Developing of physics practical module based on scientific method for students

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Abstract. This research aims at developing a module for teaching Physics in high school. The research employs Research and Development (R&D) method with ADDIE model (Analyze, Design, Develop, Implement, and Evaluation). The research ends up on the Implement stage where the researchers only validate the module to the expert for it does not require the students’ responses. The module developed by researchers is Physics Practical Module Based on Scientific Method for the Tenth Grade High School Students in the Second Semester. Validation process is based on validation from the material expert, the design expert and the language expert. The validation uses Likert scale from 1 to 5, with the scale 1 of very low to 5 of very good grades. The average validation results of the three main aspects of material or content, design and language are 4.10 or 82% and is categorized as “good” category. Thus, it can be concluded that the Physics Practical Module Based on Scientific Method for the Tenth Grade High School students in the Second Semester is appropriately to be used.

1. Introduction
Physics is one of the branches of science that can be learned through observation, experiment, measurement and analysis so that the relationship of physical quantities on it can be identified. Physics is also defined as a scientific lesson that requires observation on natural phenomenon of which its information can be measured. Series of concepts of Physics can also be explained by using various representations, symbols, texts, images, graphs, diagrams, tables, and mathematical equations [1].

Learning Physics in schools should include theoretical and practical knowledge, so the students are able to develop critical and authentic scientific questions and attitudes based on their experience. The goal of Physics learning is to enable students to be passionate, skillful, creative, independent, as well as to be able to observe and to provide questions related to what has been observed, to conduct investigations and experiments, to analyze and to interpret data and to communicate the obtained results [2] [3]. The explanation above can be interpreted that in Physics learning, it is not only focused on the giving concepts and theory, but also providing direct experience to learners through experimental activities that apply scientific method in the learning process[1].

Nowadays, many high school Physics teachers in Indonesia only teach about Physics’ concept and theoretical knowledge without involving practical experiments in the class. These conditions are seen from the researchers’ observation and interview in SMAN 3 Depok (one of the high schools in Indonesia). The lack involvement of practical experiments carried out in the class might be caused by many factors, and one of which is that students must cope with many topics for national exam.
this issue, teachers must reach their target for the students’ success in working on their national exam. This condition makes teachers not to have sufficient time for conducting practical experiments in the class. Another factor is about resources. In this issue, teachers still have difficulty in finding teaching materials such as guide book or module to do practical lesson as they need more time to find resources. Moreover, teachers also still do not have good experience when doing practical lesson or experiment in the class. The module as one of the teaching materials has one characteristic that is as the principle of independent learning [4].

The results of research from Cahyani et al [5] and Aryani [6], point out that teachers are still constrained in the 2013 curriculum, have not been able to carry out scientific learning, have not been able to prepare appropriate media and have not been able to carry out assessments according to 2013 curriculum standards. Practical lesson is not only important as students can prove what they learn in the class but also can make the lesson becomes more attractive. This will eliminate students’ boredom and will increase their motivation in learning. The new curriculum in Indonesia requires teachers to involve practical lesson in the class. As the teaching resource is very limited, teachers tend to go back to their old teaching way, that is only teaching about theoretical knowledge. Teachers do not have much time to prepare the source because they are not only teaching in the school but are also asked to do some administration jobs, such as to design lesson plan, to process students’ score and many more.

The method used in the 2013 curriculum is the scientific method. The Scientific Approach is closely related to the scientific method. Scientific method generally involves observations or observations needed to formulate hypotheses or to collect data. The application of the scientific method in learning involves process skills such as observing, classifying, measuring, predicting, explaining, and concluding [7].

Based on the explanations above, the researchers try to provide a teaching aid, specifically for practical lesson in the form of module. The researchers develop practical Physics module for the tenth grade high school students in the second semester based on scientific method. The module applies scientific method as its main way to do practical lesson in the class. Because Physics is a science, so it needs special method to support the lesson. This research is also aimed to give solution for teachers to provide a good teaching aid that is suitable to new curriculum and to make students learn not only about theoretical knowledge but also about direct experience through practical lesson.

2. Methods
To make a good resource in education, the researchers use Research and Development (R&D) method with ADDIE (Analyze, Design, Develop, Implement, and Evaluation) model. ADDIE is one of the most effective models used for developing product especially for educational purpose [8] [9]. This research ends up on the Implement stage of ADDIE model, because the researchers only use the module to get students’ response, not to evaluate students’ results in Physics lesson after using it.

The researchers use questionnaire to get validation and response for the product. The questionnaire is a method to get research data by giving some questions to the research object or to the expert for obtaining some responses about the product [10]. There are three different questionnaires to get validation from the experts, namely: material or content expert, design expert and language expert. The techniques for data analysis in this research are quantitative and qualitative.

3. Result and Discussion
This Research and Development (R&D) method uses ADDIE (Analyze, Design, Develop, Implement, and Evaluation) model that ends up at the Implement stage of ADDIE model.

3.1. Analyze
The first step is analyzing the main core competencies and the basic competencies from national curriculum (k-13) to find a suitable concept for Physics learning in the tenth grade of high school to fill in the module. The researchers use regulation from the Ministry of Education and Culture as a basis to get appropriate material. There are 4 categories of competencies that must be fulfilled in the learning
process, that is, spiritual, attitude, knowledge and skill. The researchers’ focus is on the core skills competence (KI-4) and basic skills competence (KD-4), shown in table 1 below.

Table 1. Core Competencies and Basic Competencies.

| Competencies          | Description                                                                                                                                 |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Core Competencies     | 4. Processing, reasoning and serving in the realm of concrete and abstract realms are related to the development of the self-study in schools independently and capable of using methods according to scientific rules. |
| Basic Competencies    | 4.6 Conducting experiments following the presentation of the results about circular motion, physical meaning and its beneficiaries.          |
|                       | 4.7 Conducting practicum and presentation of the results related to force and relationship of force, mass and acceleration in the motion of straight objects by applying the scientific method. |
|                       | 4.9 Applying the scientific method to propose the idea of solving motion problems in everyday life related to energy concepts, business and energy conservation laws. |
|                       | 4.10 Presenting the results of testing the application of conservation laws of momentum.                                                                 |
|                       | 4.11 Conducting a harmonic vibration experiment on a simple swing and/or spring vibration following the presentation of experimental results and their physical meanings. |

The second step is analyzing the school’s needs and the teachers’ needs. Researchers conduct observations at SMAN 3 Depok and interview the tenth grade Physics teachers. The results show that the process of Physics learning in the class only conveys about Physics’ theory or concepts and carries out paper test, the teachers do not always conduct practicum in the class. Practicum is held by the teacher only once or twice in a semester or even once in a year, conducted only to get the required skills’ scores on the curriculum.

Skills acquired by students in the learning process is not optimal, students are still not familiar with the scientific method employed in an experiment, this happens because teachers rarely conduct practicum in the class. Teachers still have difficulties in conducting practicum activities because of limited teaching materials, no books or special modules for practical activities that can be used to make the lesson easier.

Preparing a practicum really takes time and needs adequate tools. Teaching materials with the right method are needed to carry out practicum that can facilitate the teachers. Practical activities should be equipped with tools and materials that are easily obtained by the students, this will make students to be accustomed and active in conducting a research.

To solve these problems, researchers develop teaching materials in the form of a practical module for tenth grade high school students in the second semester based on a scientific method. The purpose of this module is to help students working on their practical activity in Physics class easily, effectively, as students can participate and be directly involved in the process of Physics learning to achieve the skills competencies in the curriculum.

3.2. Design

Based on the results of the analysis that has been conducted, researchers design a product of teaching materials in the form of a module that can facilitate teachers and students involving practical activities. Teachers do not need any longer preparation for practicum activities because all the steps are already available in the module. To this extent, students can independently do the practicum only by reading the practicum module and the teachers can easily give instruction to the students without giving long explanation.

The designed module is a practical module for the tenth grade high school students in the second semester based on a scientific method. The scientific method is chosen because it is suitable for Physics practicum activities that keep students active by following existing steps in the module. The module also comes with a problem that aims to determine the students’ understanding after practicing it.
3.3. Develop

At this stage, the design results are begun to be developed and made to be a product. The steps taken in the development stage are as follows.

First, to create a module framework based on topics or learning materials that will be presented into the contents of the module in accordance to curriculum analysis and needs. Second, to integrate learning materials with a scientific method used in the module. Third, to arrange the module into three main parts, namely: introduction, practicum activities and appendices. The introductory section consists of cover and title, Francis page, preface, table of contents, background, explanation of scientific method and core competencies as well as basic competencies of learning. The practicum activities consist of mind maps, basic competencies, learning indicators, experiment objectives, tools and materials, observation, making questions after observation, physics concepts, hypotheses, experiments, analysis of experimental data, exercises, conclusion and making report. The appendices section consists of appendices on how to produce practicum reports, glossaries, bibliography and profiles of authors.

Table 2. Module Framework.

| Module Section | Content |
|----------------|---------|
| Introduction   | 1. Cover and title  
|                | 2. Francis page  
|                | 3. Preface  
|                | 4. Table of contents  
|                | 5. Background  
|                | 6. Explanation of scientific approach  
|                | 7. Core competencies and basic competencies |
| Practicum Activities | 1. Mind map  
|                    | 2. Basic competencies  
|                    | 3. Learning indicators  
|                    | 4. Experiment objectives  
|                    | 5. Tools and materials  
|                    | 6. Observation  
|                    | 7. Making questions after observation  
|                    | 8. Physics concepts  
|                    | 9. Hypotheses  
|                    | 10. Experiments  
|                    | 11. Analysis of experimental data  
|                    | 12. Exercises  
|                    | 13. Conclusion  
|                    | 14. Making report. |
| The appendices   | 1. How to produce practicum reports  
|                | 2. Glossaries  
|                | 3. Bibliography  
|                | 4. Profiles of authors |

The Physics practical module based on scientific method is shown in Figure 1-4 below. Figure 1 is a subsection cover of module. There are parts of the materials that will be studied and discussed to stimulate students.

![Figure 1. Subsection Cover of Module](image-url)
3.4. Implement

The module is tested in order to obtain an appropriate feasibility assessment to identify whether the module has been developed to be used or not. There are two trial tests, that is, expert’s validation and to the user by students. This research only carries out the validation by experts. The researchers have not tested the module to the students.

Respondents were asked to answer the given questionnaire by providing an answer indicating the levels of agreement or disapproval of each question. The levels of agreement used are: 1) strongly agree, 2) agree, 3) fair, 4) disagree and 5) strongly disagree. Questionnaire responses are given to material or content experts, design experts, and language expert. The experts need to give response on 15 questions for each expert about the module. Having had the experts’ answer, the researchers analyze the score and interpret the results as explained in Table 3. The target of accomplishment in the module is said to be appropriate which is in “Good” Qualifications or about 75%–89%.

| Percentage   | Qualifications |
|--------------|----------------|
| 90% - 100%   | Very Good      |
| 75% - 89%    | Good           |
| 65% - 74%    | Fair           |
| 55% - 64%    | Low            |
| 0% - 54%     | Very Low       |

There are 4 materials or content experts, that is, 2 design experts and 2 language experts, as the response of module. The feasibility test of module material or module content is conducted by 3 expert
lecturers. The average score is 4.41 or 88% at 14 points of statements. Average score is included in the “good” category as described in table 4.

**Table 4. Material Expert Score.**

| Indicator                                                                 | Average Score | Percentage |
|----------------------------------------------------------------------------|---------------|------------|
| Curriculum                                                                |               |            |
| - Core competence shown in practicum module                               | 4.50          | 90%        |
| - Base competence shown in practicum module                               |               |            |
| Content                                                                   |               |            |
| - The content is in line with the core competence                          | 4.33          | 87%        |
| - The content is in line with the basic competence                         |               |            |
| - The material in the module is according to what was learned in high school.|               |            |
| - The purpose of the practicum is written at each practical activity        |               |            |
| - Tools and materials for practicum are difficult to find                  |               |            |
| - Evaluation is based on the material                                      |               |            |
| - Image according to material                                              |               |            |
| Characteristic                                                            |               |            |
| - Modules cannot make students active in learning                          | 4.50          | 90%        |
| - Modules do not contain the relationship between concepts and everyday life|               |            |
| - Increases student’s curiosity                                              |               |            |
| Scientific Approach                                                       |               |            |
| - Train the basic attitudes of research that exist in the scientific method| 4.33          | 87%        |
| - Practical activities can be carried out independently                     |               |            |
| Total Average                                                             | 4.41          | 88%        |

The feasibility test of module design is carried out by 2 expert lecturers. The average value is 3.90 or 78% at 5 points of statements. The average score is categorized as “good” category, as it is shown in table 5.

**Table 5. Design Expert Score.**

| Indicator                                                                 | Average Score | Percentage |
|----------------------------------------------------------------------------|---------------|------------|
| Module Design                                                             |               |            |
| - Module cover is in line with material                                   | 3.90          | 78%        |
| - Writing in accordance to the font type                                  |               |            |
| - Suitability of module content design                                     |               |            |
| Layout                                                                    |               |            |
| - Suitability of background and color                                     | 3.90          | 78%        |
| - Suitability of images with layout                                        |               |            |
| Total Average                                                             | 3.90          | 78%        |

The feasibility test of module language is conducted by 2 expert lecturers. The average score is 4.01 or 81% at 9 points of statements. The average score is in “good” category, shown in table 6.

**Table 6. Language Expert Score.**

| Indicator                                                                 | Average Score | Percentage |
|----------------------------------------------------------------------------|---------------|------------|
| Writing                                                                    |               |            |
| - The experimental procedure uses passive language                         | 4.31          | 86%        |
| - The writing is clear and easy to read                                    |               |            |
| - Structured writing                                                        |               |            |
| - Conformity of writing type and size                                       |               |            |
| - The use of sentence structure is clear                                    |               |            |
| Grammar                                                                    |               |            |
| - The sentence use is easy to understand                                   | 3.71          | 74%        |
| - The language use is communicative                                         |               |            |
| - Use formal language                                                       |               |            |
| - Sentence questions according to the level of students’ abilities          |               |            |
| Total Average                                                              | 4.01          | 81%        |
The average validation results of the three main aspects of material or content, design and language are as follows. The average score from all experts is 4.10 or 82% and is categorized as “good” category that is shown in table 7.

Table 7. Expert Validation Result

| Validator             | Average Score | Percentage |
|-----------------------|---------------|------------|
| Material or Content   | 4.41          | 88%        |
| Design                | 3.90          | 78%        |
| Language              | 4.01          | 81%        |
| Total Average         | 4.10          | 82%        |

3.5. Evaluation

This stage is an evaluation stage for module’s improvement which is developed after being validated. Suggestions and comments from experts are then accepted to improve the contents of the module. In terms of material, there are number of comments including the suitability of competence with the contents of the module, the suitability of practicum objectives with competencies, unclear experimental steps, less complex lab analysis, and evaluation of practical activities that are needed to be added.

In terms of module’s design, there are number of comments, namely the display of the module background that must be adjusted to the content of the material and the colors in the writing and background that must be clear. From the language side, there are some comments including the use of sentences adjusted to the level of understanding of students, the replacement of type of writing, and the language use must be communicative and effective.

The scientific method that is based on authentic assessment and the learning steps do not create students’ involvement optimally [11]. Learning by scientific module shows that a learning environment integrates cognitive apprenticeship and formative assessment in a series of conceptual designed tasks provides a rich context for helping students build scientific habits of mind [12]. According Saregar [13], simulation PhET which is equipped with module makes it more interesting, can increase students’ interest in learning physically and finally expected to increase the mastery of students’ concepts. Physics learning with scientific module will make students active and independent and will make students to have a good scientific attitude.

Learning science with using teaching materials in module is very useful for teachers because students will be more creative in developing themselves. Also, learning activities will become more interesting, students will get more opportunities to learn independently, the dependence on the presence of science teachers is decreased, and students will also get an ease in mastering each competence[14][2]. The learning module gains an understanding of literacy concepts and the flexibility of information, self-paced delivery of this module is an effective way for students to develop their information of literacy skills [15]. The right media selection must be considered by the teachers in preparing teaching materials used in the class[16]. With the existence of a scientific-based lab module as a learning media, it can be able to attract students to make the latest innovations in learning Physics.

4. Conclusion

Based on the experts’ validation results, it can be concluded that Physics Practical Module Based on Scientific Method for the Tenth Grade High School Students in the Second Semester is appropriately to be used.

5. References

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