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Developing Problem Based Learning Module Containing Multiple Levels of Representation of Ksp Material to Improve Students' Problem Solving Ability

Irma Sulistiyanti[1*], Sri Haryani[2], Edy Cahyono[3]

[1]Chemistry Programs, Postgraduate Universitas Negeri Semarang, Indonesia
[2,3]Department of Chemistry, FMIPA, Universitas Negeri Semarang, Indonesia

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Abstract

Research is based on the mastery of problem solving abilities is still low and the teaching materials used in learning lack training and develop students' problem-solving abilities. This study aims to develop a module based on problem-based learning and contains multiple levels of representation in the solubility material and its solubility product which is feasible and to determine the improvement of students' good problem solving abilities. The research method used is research and development (Research and Development) and the learning modules are arranged according to PBL. Data were collected through expert validation sheets, tests and questionnaires. The results of the validation of the material experts, linguists and media experts respectively showed very good results with an assessment percentage of 93.98%, 86.03% and 88.39%. The results of module trials by students through questionnaires received very good feasibility assessments with a percentage of 78.89% and the results of module trials by teachers got very good assessments with a percentage of 96.83%. The results of the application of problem-based learning modules obtained data in the form of pretest-posttest values which were tested using the n-gain test. The n-gain test results obtained a value of 0.56 in the medium category. The results of this test indicate that there has been an increase in the problem-solving abilities of students after using the module. Based on the results obtained, it can be concluded that the PBL-based chemistry learning module on the solubility material and the solubility product developed is very effective and suitable for use in chemistry learning processes in schools.

*Correspondence Address:
E-mail: irmasulistiyanti28@gmail.com

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INTRODUCTION

In the 21st century, graduates of all levels of education face extreme global competition (Afandi et al, 2019). 21st century skills are various types of skills needed by humans in facing challenges and increasingly complex lives (Redhana, 2019). The rapid development of technology and widespread globalization in the 21st century have raised the concerns of many practitioners, educators and international organizations in the world about what skills students should have for the future (Levy & Murmane; Noe et al, 2014; Wagner, 2008; National Research Council, 2010).

Indonesia states that every lesson in the 2013 curriculum uses a scientific approach to increase student creativity. One of the important components of 21st century education is problem solving ability (Wismath et.al, 2014). Problem solving is a process to achieve goals when the achievement of these goals are not clear (Ryan et al., 2016). The problem solving indicators used in this study are modified from Polya (Herlambang, 2013), those are understanding the problem, making plans, implementing plans and looking back.

Chemistry is a science that seeks answers to what, why, and how natural phenomena in relation to substances, including structure, composition, properties, dynamics, kinetics and energetics which involve skill and reasoning (Chang & Overby, 2011; Huddle & Pillay, 1996). So, studying chemistry must start by solving the problems of everyday life (Jaber & BouJaoude, 2012). When students want to solve everyday problems, of course, it begins with thinking about the individual student's skills in responding to a problem. Students' individual thinking skills will be invited to collaborate on communication skills and teamwork skills. One of the learning models to solve this problem is *Problem Based Learning*.

Problem Based Learning (PBL) is a model that instills a learning process starting from thinking, collaborating in groups, then communicating and building new student knowledge so that students can provide solutions and solve problems either individually or in group discussions (Cahyono, 2019). In the PBL situation, students integrate knowledge and skills simultaneously and apply them in a relevant context (Sudarmin et al,2019). Other than that, *Problem Based Learning* (PBL) is an approach that challenges students to "learn to learn" and work together in groups to solve real problems (Amir, 2011). This is in line with the opinion that higher order thinking skills will be better if it is associated with problem-solving based learning, because the estuary and high-order thinking patterns are able to solve problems (Widodo & Kadarwati, 2013). PBL itself is a learning model that makes problems as a basis for students to learn, where students can apply critical, creative thinking and solve problems and apply knowledge to the real world of students and issues. (Levin, 2001), where the problems presented in learning using the PBL model are problems that are able to explore students' curiosity, such as problems related to everyday life (Dutch et al., 2000). Increasing the problem-solving abilities of students in groups and individually requires appropriate learning models and media.

The results of field studies show that the use of teaching materials in chemistry learning is not optimal. Teachers only use worksheets which only contain material summaries and questions that do not include level thinking so that students' mastery of problem solving abilities is still low. Based on these problems, students' mastery of problem solving abilities must be trained. One of the activities that can be done is developing modules.

From various learning media, modules can be selected to be developed to support learning activities. Modules are teaching materials that are arranged systematically in language that is easily understood by students, according to their age and level of knowledge so that they can learn independently with minimal guidance so they can study independently with minimal guidance from educators (Prastowo, 2012: 106 By using modules, students are expected to be able to carry out independent learning and solve problems completely.

The module is expected to describe the relationship between three levels of chemical representation (macroscopic, submicroscopic, and symbolic) so that students can understand chemistry comprehensively (Gilbert and Treagust, 2009), because there are still many students who do not understand the concept of material comprehensively, especially at the submicroscopic level. and symbolic language. The findings in the field show that students can present the macroscopic level quite well, but are still weak in presenting the submicroscopic and symbolic levels, this is in accordance with the findings (Haryani, 2019). Considering that chemical concepts are abstract, such as interactions between atoms, molecules and ions (Gkitzia, et al., 2010). If the module developed includes all three levels of chemical representation, then the module developed has the potential to improve problem solving abilities (Annisa, 2018). Problem-solving skills to develop meaningful chemistry knowledge could be accomplished with the ability to carry out interpretation and transformation among the three levels of chemistry phenomena (macro, sub-micro and symbolic) through visual, verbal, symbolic, or action representation (Sunyono & Meristim, 2018).

In addition, module development is carried out to guide students in solving problems. Modules can be combined with a problem based learning model.

Based on this description, the problem in this study are how is the feasibility of a problem-based learning module containing multiple levels of representation and how is the problem-solving ability after using the module. This study aims to develop PBL-based modules and MLR content, analyze the feasibility of developing PBL-based modules and MLR-loaded modules and analyze students' problem solving abilities.

METHODS

This type of research is a research and development (Research and Development) (Sugiyono, 2008) with a modified 4D model. The subjects of this study were 65 students of class XI IPA at MA Darul Hikmah Jepara who had studied the solubility material and the product of solubility.

Sources and data collection methods include: documentation, questionnaires, tests, observations, and interviews (Tria, 2020). This study contained data analysis, namely: feasibility validation analysis, student response analysis, and problem solving ability analysis.

RESULTS AND DISCUSSION

This chemistry learning module is structured based on PBL syntax, such as: orientation of students on problems, organizing students to learn, guiding individual / group learning, presenting work, and evaluating the problem-solving process (Kristia et al, 2017). The stages are then designed to be presented in a module which is divided into 3 parts, those are the introduction, presentation, and closing.

The introduction part of the module is an introduction part and instructions for students to find out the steps of learning using PBL-based multiple level of representation based learning modules to be implemented. In this introduction section several stages are given, there are Module Descriptions, Instructions for Using Modules, Core Competence, Basic Competence, and Learning Objectives, as well as a Concept Map for the solubility material and the product of solubility. The existence of PBL learning steps is expected that students can understand and be able to prepare themselves to participate in learning activities well.

The module presentation section is the part after the introductory section where there are learning activities to be carried out. The presentation section generally consists of three case studies, three discussion columns, and three learning activities in which there are discussion activities, material descriptions, summaries, and independence tests. The learning activities are then arranged in a module based on the PBL syntax.

The first stage is the orientation of students towards the problems, at this stage the module presents articles about the problem and guides students to find the concepts in the article. The first stage is presented in the case study column, in the case study column of students in each section of the Learning Activity there are examples of natural phenomena related to solubility material and solubility products, one example in Learning Activity 1 is the solubility of lime compounds in water, which is shown the phenomenon of limestone groundwater in Toroh Sub-district in a limestone mountain area in Central Java Province where people often complain about the appearance of white deposits / crusts from the water used.

The next stage is to organize students for learning presented in the Discussion Column section. In this section students are directed to form groups and discuss. Next is the Learning Activity, at this stage students carry out learning independently or in groups. This section contains material descriptions, examples and exercises, summaries, and independent tests. The description of the material is divided into three, the first part contains a description of the concept of solubility and the product of solubility, the second part contains the concept of changes in the solubility equilibrium because of the influence of namesake ion, pH, and the third part is predicting precipitation. Similar to the Discussion Column section, the Learning Activities section is divided into three parts. At this stage students are expected to be able to learn independently, both individually and in groups to master the concepts presented, and also by practicing through existing sample questions. To understand the description of the solubility material and the product of solubility, in the learning activities section, the material presented contains three levels of representation, those are macroscopic, microscopic and symbolic.

The stage of presenting the work, and evaluating the problem-solving process is presented in the Discussion Report, Learning Assessment and Reflection section. In this section students make a written report on the results of the discussion in the Discussion Column, which they do with their groups. The report framework can be seen in the picture and students are also guided to deliver the results of the report orally (presentation). With self-assessment through learning assessment tables and teacher reflection tables to help students evaluate what they have done during teaching and learning activities

The last part of the developed module is the closing part, this section is a complement to the module content, in the form of a glossary, a data table of compound solubility products, answer keys to practice questions and independent tests, and a bibliography. The existence of a glossary is expected to help students understand the meaning of the terms in the module. And with the practice answer keys, students can check their answers so they know what parts need to be fixed.

After designing the teaching material instrument, then the next stage is the development stage by realizing the module design that has been designed into a module that is ready to be validated. Validation was carried out on material experts and media experts consisting of 2 Chemistry Education lecturers and 1 high school chemistry teacher. Validation is carried out to determine the feasibility of the module. The results of the material expert and media expert validation are presented in Table 1.

Table 1 Module Validation Results

Module Presentation	1	80 %	Good
Graphic Eligibility	6	85 %	Very Good
Display Quality	1	70 %	Gook

Based on the analysis of module validation results from material experts, the ideal percentage was 90.04%. This means that the feasibility of the module in terms of material is included in very good feasibility. Meanwhile, the results of module validation from media experts showed that the ideal percentage was 78%. This means that the feasibility of the module in terms of media is included in good feasibility. The module has been equipped with several learning activities that can attract students' interest in learning the material, in accordance with the objectives of the PBL model, which is to make learning more effective and student-centered (Sujiono & Widiyatmoko, 2014). This is in accordance with the opinion of Strobel & Barneveld (2009) which states that the PBL model is successful in creating effective learning strategies. However, input and suggestions from the validator were still considered to make improvements to the developed module before being tested. Some of the improvements made to the module, such as not being able to explain the meaning of solubility and solubility product, the concept map is not clear, the material is still unclear about the name ion effect, the source has not been included, and many typos in writing.

The revised module was ready to be piloted on a small scale. A small scale trial was conducted to determine the readability level of the module being developed. Small-scale trials were carried out by distributing module to 9 students in 11^{th} grade Science 1. After finishing the students filled out the module questionnaire sheet. The recapitulation of the module readability questionnaire scores can be seen in Table 2.

The response of students to the module as a whole showed that the developed module got a good response from students and was feasible to use as a learning resource which can be seen from the average score of 81.83%. However, in filling out the questionnaire, there were input and suggestions from students, such as the printing of the module was not large enough, there were less examples of questions and unclear images. The improved module was then tried out on a large scale.

Table 2. Recapitulation of module readability questionnaire scores

Assessment Aspect	% Ideality	Eligibility Category
Ease of understanding the material	97.7%	Very good
Independent learning	78.8%	Good
Learning activeness	70.3%	Good
Module interest	79.3%	Good
Presentation of the module	83%	Very good
Use of modules	85.5%	Very good
Multiple Level of Representation	83%	Very good
Problem Based Learning	77%	Good

Large-scale trials were conducted by distributing modules to 65 students for use during solubility learning and solubility results. After completion, students filled out a questionnaire response sheet to assess the feasibility of the module being developed. The results of the questionnaire score recapitulation in large-scale trials are presented in Figure 1

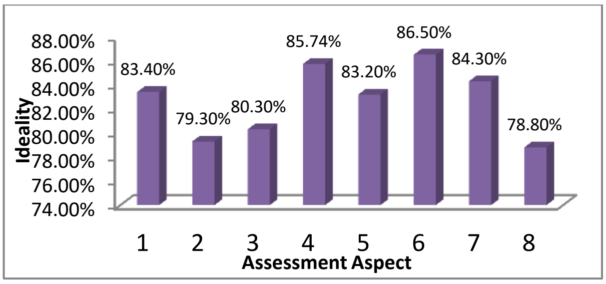

Figure 1. Diagram of the results of a large-scale student response questionnaire

Information :
1. Ease of understanding the material
2. Independence in learning
3. Learning activeness
4. Module Interest
5. Presentation of the module
6. Use of modules
7. Multiple Levels of Representation
8. Problem Based Learning

The results of respondents from scale students got a mean value of 82.69%. When converted to a Likert scale, it is included in the criteria for both learning media. In addition to assessing the feasibility of the module, students were asked to provide suggestions and criticism. In general, the suggestions and criticisms given were very positive for the module media such as:

a. The PBL based chemistry learning module with multiple levels of representation is good and interesting.
b. This module is very interesting because there are pictures that are quite clear and the material is easy to understand.
c. This module is very interesting because there are steps in solving problems in learning
d. Using modules makes it easier to learn independently.

In large-scale trials, before learning began students were given pretest questions and after learning were given post test questions. The students 'pretest and post test answers were then assessed to determine the increase in students' problem solving abilities. The pretest and posttest results were then analyzed by using the n-gain test. Based on the n-gain test carried out on students, the results obtained in Table 3 and Table 4.

Table 3 Recapitulation of Students' Problem Solving Ability

n-gain Score	Classification	Total of The students
0.70 < n-gain ≤ 1.00	High	45
0.30 < n-gain ≤ 0.70	Moderate	13
n-gain ≤ 0.30	Low	7

Table 4 The results of the average n-gain test on students' problem-solving abilities

Grade	Average Score		N-gain	Classification
11^{th} Grade Science 1 & 2	Pretest	Post test		
	19,55	61,45	0,56	Moderate

The result of the overall n-gain test by calculating the average value of the pretest and post test, it was obtained that it was 0.56 which was included in the moderate category. It showed that the module of problem-based learning containing multiple levels of representation which is developed can increase the students' problem-solving abilities in the solubility material and the product of solubility. This increase is marked by the students' ability to answer post test questions better according to the steps that have been spaced than when students work on pretest questions.

CONCLUSION

Based on the research that has been done, it can be concluded that the problem-based learning module for students to improve the students' problem-solving abilities is feasible. The analysis of the feasibility of the product obtained from the material and media expert validator resulted in a total percentage of the material and media expert validator respectively 90.64% and 78%, which means good feasibility and the average score of the response of students was 81.83%. It showed that students can easily learn using the solubility module and the solubility product. The improvement of students' problem-solving abilities after using the problem-based learning module was shown by the n-gain test with a result of 0.56 which was classified as moderate.

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