Validity of physics learning module based on problem based learning to improve students metacognitive skills

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Abstract. Metacognitive includes to high-level thinking domain that involves active control in the cognitive process to solve a problem. Various efforts to improve the mastery of metacognitive skills was indispensable, one through the use of module that stimulated the metacognitive skills of students. This research and development (R&D) aims to produce physics learning module based on problem based learning on topic of momentum and impulses. Module development used Plomp model. To use this module, validation is required. Module was validated by five experts (three lecturers of Universitas Negeri Padang and two physics teachers of senior high school 1 2X11 Enam Lingkung). The data collection used questionnaire method. Aiken's V was used to analyze validity. The validation results showed that content validity were 0.89 by expert and 0.86 by practitioners, construct validity 0.84 by expert and 0.87 by practitioners, and language validity 0.84 by expert and 0.83 by practitioners with valid category and can be used to determine the improvement of metacognitive skills of students. Suggested to physics teachers to implemented the problem based learning module and emphasised metacognitive skills in learning process.

1. Introduction
Education is a conscious effort made by man to increase knowledge and skills. Efforts to improve the learning quality of students should be supported by many aspects, that is aspects of knowledge, attitude, and skills. The learning process in the classroom should provide the students experience in the form of skills, attitudes, and knowledge simultaneously. Based on curriculum 2013 demands, students are expected to understand, implement, and analyze the factual, conceptual, procedural, and metacognitive knowledge by studying lesson topics. To achieve these competencies, students are required to learn the independent, active, and scientific learning process.

Based on the observation of learning activities at senior high school 1 2X11 Enam Lingkung conducted on October 11, 2017, it is seen that the learning process in the classroom has not been in accordance with the demands of the curriculum 2013. Application of approaches and methods/learning models and learning resources is still not optimal. In fact, physics teaching in schools has tended to focus on teachers so that during the learning process the students are less participated. Through such learning, the lack of involvement of students in constructing their knowledge of learning materials and ultimately make the learning process becomes less effective. This resulted in the competence of students knowledge is still in the low category.
Students often seem confused with the problem-solving problem that is arranged in the form of a story. In solving the problem is usually students directly apply one of the formulas it knows, without identifying what is needed in solving the problem. Meanwhile, to be able to solve the problem should be linked between one concept with other concepts that have been previously studied.

The low activity of thinking is very influential on the competence of students, one of them metacognitive skills. As Khun and Dean explain, metacognitive is what enables a student who has been taught a particular strategy in a particular problem context to retrieve and deploy that strategy in a similar but new context [1]. Through metacognitive students can train their skills in selecting information used in solving a problem, linking a concept with other concepts, or linking conceptual understanding with procedural experience. However, students are poorly trained in solving contextual problems that require reasoning in understanding the problem. In addition, the questions given in the learning process focus more on routine issues so that high-level thinking processes have not been touched. Therefore, it needs a learning model that can involve the active participation of students during the learning process, that is one is problem based learning.

Problem Based Learning (PBL) is a student-centered learning model that empowers students to conduct research, integrate theory and practice, and apply knowledge and skills to develop appropriate solutions to predetermined problems [2]. PBL is a learning that is based on the theory of constructive learning by presenting authentic problems to students, so that students can construct their own knowledge and learn independently to solve a problem.

Research results revealed that problem-based learning can significantly improve students metacognitive skills [3]. Through the application of problem-solving learning model, students metacognitive skills can be built [4]. This learning model offers and trains problem solving strategies that enable students to predict, monitoring, correct, and assess their own problem solving strategies. During the problem-solving process, students metacognitive awareness can be nurtured because it provides direction for students to ask themselves whether to understand what is being learned. The results of other research also indicate that students who are learned through PBL strategies have an increased average score of metacognition skills higher than students who were taught through conventional cooperative strategies. In addition, the implementation of the PBL strategy was also responded positively by students who were taught using the strategy [5].

In applying problem based learning, the teacher acts as a facilitators and motivators for students. During the learning process, teachers should provide a teaching material that can be used by students. One of the teaching materials that can lead students to learn independently is the module. Through the use of modules in learning, is expected to be a means for students in developing their metacognitive skills. Based on this problem, it is necessary to develop physics based learning problem based learning module to improve metacognitive skills that is on momentum and impulses material.

2. Research Method
This research was research and development (R&D), methods that was used to produce a particular product, and tested the affectivity of the product [6]. This research produced module based on problem based learning on the topic of momentum and impulses for senior high school. The development model used Plomp model that consists of three phases: preliminary phase, development or prototyping phase, assessment phase [7]. This research carried out until the stage of development that was the validity of the module.

2.1 Preliminary Phase
This phase is done to get information about the problems in the field of education, one of which illustrates the conditions regarding product specifications developed and can be used in learning. At this stage an analysis will be described in the following explanation. (1) curriculum analysis, aims to see the gap in the implementation of the learning process in schools with the learning expected by the 2013 curriculum. This analysis was done by giving questionnaires to physics teachers high school; (2) analysis concept, is the identification of the materials that will be discussed in the learning. This
analysis was carried out by identifying and arranging them in the form of hierarchy, and detailing the main concepts and supporting material of momentum and impulses, through several books related to physics concepts; (3) students analysis, aims to examine the characteristics of students in grade X senior high school. This analysis is done by giving a questionnaire to the student.

2.2 Development or Prototyping Phase

The products designed was learning materials in the form of momentum and impulses module based on problem based learning for senior high school student. The module was designed in accordance with the stages of problem based learning, which included five phases: (1) student's orientation to the problem, (2) organizing learners to learn, (3) developing individual and group investigations, (4) developing and presenting results, (5) analyzing and evaluating problem-solving processes [8]. The preparation module format was modified from guide books of module writing that stated by the Education Ministry [9]. In the module, the metacognitive skills indicators are trained by using the problem based learning syntax. During this stage, the prototype is developed, evaluated, and then revised repeatedly. This phase has a microcyclics that helps in developing and improving the product to produce a valid and practical final product.

The prototyping phase consists of prototype 1, prototype 2, and prototype 3 which is the result of formative evaluation. In prototype 1 self-evaluation to check the completeness of the components contained in the learning module to avoid errors, then continued with an expert review. In prototype 2 tested with One-To-One Evaluation. The purpose of this evaluation is to examine the practicalities of the module in identifying the clarity of module design, module display, module presentation aspect, problems in modules and languages used in the module. Furthermore, prototype 3 is tested with Small Group Evaluation to test the learning module's practicality about the suitability of time allocation and ease of use of learning module by the students.

The validity instrument that has been used is validation sheet compiled by using Likert scale. The validation sheet is addressed to 2 lecturers of physics Universitas Negeri Padang, 1 lecturer of Indonesian Universitas Negeri Padang, and 2 physics teachers of senior high school 1 2X11 Enam Lingkung. Validation of problem based learning modules include content validity, construct validity, and language validity. Validity data obtained was analyzed by using Aiken's V formula (equation 1) [10]:

\[
V_i = \frac{\sum s}{n(c-1)}
\]

Information:
- \(V_i\) = item validity index
- \(s = r - l_0\)
- \(r\) = the score given by validators for each item
- \(l_0\) = minimum score (in this case \(l_0 = 1\))
- \(n\) = number of validators
- \(c\) = maximum score (in this case \(c = 4\))

Interpretation of the validity of the learning module is determined by the criteria that can be seen in Table 1:

| Interval     | Category |
|--------------|----------|
| \(V < 0.667\) | Not Valid |
| \(0.667 \leq V\) | Valid |

Table 1. Criterion of the validity decision based on Aiken's V [10]
3. Results and Discussion
Based on the purpose of research and development (R&D) by using a Plomp model development, it was obtained results of the study for each stage of development. The results obtained at each stage that has been done were preliminary phase and development or prototyping phase.

3.1 Preliminary Phase
At this preliminary phase, it was found three data, those were curriculum analysis, analysis of student, and concept analysis. The result were described in the following explanation.

3.1.1 Curriculum Analysis Result. Based on the analysis of questionnaires that was given to 2 senior high school physic teachers in senior high school 1 2X11 Enam Lingkung, showed that teachers had been teaching still in the conventional method (teacher center, where as in 2013 curriculum demanded learning process that was student center). Teachers have prepared RPP as a guide of learning process, but in its implementation still not maximal. Based on analysis of competency standards of graduates, the data showed that the percentage of knowledge competence that is equal to 54.16% is still low when compared to attitude competence and skill competency which have percentage of 78.33% and 75% respectively. The learning materials used in schools was presented verbally and concepts provided directly, even though there were pictures but had not been able to fully help the students to discover concepts independently in accordance with the demands of the 2013 curriculum. This is in accordance with Fanny (2017) which states that most teachers in schools do not understand the writing of scientific papers. In addition, lack of interest in writing causes teachers to rarely write, including developing teaching materials used in learning [11]. Based on the above issues, it should be developed a learning materials that can make students active, creative and innovative that demanded to 2013 curriculum. This study developed a learning material, namely momentum and impulses module based on problem based learning that was expected to lead students in concept invention, to improve the activity of students in the learning process, and improve the students' understanding of the material being studied.

3.1.2 Analysis of Student Result. Student analysis has been done by analyzing the characteristics of students of class X IPA through the questionnaire. The thing done is to see the tendency of learning, the characteristics of students in thinking, and the skills of students in learning and the interest of learners in using the module. Based on the results of the analysis of students thinking skills obtained that students creative thinking skills are still low. This can be seen from the low results of learning physics. The ability to think creatively is characterized by the ability to think fluently. The ability to think fluently is characterized by the ease of solving problems and being able to build interrelationships between concepts [12]. Therefore, students need to improve their creative thinking skills. Furthermore, based on the analysis of questionnaires filled by students, obtained data that the interest of students on physics learning is still relatively low at 46.74%, this is due to the learning process that tends to be fixed on one source of learning that is textbooks. Furthermore, based on the analysis of learning styles of students seen that students prefer visual style of learning with a presentation of 64.43%. Therefore, it is necessary to develop teaching materials that can increase the interest and motivation of students to learn, and can make students learn independently one of which is a module. Furthermore, based on the interest analysis of learners in using the module is a module that presents contextual problems and natural phenomena associated with the subject matter, has an interesting blend of colors, and also has a balance between images and writings. The results of this analysis is one of the consideration in developing and preparing the material in the form of module. Developed modules have a color display which was expected to make students interested in learning, increase the activities of students and motivate them in learning.

3.1.3 Concept Analysis Result. In concept analysis, submission of momentum and impulses are identified and organized systematically then grouped by facts, principles, concepts, and procedures.
Based on analysis of the main concepts of momentum and impulses, the concepts obtained in momentum, impulses, and correlation of them, the law of conservation of momentum, the types of collisions, and the application of conservation laws of momentum in everyday life.

3.2 Development or prototyping phase
This stage was the stage to generate learning module design on momentum and impulse material based on problem based learning to improve metacognitive skill of class X high school students. The module sections are designed through modifications of the module components presented in the manual for module writing by the Education Ministry. In this research the module is developed with the structure: 1) the opening section: consisting of cover, introduction, table of contents, concept maps, description of module contents, prerequisites, module usage instructions, and competencies to be achieved; 2) the core part: consisting of learning activities undertaken by students include learning objectives, material descriptions, worksheets, formative evaluation, tasks, and summary; and 3) the closing section, which consists of summative evaluation, assessment guidance, glossary, bibliography, and answer key. The learning module is based on a problem-based learning model. Syntax of problem-based learning model was reflected in the learning module.

3.2.1 Validity of Module. Data validity of module based on problem based learning can be seen in Table 2. Table 2 showed that module developed had valid for all components of the assessment that included the feasibility in terms of content, construct, and language.

| Components          | Validator Assessment | Average (%) |
|---------------------|----------------------|-------------|
|                     | Expert US RL AB P1 P2 |             |
| Content validity    | 0.89 0.88 - 0.86 0.85 0.89 | Valid 0.86 Valid |
| Construct validity  | 0.89 0.79 - 0.85 0.89 0.84 | Valid 0.87 Valid |
| Language validity   | 0.95 0.80 0.83 0.80 0.85 0.84 | Valid 0.83 Valid |

In the aspect of the contents obtained module validity index is 0.89 by expert and 0.86 by practitioners with valid criteria. This indicates that the material in module has been referring to the 2013 curriculum and has included materials in accordance with core competencies and basic competencies as well as sufficient to achieve indicators of achievement of competence. Based on the content of the module, the validators judged that the developed module as a medium of learning are relevant to the objectives that must be achieved student, including the suitability of the content, clear instruction, structure of the materials, the materials that are practiced were relevant to the instructional media, the design supported by pictures and texts to make it easy for the students to understand the learning materials. In addition, in the module, there is also a way of evaluating each submateri that aims to students can learn by themselves. This is in line with the opinion of Sudjana and Rivai, the purpose of teaching with the module is that students can follow the teaching program according to their own speed and ability, more self-study, can know their own learning result, and emphasize the optimal mastery of learning materials [13].

In the construct aspect, module based problem based learning have valid criterion with validity index 0.84 by expert and 0.87 by practitioners. This indicates that activities in module have been systematically compiled from title to assessment and indicate that module already contains a way of presenting the material in accordance with problem based learning steps. module also contains clear learning instructions, where instructional guidance is a guide for teachers and students in using module in the learning process. The module was based on the characteristics of high school students. The
module was consistent in the used of symbols, shape and font size. The layout of the module content is precise, the images presented in module are clear, the use of colors in module is appealing and the overall module display design is interesting. This is in accordance with Rustaman that the module should be well designed to attract readers, both in size (paper, letters, and pictures) and from the variations [14].

The last validity assessed is the aspect of language. The module had valid in aspect of language which means that the module was communicative, clarity of information, in accordance with Indonesian Spelling, in accordance with the level of understanding of students, and used the language effectively and efficiently. The things that need to be considered in the preparation of the module are the accuracy in preparing the sentences so that the module is composed communicative and easy to use as a learning guide for students [15]. This is also reinforced by Prastowo, module is basically a teaching that is arranged systematically with language that is easily understood students, according to their knowledge level and age [16].

4. Conclusion
Based on the results of research and data analysis, it was concluded that the momentum and impulses module based problem based learning developed was valid for high school physics teaching. Module developed had high validity categories that is the content validity ($v = 0.89$), construct validity ($v = 0.84$), and language validity ($v = 0.84$). Therefore, this module can be recommended to use in a real learning in senior high school, so that can improve metacognitive skill of students.

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