The effectiveness of research-based physics learning module with predict-observe-explain strategies to improve the student’s competence

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Abstract. The preliminary study shows that many students are difficult to master the concept of physics. There are still many students who have not mastered physics. Teachers and students still use textbooks. Students rarely do experiments in the laboratory. One model of learning that can improve students’ competence is a research-based learning with Predict-Observe-Explain (POE) strategies. To implement this learning, research-based physics learning modules with POE strategy are used. The research aims to find out the effectiveness of implementation of research-based physics learning modules with POE strategy to improving the students’ competence. The research used a quasi-experimental with pretest-posttest group control design. Data were collected using observation sheets, achievement test, skill assessment sheets, questionnaire of attitude and student responses to learning implementation. The results of research showed that research-based physics learning modules with POE strategy was effective to improve the students’ competence, in the case of (1) mastery learning of physics has been achieved by majority of students, (2) improving the students competency of experimental class including high category, (3) there is a significant difference between the average score of students’ competence of experimental class and the control class, (4) the average score of the students competency of experimental class is higher than the control class, (5) the average score of the students' responses to the learning implementation is very good category, this means that most students can implement research-based learning with POE strategies.

1. Introduction
The quality of education is the hope of the whole community. One of the efforts that can be done to support the realization of the goals of national education, especially in physics subjects in high school can be done through the implementation of the effective learning model. Learning model must be able to improve student competence. Instructional is a process of interaction between teachers and students. Teachers are expected to be able to facilitate students to achieve the expected competence and character. Teachers should be able to plan, implement, and evaluate learning. Thus, teachers and students have a strategic position in improving the quality of learning, one of which is physics learning.

In physics learning, the teacher must implement the exploration activities and experiments to achieve the learning objectives of physics. One of the supporting factors for the achievement of physics learning objectives is teaching materials. Teaching materials play an important role in making learning-teaching process in Physics courses efficient, by presenting signs and explanations to students and making students comprehend these signs and explanations. Teaching materials provide a great deal of
convenience in teacher’s ability to convey a message to students in an accurate, proper, clear and understandable manner; in making abstract knowledge concrete and in enabling students to comprehend complex ideas through simplification. When properly used, printed materials, audiovisual materials and experience-giving methods, help make the learning process easy and enduring [1]. Teaching materials can facilitate students to learn independently. Therefore, teaching materials need to be developed so that learning can achieve the goals. One of the teaching materials is the learning module. The learning module is a form of teaching material that is packed in a whole and systematic that contains a set of the learning experience and is designed to help students master the learning objectives.

The results of observations and interviews with teachers and students at SMAN 1 X Koto Singkarak revealed that physics learning process implemented in schools has not been successful. It is caused by several factors including the most commonly used methods in the learning process is not to be the student centre, lack of experiments activities and teaching materials used are in the form of textbooks and modules. This is very influential on student competence. The average mastery of students learning of X MIA grade at academic year 2015/2016 in SMA Negeri 1 X Koto Singkarak is 56.8%. This means that the majority of students have not met the minimum criteria of mastery learning (KKM) that is 75.

To determine the cause of low physics competence, given the questionnaire on students about the learning process. Based on the questionnaire, it is known that physics learning is still teachers centre, students have not been actively involved in finding facts, concepts, and principles that applied to solve the physics problems in everyday life, and students rarely do experimental activities in the laboratory. Most students have difficulty learning physics and do the tasks assigned by the teacher.

Teachers are already using the module but not all of the material yet and are not in accordance with the module structure. The module that teachers use is a module that already exists, not a module developed by the teacher. Although the module has been designed according to the Curriculum 2013 and is equipped with character values, the module does not in accordance with the criteria of a good module. Judging from the content feasibility component, the module has included core competence, basic competence, and achievement indicators of competence, but has not yet stated the learning objectives to be achieved by the students. In addition, the concept map contained in the module has not seen a link between material in the form of facts, concepts, principles, and procedures with competence. While in terms of presentation, the module already contains a scientific step, but the steps are only found on the student worksheet and have not been able to motivate students to learn independently.

To solve the problem in learning physics, one model of learning that can be used is a research-based learning with Predict-Observe-Explain (POE) strategies. The research-based learning is the learning based on a research approach as a step to implement learning. Research-based learning is multifaceted with reference to various learning methods, so that the students’ learning outcomes come from simple research that they do, for example through experiments and field studies [2-4]. Research-based learning gives students the opportunity to formulate problems, review the theories, formulate the hypotheses, collecting the data, analyze the data, and conclude the results. There are six stages of the research-based learning models, namely (1) identifying problems, (2) formulating the problem, (3) reviewing theories, (4) formulating hypothesis, (5) collecting and analyzing data, and (6) interpreting and concluding research result [5].

The POE strategy can be used to identify students’ understanding, provide information about students’ thinking, and motivate students to master the concepts of physics. This strategy has three main steps in learning that are: (1) Predict is the process of making allegations against the phenomenon or problem. Students predict the answer to the problems the teacher gives, writing down the prediction with the reason. Students make initial guesses based on their initial knowledge. (2) Observe is what happened. Students do the experiments, student’s record what they observe, link their previous predictions with the result of observations. (3) Explain that provides an explanation of the conformity between allegations with experimental results on the observation phase [6].

The POE learning strategy begins with problem presentation, students are invited to guess the solution of the problem, followed by observing the problem, and then proven by doing the experiments to be able to find the truth of the initial guess. The POE learning strategies were the effective learning
strategy to improve the student competence, generate student ideas, and conduct discussions of their ideas [7]. The POE learning strategies can improve the students' abilities to predict and reason do they give predictions on the problem, then make observations, and explain the comparison between predictions and the results of scientific observation [8]. The effectiveness of POE strategy depends on how the teacher implements the strategy. If there is a discrepancy between prediction and observation, the teacher must be able to assist the students to reconcile the inconsistency between the students' predictions and observations [9].

Based on the learning condition of physics that has been described then conducted the research on the effectiveness of research-based physics learning module with POE strategy to improve the student competence. The research problem is formulated as follows: How is the effectiveness of research-based physics learning module with POE strategy to improve the student competence?

2. Methods
This research used a quasi-experimental with pre-test post-test group control design [10]. Pre-test and post-test gave to student’s experimental class and control class using the same matter. The experiment was conducted on students X MIA grade at SMAN 1 X Koto Singkarak in physics subject. The research phase is: (1) conduct a preliminary survey, (2) develop research-based physics learning module with POE strategies, (3) validate the learning module, (4) develop research instruments, (5) testing the learning modules and research instruments, (6) analyze the data, (7) provide pre-test, (8) implement the research-based learning with POE strategies in experiments class, while the control class implementing the teacher-centre learning, (9) provides post-test, (10) analyze the data and interpret the results. The instruments used in the research are observation sheet, achievement test, and questionnaire of student responses to the implementation of learning. Observation sheets are used in conducting preliminary surveys.

The effectiveness of the implementation of learning module in terms of learning outcomes and student responses to the implementation of learning. Improving student learning outcomes were analyzed by the normalized gain score of scores of pre-test and post-test. The mean differences in the students' learning outcomes of the experimental class and the control classes were analyzed using the t-test. The data of students' responses to the implementation of learning is analyzed by comparing the average score with score category.

3. Result and Discussion
The effectiveness of the implementation of research-based physics learning module with the POE strategy in improving the students' competence is based on: (1) students' learning mastery, (2) improvement of student competence, (3) difference between the average score of students' competence of experiment and control class, (4) student responses to the implementation of learning. Further analyzed each of these aspects to determine the effectiveness of the implementation of learning modules.

3.1. Students Learning Mastery
The student’s competence of knowledge domain seen from the pre-test and post-test using essay test. Pre-test did before the students learning to use the module, while the post-test conducted at the end of each sessions. Results of students' learning mastery analysis in the knowledge domain can be seen in Table 1.

Table 1 shows that each sessions has an increased percentage of students' learning mastery. The average value of all four sessions was 79.55 with a percentage of students' learning mastery is 86.1%. From the result, it can be concluded that the students' learning mastery is more than 85%, which states that the learning module effectively in improving students' competence in the knowledge domain.
Table 1. Students Learning Mastery in the Knowledge Domain

| Sessions | Average value | Learning mastery (%) |
|----------|---------------|----------------------|
| 1        | 75.19         | 70.4                 |
| 2        | 77.89         | 85.2                 |
| 3        | 80.30         | 88.9                 |
| 4        | 84.81         | 100                  |
| Average  | 79.55         | 86.1                 |

3.2. Improving Student Competence

Improving the student’s competence in the knowledge domain were analyzed using a normalized gain score. In Table 2 it can be seen that the students' competence in the knowledge domain has increased at each sessions. The value of gain score at the high category at the fourth sessions.

Table 2. Value of Gain Score of Students on Knowledge Domain

| Sessions | Pre-test  | Post-test | Gain score | Category |
|----------|-----------|-----------|------------|----------|
| 1        | 35.26     | 75.19     | 0.62       | Medium   |
| 2        | 42.22     | 77.52     | 0.61       | Medium   |
| 3        | 44.07     | 80.11     | 0.64       | Medium   |
| 4        | 46.11     | 84.81     | 0.72       | High     |

Assessment of students' competence in the psychomotor domain is obtained when students do the experiment. Assessment of student psychomotor is performed at each sessions by the observer using a skill assessment sheet. The results of student psychomotor assessment can be seen in Table 3.

Table 3. Results of Student Psychomotor Assessment

| Sessions | Average value | Percentage of students who have good skills |
|----------|---------------|--------------------------------------------|
| 1        | 75.31         | 70.4                                       |
| 2        | 79.19         | 81.5                                       |
| 3        | 84.66         | 96.3                                       |
| 4        | 88.71         | 100                                        |

Based on Table 3 it can be seen that the students' skills have improved based on the average value from the first to the fourth sessions. From these results, it can be concluded that the students' skills are classically more than 85% which good categorized at the third and fourth sessions. This shows that the learning module is effective in improving students' competence in the psychomotor domain.

Student competence data on affective domain obtained from the student observation during the learning process. Assessment of student attitudes conducted every time the sessions by the observer using an attitude assessment sheet consisting of four aspects assessment. The results of students' attitude assessment can be seen in Table 4.

Table 4. Results of Student Attitude Assessment

Based on Table 4 it can be seen that students' attitudes have improved based on the average score from first to fourth sessions. From these results can be concluded that students' attitudes classically more than 85% are good categorized. This shows that the learning module is effective to improve students' competence in the affective domain.
Table 4. Results of Students’ Attitudes Assessment

| Sessions | Average value | Percentage of students who have good attitude |
|----------|---------------|---------------------------------------------|
| 1        | 72.22         | 88.9                                        |
| 2        | 78.94         | 92.6                                        |
| 3        | 84.95         | 100                                         |
| 4        | 92.36         | 100                                         |

3.3. Mean Difference of Students Competency of Experiment Class and Control Class

Before analyzing the data to know the difference between the mean student’s competence of the experimental class and control class, using the t-test, firstly tested the normality of data distribution and data homogeneity. The result of normality test of data distribution shows that the student’s competence score of experiment class and control class before learning is the normal distribution at significance level $\alpha = 0.05$. Same result for student competency data after learning. The result of homogeneity test of student competence data before learning showed that the students' competency data of experimental class and control class were homogeneous ($\alpha = 0.05$), as well as student competency data after learning.

Based on normality test of data distribution and homogeneity test of students competency data of experiment and control class, it can be determined that the mean difference test of students' competency can use t-test (with the formula for normal and homogeneous data). After the mean difference test on student competence data before the learning obtained the result that the average score of students competency of experiment class and control class did not differ significantly ($\alpha = 0.05$). Thus it can be stated that the student's competence before the learning is the same in both classes. Mean different test of students' competency score after learning shows that the average of students competency score of experiment class and control class differ significantly ($\alpha = 0.05$). Thus it can be stated that the competence of students after learning is different in both classes. The average score of student competence of the experimental class is higher than the control class.

3.4. Student Response to the Implementation of Learning

Results of data analysis of student responses to the implementation of learning show that the average score of student responses of 88.9 with deviation standards of 5.3 and including the very good category. The score categories of student responses based on ideal scores and ideal deviation standards. This shows that most students can use and understand research-based learning modules with the POE strategy.

Based on the results of data analysis that has been described can be concluded that: (1) mastery learning has been achieved by the majority of students, (2) improving the students competency of experimental class including high category, (3) there is a significant difference between the average score of students' competence of experimental class and the control class, (4) the average score of the students competency of experimental class is higher than the control class, (5) the average score of the students' responses to the learning implementation is very good category. Thus it can be concluded that research-based physics learning module with POE strategy effective to improve the student competence.

3.5. Discussion

The good learning module is a learning module that accordance with the needs of students. Learning modules used as learning materials in learning. The research-based learning module with POE strategy can help the learning process be implemented. The effectiveness of the learning module is seen from the improvement of students' competence in knowledge, attitude, and skill domain after using the learning module. Student competence in the knowledge domain at the first sessions there are still many students who have not mastery that their learning. This is because at the first sessions students are not familiar with the learning model used. They find it difficult to follow research-based learning stages with POE strategies.
In research-based learning, students are given problems that must be solved through formulated hypotheses and tested by experiment. This activity is able to students' curious to learn more about teaching materials. In addition, in research-based learning, there are experimental activities, discussions, presentations, and reporting. At the fourth sessions, all of the student’s mastery of their learning. The POE strategy was effective in terms of gathering students’ predictions and reasons for the prediction of outcomes in an open-ended format [11]. The POE strategy can improve students' competence in science lessons [12,13].

Student competence in the psychomotor domain is obtained from the observation sheet that observed by an observer at each sessions. The average of student’s skill increases at each sessions. On the first sessions the students still difficulty in using the experimental equipment, reading, and recording of experimental results are also not maximized so that the impact on skills student. At the second to fourth sessions, there was an increase. The POE instructional strategy is an effective means of improving the Basic Science of practical skills of students [14,15]. The research-based physics learning model with scientific approach effective to improve the scientific process skills and students competence [16].

The students' competence in the affective domain shows an increase in each sessions. This increase occurs because the use of learning modules can require students to find out for themselves and carry out experiments based on the concepts they have learned. Students are independent and responsible for themselves in the learning process in the classroom and in everyday life. Students are accustomed to discipline in doing the task. Students have shown hard work in answering the question of summative evaluation and formative evaluation. Students learn with the help of learning modules so that they can relate problems with learned concepts.

Improved the student’s competence is the impact of research-based learning with POE strategies. The implementation of research-based learning can improve the activities, skills, and knowledge of students in science lessons [17,18]. The research-based physics learning effectively improves students' competence in the knowledge, skills and attitudes domain [19].

4. Conclusion
The research of results showed that research-based physics learning module with POE strategy was effective to improve the students’ competence, in the case of: (1) mastery learning of physics has been achieved by the majority of students, (2) improving the students competency of experimental class including high category, (3) there is a significant difference between the average score of students’ competence of experimental class and the control class, (4) the average score of the students competency of experimental class is higher than the control class, (5) the average score of the students' responses to the learning implementation is very good category, this means that most students can implement research-based learning with POE strategies. Suggestions to physics teachers to implement the research-based learning with POE strategies.

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