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The Development of Problem Based Learning (PBL) Module on Mathematical Logic Course

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Abstract. This study aimed at developing and to determining a qualified teaching materials in the form of Problem Based Learning (PBL) module on Mathematical Logic Course. PBL module is a form of systematic teaching material to support the learning process that can also be studied by students independently with authentic and meaningful problems or situations. This research can be catagorized as Research and Development or R&D. This development model was employing 4-D model with 4 stages of define, design, develop and disseminate stages. In this study, there was only 3 stages that were performed, namely define, design, and develop. The research instrument was using a module validation sheet. The product assessment was carried out by three validators consisting of two material experts and a media expert who were the lecturers of mathematics education study program. The results showed that the assessment of the two material validators towards PBL module on Mathematical Logic Course indicating the total mean score of 3.65 with the "very valid" criteria while, according to the media experts,the total mean score was 3.8 that can be catagorized as "very valid". It means that the developed PBL module on Mathematical Logic Course has fulfilled the valid criteria, so it is feasible to be used in mathematics logic lectures.

Keywords: Module, Mathematical Logic, Problem Based Learning

1. INTRODUCTION

Logic is a field of science that studies the principles of correct reasoning and valid conclusions, either deductive and inductive by (Sukirman, 2005). It is in line with the opinion from Kusumah (1986) which states that logic is a method and principle that can explicitly separate between right and wrong reasoning. The benefits of logic learning are helping individuals to think rationally, critically and systematically, and to improve the ability of objective and careful thingking (Jupri, 2009). Moreover, the mental processes that occur in the individual during the mind development in facing several cases or problems are called individual reasoning abilities (Pamungkas & Yuhana, 2016). The individuals who have good reasoning ability will be able to take the right decision in every action and vice versa since naturally human has bornwithsome ability to think logically. However, as the problemsgetting more complicated, the natural logic is not enough to

solve these current problems, thus, scientific logic is needed or usually called mathematical logic.

Logic can be illustrated as an infant of mathematics while mathematics is a mature period of logic (Jupri, 2009). It indicates that all mathematical concepts and propositions can be returned to logic, or also called mathematical logic. In college, especially for the mathematics education study program, it is a compulsory subject with a 3-credit course. The purpose of this course for education study program is to prepare the students to teach the concept of mathematical logic in senior secondaryeducation level (SMA/MA/SMK).This is in accordance with the ultimate goal of the graduates of the mathematics study program, who are expected to be professional teachers. By studying the mathematical logic, the students are also expected to be able to understand the concepts of logic and solve mathematical problems logically and systematically in tehir daily life. To accomplish the objective, it must be of course supported by teaching materials that are appropriate with the students 'needs and the characteristics.

The teaching materials are arranged systematically that can be used by teachers and students in the process of learning (Belawati, 2007). As stated by Panen, P. & Purwanto (2001), teaching materials are systematic materials or lecture information in the learning process. Teaching materials have a systematic structure and sequence. It is functioning to explain the instructional objectives, motivate students, provide summaries, and be generally individual-oriented. Teaching materials are usually independent, meaning that they can be independently studied by students due to its systematic arrangement and completeness. Several types of teaching materials commonly used in lectures include handouts, books, worksheets and modules.

However, in fact, in mathematical logic course, the teaching materials are only the textbooks provided by the lecturers. Based on the interview result with the students, it is revealed that they find it difficult to understand the textbooks because the language instruction and the material explanation require a high analysis. It becomes a big problem for the students as this course is relatively new for them. In addition, there are notations or symbols in the books that are different from those used in other lectures. Based on the condition above, it is crucial to develop a teaching material for mathematical logic. In this case, the developed instructional material is a mathematical logic module based on Problem Based Learning (PBL).

The selection of PBL approach is due to its appropriateness with the material of mathematical logic. One of PBL characteristics is it encourages students to be able to find problems and elaborate them by proposing assumptions and planning solutions as well as to reflect the effectiveness on their way of thinking in solving problems (Herman, 2007). Through the development of PBL modules, it is expected that the students can be independent learner, individually or in groups. It is also createdas an alternative teaching material that can be used in mathematics logic lectures.

Based on the description above, this study aimed at (1) developing PBL modules for mathematical logic course; and (2) knowing the validity of the developed modules.

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2. RESEARCH METHOD

A. Research Type and Procedure

This research can be catagorized as Research and Development (R&D). According to Sugiyono (2010), R & D is to produce certain products and test the effectiveness of the developed products. The procedure for developing this module uses a 4-D model, namely define, design, design, and disseminate stagesIn this study, there was only 3 stages that were performed, namely define, design, and develop. The research design can be described as the following procedure:

1. Define
   This stage was carried out to know the learning process of Mathematical Logic Course in Mathematics Education Study Program of Riau Kepulauan University (UNRIKA). After that, some problems were analyzed based on the real condition. These process included analyzing the curriculum, analyzing and reviewing reference books, studying the characteristics of students, and conducting discussions with peers.
2. Design
   The design stage was reffering to the defining result. At this stage, some actions were taken to design the module of Mathematical Logic. The module contained preface, modules instructions for lecturers and students, table of contents, material descriptions starting with the problem and followed by the blank space to lead students to understand the concepts of mathematical logic, samples of questions, exercises, glossaries and bibliography.
3. Develop
   In this stage, the developed module were validatedthrough consultation and discussion with the validator in order to know the extent to whichthe valid criteria representingthe feasibility aspectsof content, presentation, and language. Aftarewards, the trail of the module was done to reveal the module effectiveness through questionnaire distribution to students. However, in this study, it just covered the module validation stage that was performed by three validators comprising two material experts and a media expert.

B. Research Instrument and Data Collection Technique

The research instrument was the module validation sheet. It was used by the validator to assess the developed product to know the feasibility aspect of the content, the presentation, and the language. The data from the validation sheet were processed through the following steps:

a. Calculating the mean score of each assessment aspect from all validators with the formula of:

$$\bar{x} = \frac{1}{validator \;\; number} \text{X} \frac{\sum x}{n} \qquad (1)$$

Explanation :
$\bar{x}$ =mean scores
$\sum x$ = the obtained scores
n = the number of question items

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b. The mean score was, then, converted into five-scale qualitative data, as shown in the following table (Widyoko, 2017):

Table 1.Conversion of Five-Scale Qualitative Data on Module Assessment

Score Range	Score	Criteria
$\bar{x} > M_i + 1{,}8SB_i$	A	Very Valid
$M_i + 0{,}6SB_i < \bar{x} \leq M_i + 1{,}8SB_i$	B	Valid
$M_i - 0{,}6SB_i < \bar{x} \leq M_i + 0{,}6SB_i$	C	Moderate
$M_i - 1{,}8SB_i < \bar{x} \leq M_i - 0{,}6SB_i$	D	Less Valid
$\bar{x} \leq M_i - 1{,}8SB_i$	E	Invalid

Explanation:

$\bar{x}$ = Mean score

M_i = $\frac{1}{2}$ (ideal maximum score + ideal minimum score)

SB_i = $\frac{1}{6}$ (ideal maximum score- ideal minimum score)

c. Table 1 was developed with the ideal maximum score of four-scale and one-scalewasfor the ideal minimum score. The development table is shown in Table 2 below:

Table 2. Criteriaof the developed Module Validity

Score Range	Score	Criteria
$\bar{x} > 3{,}4$	A	Very Valid
$2{,}8 < \bar{x} \leq 3{,}4$	B	Valid
$2{,}2 < \bar{x} \leq 2{,}8$	C	Moderate
$1{,}6 < \bar{x} \leq 2{,}2$	D	Less Valid
$\bar{x} \leq 1{,}6$	E	Invalid

The module can bedeclared“feasible” to be used if the minimum criteria are in thecriteria of“valid”.

3. RESULT AND DISCUSSION

This study aimed at developing PBLmodules fro Mathematical Logic Course. The development procedure used 4-D model but this study was only through 3 stages of define, design, and develop. The implementation results of the development procedure are described as follows:

1. Define Stage
   a. Curriculum Analysis

      The purpose of this curriculum analysis was to decide the competence of the developed teaching materials. In this stage, Semester Learning Plan of Mathematical Logic Course in Riau Kepulauan University was analyzed and three topics were chosen to be developed, namely introduction to logic, statements and its operations arguments, as well as deduction methods.

   b. Textbook review and analysis

Here, the textbooks used on mathematical logic lecturg were collected which were relevant to the subject being developed.

c. Students' Characteristic Analysis

The second semester students of Mathematics Education Study Program in the academic year of 2017/2018 came from different educational backgrounds. Based on data collection results,the students were graduated from senior high school with majoring of science and social studies, other were from vocational high school and islamic school. It certainly affected the students' initial ability of mathematical logic. Furthermore, based on the interview result in the beginning of the lecture,most of studentsadmitted that they never received material of mathematical logic during their high schools, so that this material wasrelatively new for them. Besides, the this interview sessionwith the students was conducted to obtain information on teaching materials, especially their expectation forMathematics Logic Course. The interview results indicated that students expected teaching materials in the form of dictates or modules that can be learned independently beyond the classroom. They also wanted that the modules used understabable language and symbols to guide them to discover the concepts of mathematical logic independently or in groups.

d. Peer discussion

This peer discussions session was to gather information related to mathematical logic course according to the lecturers point of view who were teaching mathematics logic courses. From the results of the discussion, it was revealed that the reference book in the mathematics logic course was only one book. Unfortunately, the students did not take any initiative actions to find other references, they just waited and followed the material from the lecturers. The symbols in the book were also not commonly used by the students.

2. Design stage

Referring to the define phase, PBL module for mathematical logic was developed. The module layout consisted of 1) cover, 2) preface, 3) module instructions for lecturers and students, 4) table of contents, 5) material description, 6) glossary and, 7) bibliography. In each chapter, there were introduction, standard of competence, material description, samples of questions, blank space and exercises at the end of chapter.

3. Develop stage

After the design phase was complete, the validation stage with media experts and material experts was done to reveal the validity of the developed module. The material expert validator was MarfiArio, M.Pd., from PasirPangaraian University and Nina Agustyaningrum,M.Pd., Riau Kepulauan University. Meanwhile, the media expert was Dr.Laswadi, M.Pd from the State Islamic Institute of Kerinci. The validation sheet for material experts consisted of 30 statements with the details of 12 statements for content feasibility, 9 items for presentation and language feasibility. The results of the module validity assessment from the validators are presented below.

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Table 3. The Validation Results from Material Experts

No	The Feasibility Apect	Mean score from the validator of		Mean score	Criteria
		1	2		
1	Content	3,6	3,4	3,5	Very Valid
2	Presentation	3,5	3,7	3,6	Very Valid
3	Language	3,9	3,8	3,85	Very Valid
Total of mean score				**3,65**	**Very Valid**

The following is the result of validation results from the media expert in case of feasibility assessment on its graphicality.

Table 4. The Validation Results from Media Experts

Assessment Aspect	Indicator	Mean score	Criteria
Feasibility	Module size	4	Very Valid
Graphicality	Cover design	3,6	Very Valid
	Content Layout	3,9	Very Valid
total of mean score		**3,8**	**Very Valid**

Based on the validation results in Table 2 and 3 above, the total mean scores were 3.65 and 3.8 that can be categorized as "very valid" criteria with the accomplishment of each aspect and the indicator had exceeded the score of 3.4. According to the established validity criteria, the developed PBL module for mathematical logic can be declared"valid" and "feasible" to be used in learning process.

The conclusion of the three validators showed that the module was appropriate to be used with some revisions. The following were some inputs from the three validators (a) providing some contextual questions that arouse students' motivation to learn material, (b) providing problem exercises, (c) revising some errors in compiling the truth tables, (d) using commonly terms or symbols, and (e) providing more questions and giving readers opportunity to answer their own problems, (f) providing the tables with names and numbers to easethe reading process.

Several parts of the module were also revised based on the validator feedback. The improvements were in the symbol writing, the material description as well as the samples of question by providing the blank space to guide students to be more active in solving problems. Moreover, several contextual practice questions were added.

4. CONCLUSION

Based on the research results and discussion, it can be concluded that, (1) the development of PBL module for mathematical logic was carried out through 3 stages of 4-D model, they were define, design, and develop. The development result was in the form of mathematical logic module consisting of three chapters, introduction, statements and its operations& arguments as well as deduction methods, and (2) the results of the module validity test from the three validators with the total mean score of material experts and

media experts were 3.65 and 3.8 respectively categorized as “very valid” criteria. Therefore, the developed module is valid and feasible to be used.

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