

The Development of Integration Technique Teaching Materials based on Problem Based Learning in Integral Calculus Course

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Keywords: Integration Technique, Teaching Materials, Problem Based Learning.

Abstract: This study aims to develop teaching materials of integration technique in Calculus course based on Problem Based Learning approach that meet valid and practical criteria. The research method is development research which consists of three stages: planning, development, and testing. The subjects of this study were the third semester students of Mathematics Education involving 40 people. The data collection instrument consists of validity and practicality sheets of teaching materials. The data collection technique was conducted with non-test technique. The data analysis used descriptive quantitative technique. Based on the results of the study, the teaching materials have met the valid criteria by 88.96% with Very Valid criteria. Furthermore, the teaching materials also met practical criteria by 88.75% with Very Practical criteria. Therefore, the findings of this study indicate that the integration technique teaching materials based on Problem Based Learning in Integral Calculus course meet very valid and very practical criteria.

1 INTRODUCTION

To improve the nation's competitiveness in facing the globalization era, higher education is needed to develop science and technology. Higher education as part of the National education system has a strategic role in educating the nation's life and advancing science and technology. According to Law Number 12 of 2012 concerning Higher Education Article 4, the functions of higher education are: (1) developing capabilities and forming dignified national character and civilization in order to educate the nation's life; (2) developing academicians who are innovative, responsive, creative, skilled, competitive, and cooperative through the implementation of Tridharma Perguruan Tinggi (the University's three main purposes); (3) developing science and technology by paying attention to and implementing the values of humanities.

As one of the formal education institutions, Universitas Islam Riau (UIR) is one of the institutions which take part in realizing the function of higher education that has been described above. In the field of teacher training and education, FKIP (Fakultas Keguruan dan Pendidikan—Faculty of Teaching Training and Education) is a pioneer in producing professional and reliable education personnel.

So far, the Mathematics Education, one of the

study programs in FKIP UIR, has tried to take various actions in order to achieve the goals of higher education, namely by trying to produce professional and reliable education personnel. There are several important elements, one of which is teaching staff or lecturers. Law Number 12 of 2012 concerning Higher Education Article 12 states that: (1) lecturers as members of the academic community have the task of transforming the knowledge and/or technology they master to students by creating a learning atmosphere so that active students develop their potential; (2) lecturers as scientists have the task of developing a branch of science and/or technology through reasoning and scientific research and disseminating it; (3) lecturers individually or in groups must write academic textbooks, which are published by universities and/or scientific publications as a source of learning and for the development of academic culture and civilization of writing activities.

The reality, however, contradicts the statement above. Scientific writing in Indonesian universities is unsatisfactory. The contribution of scientific publications by Indonesian universities is only 0.0125% (Suroso, 2004; Mokhtar et al., 2010). He supposes that Indonesia has 45 state universities and 1400 private universities with a total of 1,850,000 lecturers. If every lecturer in one year writes a book, there will be 1,850,000 titles. But in reality, it is

different. He added that the cause of lecturers' weak writing ability is the low activity of accessing the internet. Lecturers do not have writing facilities such as availability of collections, laziness in library visits or downloading on the website. Furthermore, the ability of lecturers to buy books, subscribe to journals, and allocate a portion of their money to complete their writing activities is also low, and include poor translation skills. Besides, their weak writing ability is also caused by people's low interest in buying books.

Meanwhile, according to Team Jago Nulis Publisher Deepublish (2016), there are several benefits from writing activities, including: (1) obtaining passive income; (2) as a medium for promotion / position; (3) self-promotion and institution of work; (4) obtaining invaluable pride; (5) getting credit points; (6) giving valuable contribution to the people; (7) avoiding senility and improving self-quality; (8) passing on the knowledge of future civilizations.

Due to the benefits and the effort to carry out the Law on Higher Education, the researchers are interested in developing teaching materials. In addition, the development of teaching materials is based on several observations, experiences and interviews that the researchers have done as the permanent lecturers in the Mathematics Education Study Program. The researchers found that: (1) most teaching materials are not available for each subject, so that this can raise doubts about the professionalism of the lecturers who teach the subject; (2) learning resources available to students are very limited, especially textbooks that are prepared exclusively for certain subjects by lecturers; (3) the interaction of students in the class when lecturing takes place is very low because some students do not bring the learning resources and some bring the intended learning resources but they have difficulties in learning and understanding the material.

In addition, based on an unstructured interview with several students during the lecture process in the second semester in the academic year of 2017/2018, it was found that; (1) students are easy to find book references related to the subjects, but find difficulties in determining which material should be studied in accordance with the competencies that must be possessed while participating in the course. Then, there are several materials in many different books. Consequently, students must have many books as learning resources, while they have financial constraints to buy them. (2) students often find learning resources that are invalid (incomplete); (3) the authors of the books (articles) they find on the

internet are often ambiguous especially from blogs; (4) if the lecturer assigns certain materials to the students, then they only take what is relatively easy to understand, while the relatively difficult one is disposed because it is not understandable, so the urgency or point of learning is not achieved; (5) students are most happy during the group's paper presentations, because their presentations are clarified by lecturers in the class.

The findings presented above also occur in the subjects that the researchers have been able to teach so far, namely Integral Calculus. Integral Calculus is one of the compulsory courses in Mathematics Education study program. With 3 credits, students are required to pass this course, because this course is prerequisite for advanced calculus courses, Differential Equations, and Initial Value Problem and Boundary Condition Problem. Therefore, it must be mastered by the students.

It is considered important and urgent to do a development research that can produce Integral Calculus teaching material. In the teaching of science and biology the didactic materials are fundamental tools in the teaching-learning process, being an important and variable alternative in schools of public schools system. The use of these materials can help the student in the contextualization of knowledge, filling many gaps felt during learning, facilitating the students to build their own conceptions of scientific knowledge in relation to common knowledge, and the socialization to common knowledge and the use the construction of new designs more elaborate. The availability of references for Integral Calculus is now very large and accessible. However, the references do not support the achievement of competency standards. In addition, several references only teach students to calculate. Even though the demands of integral calculus courses do not only provide skilled students in calculating integrals, but also provide understanding about integrals and using them in solving various problems associated with them. Therefore, teaching materials must be created to teach and encourage students to actively involve and construct their own knowledge.

To be able to develop teaching materials, the teaching materials can be arranged based on problem based learning. Problem-based learning is an alternative learning model that allows students to develop thinking skills (reasoning, communication, and connection) in solving mathematical problems (Rusman, 2010). Ben Martz and Morgan Shepherd. (2005: 1-2) states, "*PBL at its core is an interactive tool that uses problems as the context for students to acquire knowledge. Problem Based Learning in*

centered on providing the student with a problem environment which that students can create and store memories and meanings”.

Furthermore, Wina Sanjaya (2011) suggests that there are 3 main characteristics in a problem-based learning strategy, namely: (a) a problem-based learning strategy is a series of learning activities, meaning that in implementing a problem-based learning strategy there are a number of activities that students must do. The problem-based learning strategy does not expect students to simply record, listen, then memorize the subject matter, but through problem-based learning strategies students actively think, communicate, search and process data, and finally conclude; (b) learning activities are directed at solving problems, meaning that problem-based learning strategies place problems as keywords of the learning process, without problems there is no possible learning process; (c) problem solving is done by using a scientific thinking approach. This is similar to what was conveyed by Savin-Baden in Wendy Barber, et al (2015):

”There are significant characteristics of PBL that include: (1) Complex real world situations that have no one ‘right’ answer are the organizing focus for learning; (2) Students work in teams to confront the problem, to identify gaps, and to develop variabel solutions; (3) Students gain new information through self-directed learning; (4) Staff act as facilitators; (5) Problems lead to the development of clinical problem-solving capabilities”.

Based on the problems above and due to time constraints, the researchers are interested in conducting this research entitled *”The Development of Integration Technique Teaching Materials in Integral Calculus Courses Based on Problem Based Learning”*. The textbook is systematically organized as follows: Cover, chapter titles, material concepts, competency standards, basic competencies, indicators, sub-chapter headings, material presentation that directs students to do activities with the following steps entitled: (1) let’s focus on the problem; (2) let’s collaborate with your group members; (3) let’s start working; (4) let’s innovate and understand the results; (5) let’s analyze and evaluate, examples of exercises, summaries, exercises.

2 RESEARCH METHODS

Research that produces a product is known as development research. According to Sugiyono (2010), research and development is a research

method used to produce certain products and test the effectiveness of these products.

Nana Syaodi Sukmadinata (2008) (Sukmadinata, 2011) stated that the steps of research and development broadly consist of: (1) a preliminary study consisting of literature review. In the literature review, find and read articles in international journals and national journals as well as source books related to the textbook material that you want to develop; (2) product development; activities carried out from drafting instruments, validating instruments and revising instruments, lastly (3) product testing. The activity is to test the testing instruments that have been valid and revised by the validators, and carry out the analysis. Thus, in general the research design consists of three stages including: development stage (conducting observations and interviews, conducting material analysis, analysis of competency standards and learning indicators), planning stage (compiling teaching materials according to material that has been analyzed at the planning stage, compiling the validity sheet and practicality sheet of teaching materials, validating teaching materials to 3 experts, conducting an analysis of the validity result, revising the teaching materials that have been validated by the experts, and the testing stage (conducting trials and revise teaching materials based on the result of the tests).

This research was conducted in the Mathematics Education Program FKIP UIR in the odd semester of 2018/2019. The subjects in this study were the third semester students of the FKIP UIR Mathematics Education study program who had taken part in Integral Calculus course. The location, research time and the subject of this study were selected on certain considerations, namely:

- Ease of communication between researchers and students because researchers are lecturers from the students concerned.
- A research on the development of teaching materials for integration techniques based on Problem Based Learning in integral calculus course has never been conducted in Mathematics education study program.

The research instrument used to collect data in this study is the validity sheet of teaching materials compiled using several aspects: presentation, content, compatibility with the principles of problem based learning and mathematical critical thinking skills, and language. Then, the practicality sheet of teaching materials is compiled using the following indicators: Interest in mathematics teaching materials based on Problem Based Learning, Effect of Problem Based Learning teaching materials on student learning activities and motivation, Use of sentences in teaching

materials based on Problem Based Learning, Ease of understanding material in teaching materials based on Problem Based Learning, teaching materials support mastery of material, teaching materials based on Problem Based Learning in accordance with students' thinking background, Teaching materials help construct understanding of a material, Delivery of the material is associated with daily life, Teaching materials help facilitate the students' mathematical critical thinking ability, Questions based on Problem Based Learning are straightforward and challenging, and It is good or not to be used in Mathematics learning.

Data collection technique is carried out with non-test technique. To get the data about the validity of teaching materials, the researcher requested validity from the experts by using the validity sheet that had been designed. Lastly, to obtain the data about the practicality of teaching materials, the researchers used a practicality sheet given to students during the testing process. The result of validity test was analyzed in the following stages:

- Add the values of each indicator of the validity sheet.
- Find the average value of each indicator given by the validator with the following formula:
- Determine the combined validity with the following formula:
- Determine the average value category based on the Likert scale and determine the textbook validity category. The following are the validity categories of teaching materials.

Table 1: Interpretation Criteria for Teaching Material Validity

Mean Score	Category
$85,01\% \leq V \leq 100\%$	Very practical, or can be used without revision
$70,01\% \leq V < 85,01\%$	Quite practical, or can be used with minor revisions
$50,01\% \leq V < 70,01\%$	Less practical, it is recommended not to use because it requires major revisions
$V < 50,01\%$	Not practical, or may not be used.

Source: Sa'dun Akbar, 2013

Next, the data from the practicality questionnaire was analyzed by calculating the percentage of practical teaching materials. According to Sudijono (2008), the percentage of a value can be calculated using the following formula:

$$P = \frac{f}{N} \times 100\% \tag{1}$$

Description:

P: Percentage of assessment

f: Score obtained

N: Total Score

The category of mean score and textbook validity is determined based on the Likert scale. The following table describes the categories of teaching material validity.

Table 2: Interpretation Criteria of Teaching Material Practicality

Mean Score	Category
$85,01\% \leq v \leq 100\%$	Very valid, or can be used without revision
$70,01\% \leq v < 85,01\%$	Quite valid, or can be used with minor revisions
$50,01\% \leq v < 70,01\%$	Less valid, it is recommended not to use because it requires major revisions
$v_i < 50,01\%$	Not valid, or may not be used.

Source: Modified from Sa'dun Akbar, 2013

Figure 1 describes the procedures of this research.

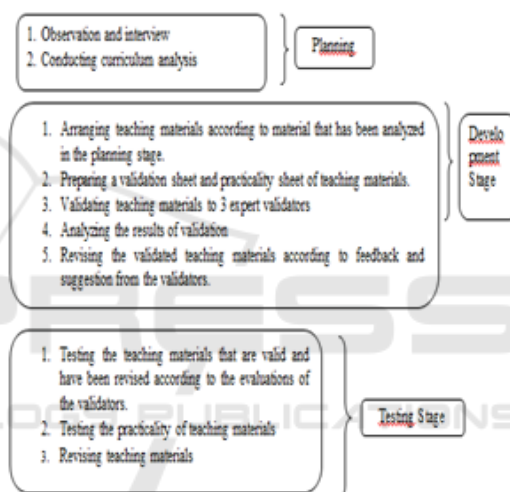


Figure 1: Procedures of the Research

3 FINDINGS AND DISCUSSIONS

3.1 Findings

Based on the development procedure in the planning stage, the researcher conducted several things, including:

3.1.1 Planning

The planning phase begins by analyzing the curriculum. Curriculum analysis is carried out by conducting reviews and discussions. The results of curriculum analysis of the teaching material to be examined are presented in Figure 2.

Moreover, in the planning stage, researchers have also done observations and interviews with the

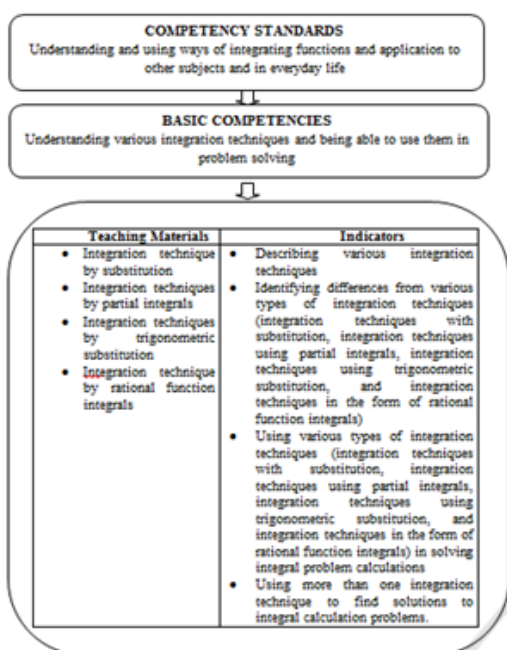


Figure 2: Curriculum analysis of the teaching material.

lecturers who teach integral calculus courses. The information was obtained that innovation is needed in conducting integral calculus learning. One of the innovations is the development of teaching materials that can involve students actively. In addition, most students want integral calculus material to be straightforward especially the material of integration technique. Then, the learning process can involve students and improve their mathematical thinking ability.

3.1.2 Development

After the planning stage is carried out, the next step that the researchers do is to develop teaching materials. Teaching materials include: (1) cover; (2) introduction; (3) table of contents; (4) Explanation of basic learning competencies; (5) Explanation of learning indicators; (6) A description of the focus of teaching materials; (7) Instructions for using teaching materials; (8) Exposure to teaching material presented with the following activities namely let's focus on the problem, let's have a discussion with your group members, let's start working, let's innovate and understand the results, let's analyze and evaluate ; (9) Sample Questions; (10) Summary; (11) Exercise.

The draft of teaching materials will be validated by 3 experts. Experts will provide validity of teaching materials with aspects of presentation feasibility, content feasibility, conformity with the principles of

Problem Based Learning and mathematical critical thinking skills and language feasibility. The results of the validity can be seen in Table 3 and Figure 3 below.

Table 3: Teaching Material Validity Result by Experts

Aspects Assessed	Percentage (%)	Criteria
Presentation Feasibility	95.83	Very Valid
Content Feasibility	88.72	Very Valid
Conformity with the principle of problem based learning and mathematical critical thinking skills	82.29	Quite Valid
Language Feasibility	86.46	Very Valid
Overall Percentage (%)	88.96	Very Valid

tSource: Processed Data

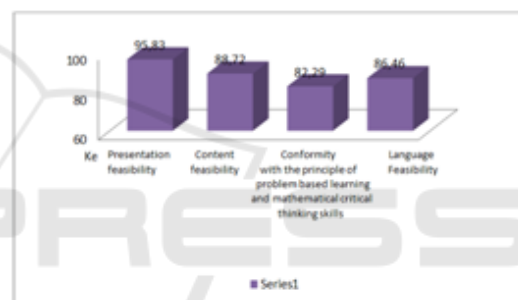


Figure 3: Curriculum analysis of the teaching material.

Based on the result of the validity from the experts, it can be seen that overall the validator assessed that the teaching material has been very valid and feasible for testing with minor revisions. At last, referring to the feedback from the experts, the researchers revised the teaching material that had been developed.

3.1.3 Testing

The product testing was conducted on 40 third semester students of Mathematics Education who had attended Calculus II course. The test was conducted on October 18, 2018 in room 6.09 Building A, 2nd floor. The trial process started from 13.30 - 16.00 WIB. The test was carried out in several stages, including: (1) Opening lessons by conveying apperception, giving motivation, delivering learning objectives, and explaining the steps of learning to be carried out by students in the class; (2) instructing students to study in groups that have been formed at the beginning of the meeting; (3) Providing revised teaching materials; (4) Instructing students to study

with other group members by following the learning steps contained in the teaching material; (5) At the end of the meeting, the researcher distributed questionnaire to students which serves to provide an assessment of the new instructional materials in terms of practicality. Table 4 shows the result of the practicality of teaching materials according to students.

Table 4: Practicality Result of Teaching Materials

No.	Indicators	Percentage (%)	Criteria
1	Interest in mathematics teaching materials based on Problem Based Learning	87.5	Very practical
2	Effect of Problem Based Learning based learning materials on student learning activities and motivation	86.56	Very practical
3	Use of sentences in teaching materials based on Problem Based Learning	90	Very practical
4	Ease in understanding the material in teaching materials based on Problem Based Learning	84.06	Quite practical
5	Teaching materials support mastery of the material	86.88	Very practical
6	Teaching materials based on Problem Based Learning are in accordance with students' thinking backgrounds	88.75	Very practical
7	Teaching materials help construct understanding of the subject	84.34	Quite practical
8	Submission of material is associated with everyday life	88.13	Very practical
9	Teaching materials help facilitate students' mathematical critical thinking skills	79.69	Quite practical
10	The questions given in teaching materials based on Problem Based Learning are straightforward and challenging	70	Quite practical
11	It is good or not to be used in mathematics learning	88.75	Very practical
	Overall Percentage (%)	88.75	Very practical

After testing and getting the students' practicality result of teaching materials with very practical criteria, it can be stated that the final product of teaching materials has been produced.

3.2 Discussion

In developing both the development of mathematical critical thinking ability test instruments and teaching materials, researchers have followed the stages and procedures. Testing and processing of test result have also been done by researchers with the procedures and steps stated in chapter 3. The results of the validity test showed that the teaching material falls into a very valid category, can be used with a slight revision. But there is a validator who considers that the sample

questions and exercises presented in the teaching material have not been able to stimulate students' HOT skill. It is mentioned that the sample questions and exercises are too easy for students, even though they are based on indicators of mathematical critical thinking. Meanwhile the other validators consider the sample questions and exercises to be appropriate but the variations are lacking, so it must be added. The feedback is actually good, but the researchers have other considerations, related to the difficulty level of the sample questions and exercises. The researchers consider that the sample questions that the researcher presents with steps, but students also still have to find it themselves, adjusted to the level of ability and needs that researchers get based on research and experience of researchers as the lecturer who teach integral calculus course. It is assumed that such teaching materials can help the students' learning process in integral calculus. We can compare this with the results of the practicality questionnaire obtained from the testing of the use of integral technique teaching materials based on *Problem Based Learning*.

The result of the testing shows that that the teaching materials are "very practical". However, there are Problem Based Learning indicators in teaching materials that are straightforward and challenging. Teaching materials that help facilitate the students' mathematical critical ability have practical criteria and have the smallest percentage score compared to other indicators. This was in line with the statement that the sample questions and exercises had not been able to stimulate HOT students. But based on the interviews with the students, the sample questions and exercises were too difficult for them to complete. Based on these statements, the researcher assumed that the statement by the validators and the students had different meanings. The former stated that the questions and exercises must be changed and the level of difficulty increased so as to stimulate students' higher order thinking skills, while the latter stated that the sample questions and exercises were too difficult for them. In conclusion, the teaching materials that the researchers have developed are "very valid" and "very practical".

4 CONCLUSIONS AND SUGGESTIONS

In conclusion, teaching materials of integration technique based on Problem Based Learning are considered very valid and very practical. The researchers have developed valid and practical materials to be used in teaching integration technique

in integral calculus course. The researchers suggest that the practicality of students in using teaching materials should not be used as a benchmark in determining or seeing an increase in students' abilities. The practicality does not describe their abilities. Then, teaching materials must be presented in steps with a variety of problems that are more straightforward.

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