying and controlling variables, (f) formulating hypotheses, (g) experimenting.

1.3 Oriented Research Learning Materials

Inquiry comes from the English "inquiry", which means the question, inquiry, or search. In the research and development work was subsequently used term investigation. The investigation is one component of the approach to CTL (contextual teaching and learning). The knowledge and skills acquired are expected not result given set of facts but of finding themselves. Lecturers should always design the program refers to the finding activities for all teaching materials are taught. That is, the learning activities used by lecturers are teaching strategies that student centered. Investigation strategy is a series of learning activities that emphasizes the process of thinking critically and analytically to seek and find their own answer to the problem in question [5]. Inquiry-oriented learning is affected by the flow of cognitive psychology. According to the flow of learning psychology is essentially a process of mental and thought processes to take advantage of all the potential of every individual is optimal. Learn more than just the memorization process and accumulate knowledge, but how knowledge gained through meaningful to students thinking skills [5].

Besides influenced by the flow of cognitive psychology, learning strategy investigation refers to the constructivist theory of learning theory developed by Piaget, stating that it would be meaningful when knowledge will be sought and found by students. According to Piaget humans since childhood every individual seeks and is able to develop his own knowledge through existing schemes in cognitive structure. The scheme is continuously updated and changed through the process of assimilation and accommodation [5]. In practice, the investigations strategy consists of five stages, they are: a) observation, b) questioning, c) hypothesis, d) data gathering, and e) conclusion. Steps investigation activities are: a) to formulate the problem; b) to observe or observation; c) to analyze and to present the results in writing, pictures, reports, charts, tables, and other works; d) to communicate or to present product of works toward the reader, classmates, teachers, or other audiences [11]. With slightly different terms investigations strategy referred to as a general model of scientific investigations which consists of five stages: a) to identify problems b) to develop a possible solution (proposed hypothesis): c) to collect data; d) to analyze and to interpret data; and e) to examine the conclusions [12]. To optimize application of inquiry-oriented learning strategy, every lecturer in selecting measures learning activities refer to the principles investigation strategy. The principles are: 1) oriented in intellectual improvement, 2) interact, 3) ask, 4) learn to think, and 5) the disclosure [5].

In its application, professors serve as: 1) motivator, 2) facilitators, 3) writer, 4) administrator, 5) steerer, 6) manager, and 7) rewarder [4]. Investigations strategy has three main characteristics, namely: 1) emphasize on activities student activities, 2) all activities undertaken are directed to seek and find the answers themselves from something that is questionable, which is expected to foster a self-belief, and 3) aims to develop the ability to think in a systematic, logical, critical, or develop intellectual abilities as part of the mental process [5]. Investigations strategy is one strategy that fits in the learning of science with some advantages as follows: (1) create and develop "self-concept" of students, so that understand the basic concepts and better ideas, (2) help in using memory and transfer the new learning situations (3) encourage to think and work on his own initiative, be objective, fair and open, (4) encourage to think intuitively and formulate their own hypothesis. (5) give the satisfaction that is intrinsic, (6) the situation of learning process becomes more stimulating, (7) able to develop their talents or skills of individuals, (8) give the freedom to learn on their own, (9) can be avoided from the ways of learning traditional and (10) able to give time to sufficiently so that it can assimilate and accommodate the information.

2. Method

This type of research is is the Research and Development. To produce the inquiry-oriented general physics learning materials are adapted from the model design Dick and Carey phases: (1) analyzing of the competence, (2) analyzing of student characteristics, (3) analyzing of learning resources (4) formulating learning objectives,

(5) developing the test, (6) designing learning strategies, (7) developing learning materials (8) planning and implementing the formative tests. [13]. Formative tests aim to obtain design weaknesses physics learning materials commonly used to revise the learning materials produced so that the resulting product to be better than ever. Application of this formative test was carried out through four stages, namely: (1) validation by three experts namely materials experts, general physics lecturer, and media experts; (2) evaluation of the one numbered 3, (3) testing a small group of 15, and (4) a large group trial / field numbered 30 people. Students involved in the formative test consists of three categories, namely capable of low, medium, and high. The instrument used for data collection was a questionnaire and tests of competence dynamics.

3. Results and Discussion

The results of the general development of learning materials physics I oriented investigations that were analyzed were as: **Competence Analysis**, Competencies analysis is carried out on GBPP/General Physics I Course Syllabus contained in GBPP/Physics Syllabus of Physics Education Program of State University of Medan that used when research is conducted. The limited time, funds, and the ability of researchers, the competencies analyzed only with respect to the subject matter of the dynamics and aspects of knowledge and skills. **Analysis of Student Characteristic**, Analysis of the characteristics of the students in question in this study is limited to three (3) parts, namely: (1) registration documents of the national exam (UNA) subjects Physics, (2) test the ability of beginning physics, and (3) students' perceptions of learning materials is used for this. The results of the analysis illustrates that the national exam (UN) less contributes to the value pretest general physics. As many as 90% of the value of the UN both sample groups had reached a value of 70 (the value of the minimum standards for graduate courses, while the value pretest general physics I no one student (0%) in both groups reached a value of 70. Relation to the students' perceptions of learning materials used so far has been pretty good. Parts of the learning materials that need to be improved include illustrations/pictures laid out better and multiplied in number, examples of problems reproduced according to its competence, the content of the learning materials should be linked with their surroundings and are equipped with the questions that lead to exploratory activities [14].

Analysis of Learning Resources, Learning resources for the purpose of this research is the general physics I learning materials, internet sites, and other relevant sources. General physics I learning materials and internet sites set by the lecturer is a source of learning required to accomplish the tasks that have been written in the contract of general physics I course lectures. **Formulates Learning Objectives**, The formulation of learning objectives resulting in limited activity on cognitive aspects adapted from cognitive theory Bloom. The selection is based on the aspects of the competency test results a few years (last 3 years) is still very low. The competency tests used are still limited to the cognitive aspect. **Develop Student Tests and Assignments**, General physics I competency test was developed based on the formulation of core competencies which have been formulated previously. Number of subject matter competency test dynamics have developed a total of 20 questions. The test is a multiple-choice test with 5 five answer choices. **Learning Strategy Design**, Learning strategy used is based on the strategy of the investigation, the nature of science. The main sequence of learning that has been set is: a question that can lead the student to investigate, to formulate hypotheses by students, to collect data, to test hypotheses and discussion, to make inferences, presentation or to communicate the results.

Develop Learning Materials, General physics learning materials that have been developed are 8 inquiry-oriented subject matter of the investigation, but that is studied in this paper is limited to the principal dynamics. The teaching materials developed referring to the formulation of competence, student characteristics and learning conditions. Inquiry-oriented learning materials are learning materials in the form of printed materials. The main structure of teaching material that has been developed are: submission of the problems created in the form of a question, hypothesis formulation, literature, hypothesis testing, analysis of the results, write conclusions. **Plan and Implement the formative tests**, Implementation of formative tests is carried out through three stages, namely : (a) review by three expert reviewers that are subject matter experts, general physics lecturers, and media experts ; (b) the evaluation of one -on-one , and (c) small group trial.

Expert Reviewers, Implementation of the pilot study materials involving three expert reviewers: 1) subject matter experts, 2) general physics lecturers, and 3) media expert.

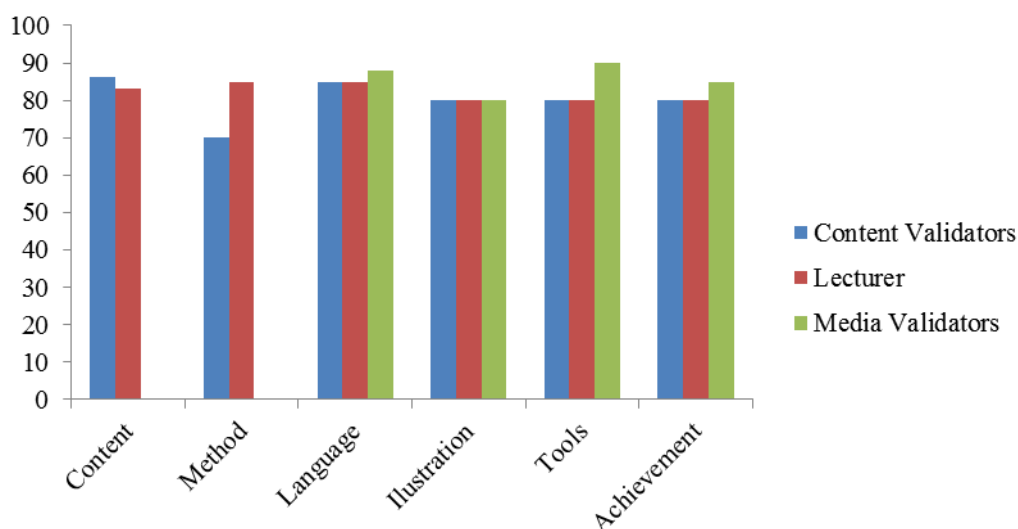


Figure 1. Validation test score by 3 expert reviewers

From Figure 1 above, the assessment scores by three expert reviewer; range of assessment scores by subject matter experts from 80 to 86.3 with average of 80.2, by the general physics lecturer is from 80 to 83.3 with an average of 82.2, and by media experts 80-90 with an average of 84.5, From diagram 1 above score aspect of the method of presentation scores by subject matter experts is 70 while a score by the general physics lecturer was 85. The difference in the assessment scores after traced based on advice given by the two assessors according to subject matter experts view that the content of learning materials, especially the content learning materials that can provide direct experience still need to be added, while according to the general physics professor has been good.

One-to-one trial (*One-to-One*), Subjects involved in the evaluation of one-on-one is the students totaling 3 which is equivalent to the target population, aiming to assess and comment on the inquiry-oriented learning materials with general physics dynamics of matter that has been developed. The three students have different abilities that one person has the ability above average (high), one person has the ability average (medium) and one more person has the ability under the average (low). The ability rate of students is obtained from the documentation report of general physics student at The State University of Medan in Physics Department. Thus the three students are assumed to represent the ability of all students. Before giving the comment, first give an explanation purpose and objective of the development of this program, and how to provide feedback. After giving the information (guidance) is completed and it is clear to student intents and purposes, here in after individually, the three students were asked to rate and comment content of learning materials general physics subject matter dynamics. The objective of the trial of this one is to identify and reduce errors significantly contained in learning materials such as is the case: types, words are missing, the picture does not match, an error of use uppercase or lowercase and to get comments from students about the content or learning materials.

Small Group Trial, Implementation of this small group trial involving 15 male students that similar to the target population, aiming to assess and comment on the draft general physics-oriented learning materials investigation subject matter of the dynamics that have been developed. All 15 of these students have different abilities that 5 people have the ability above average (high), five people have the ability average (moderate), and 5 people have the ability below average (low). The implementation mechanism of small group trial commenced activities aimed to determine pretest initial ability of students before use learning materials development activities, the provision of learning materials products to the students to learn, gives instructions on using learning materials and tests of competence. After practice the use of learning materials is completed studied by all students, then given the competency test (posttest) to determine the level of competence achieved. Because limited time, limited learning materials tested in the study materials relating to the subject matter competency test purposes dynamics. Likewise, the competence tests which have been tested in these activities is limited to subject matter competency test dynamics. The result is as in Figure 2.

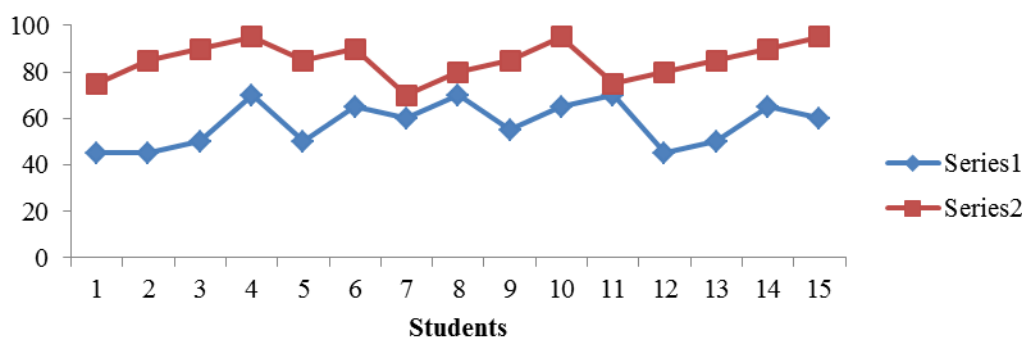


Figure 2. Trial test score of small group for 15 students

From Figure 2 above, it is illustrated that of 15 students of the trial, for the pretest score as many as three people (20 %) have a minimum competence standard (70) , 12 (80 %) have not reached the minimum competency standards. Unlike the post-test scores, as many as 15 people (100%) have reached the minimum competency standards with a range of scores 70-95, and the average score was 85 (good).

Large Group Trial/Field, In this field test involving 30 students which is equivalent to the target population, aims to test the effectiveness of learning materials. The number of students involved were 30 people with different abilities, which is 10 people have abilities above average (high), 10 people have the ability average (medium), and 10 people have the ability below average (low), The implementation mechanism of small group trial commenced activities aimed to determine pretest initial ability of students before use instructional materials, provide a product of learning materials for students to learn, gives instructions on using learning materials and tests of competence. Further to the review determines the effectiveness of the learning materials is by calculating the value of normalization with this following equation:

$$\langle g \rangle = \frac{\text{posttest score} - \text{pretest score}}{100 - \text{pretest score}} \quad [15]$$

Score of gain normalization $\langle g \rangle$ obtained is 0.67, meaning that an inquiry-oriented learning materials effective in raising the achievement of competence in the subject matter of general physics dynamics. Some research findings that are relevant to investigations strategy, among others: the study concluded that student learning outcomes that are subjected to the method of investigation was higher (64.91) than the results of the study group of students who received treatment conventional method (60.39) [6], that student learning outcomes using method of investigation was higher (76.43) than using the conventional method (64.57). [16], and concluded that the results of product testing guided model development learning investigation showed that the classical learning completeness students increased by 28% and life-skills of students by 17.66% [17]. Research findings related to investigations strategy provides better effect than the conventional strategy. Their conformity with the results of the research findings of previous research that is relevant, an increase in the pretest to posttest scores in the subject matter of the dynamics are believed actually due to the influence of learning materials as a survey oriented but not occur by chance. In addition to pretest and posttest, was also given a questionnaire aimed to get students' perceptions of teaching materials in founding which the results are inquiry-oriented teaching materials can enhance the cognitive, motivation, and to facilitate student learning dynamics material with an average of 73.5 (both categories); especially the increase of motivation score above 75. Motivation can be caused by the ease of learning as a result of the study materials it uses.

4. Conclusion

First, The quality of inquiry-oriented general physics learning materials according to the assessment of material experts, general physics lecturers, and media experts have a good category with a score of respectively 80.2 % , 82.6 % , and 84.5 % . **Second,** The response of students to inquiry-oriented general physics teaching materials are categorized good (73.5 %). **Third,** The inquiry-oriented general physics learning dynamic material is effective to increase the competence of general physics achievement, indicated by N-gain which are normalized by score of 0.67 (medium category).

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