Development of Competency-Based Teaching Materials on Initial Value Problems and Boundary Conditions Course

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ABSTRACT

Most of the lecturers do not give great attention or not considered the importance of teaching materials. This is reinforced by the lack of existed teaching materials that to supports the lectures. This study aims to develop competency-based teaching materials in for the subjects of Initial Value Problem and Boundary Condition (IVPBC) to build students' higher-order thinking skills. This research is a development research consisting of three main stages, namely preliminary analysis, product design, and development. The object of this research is competence-based teaching materials in the subject of the initial value problem and boundary condition itself. After designing the teaching materials, then it was tested and validated by experts. The instrument used is a validation sheet consisting of 35 statement items. The result of the research shows that all validators have approved every aspect of assessment of teaching materials that are (1) relevance, (2) accuracy, (3) completeness of the presentation, (4) presentation system, (5) conformity of the presentation with the demand of student-centered learning, (6) presentation technique, (7) Indonesian language compliance and (8) legibility and communicativeness. As the conclusion, the developed teaching materials are valid and can be used on a wide scale of teaching.

Keywords: competence-based teaching materials, initial value problem and boundary conditions.

Introduction

In stage of mathematics education global transition, initially emphasizing the cognitive algorithm's proficiency to the thinking competencies that has given challenges and impressions to the implementation of mathematical teaching and learning in the 21st century. Mathematical learning should take a deep attention on meaningful learning concepts (NAEYC 2002; Noor Azlan 2000) so that the students thinking competencies can be fostered well. Thinking competence is the most basic skill that should be developed in the lecture and is the key to achieve a high learning outcomes for all students (Nessel & Graham, 2007).

Mathematics education is one of the study programs at the Faculty of Teacher Training and Education (FKIP) Universitas Riau (UR). In the Mathematics education, the load of courses is presented for the total of 144 credits. These is divided into 5 groups of study areas, namely (1) self-development courses of 8 credits, (2) working subjects of 15 credits, (3) the professional subject of 27 credits, (4) 14 credits for human relationship and (5) scientific and skill courses (MKK) of 80 credits (Prodi pend.mat FKIP UR 2013).

The distribution of subjects in the MKK group includes 5 groups of disciplines namely (1) Analysis, (2) Algebra, (3) Geometry, (4) Statistics, and (5) Applied Mathematics. One of the courses in the applied field of applied mathematics is the Initial Value Problem and Boundary Condition (IVPBC). It is a further differential equation or rather it is said to be applied from of Differential Equations on various real problems such as in Engineering, Physics and others. The IVPBC course aims to develop analytical skills, mathematical logical thinking ability by understanding the mathematical model of a real problem in the form of ordinary differential equations with or without initial values and able to solve real simple problems in mathematical models of ordinary differential equations either partial differential equations with initial values or boundary conditions (DIRJEN DIKTI 1991).

In line with this on the competency-based curriculum of Mathematics Education program FKIP UR 2014, it explained that the IVPBC course provides a solid foundation for solving mathematical models that appear in other disciplines. In this course, there are eight major topics, namely: (1) Understanding of initial value problem and solution; the problem of boundary conditions and solutions; (2) Preliminary value problems and its ordinary, (3) Sturm-Liouville problem, (4) System orthogonal function, (5) Fourier series, (6) MSB; The real problem for the one-dimensional wave equation, (7) MSB; The real problem for a one dimensional heat flow, and (8) MSB; The real problem for a two-dimensional heat flow in a stable state (Tim Curriculum Prodi Pend. Mat.FKIP UR, 2014).

Based on the experience of researchers who have more than 10 years involvement, in the IVPBC subjects, students have difficulty in finding completion, especially in choosing the appropriate method / technique to complete MNA / SB according to the type and form of differential equation. This has an impact on student achievement outcomes in the last three years. Table 1 presents the mark distribution of students in the even semester of academic year 2015/2016.

Table 1. Achievements of Student Outcomes in IVPBC courses

Grade	Class A (Student)	Class B (Student)
A	3 (7,1%)	4 (9,5%)
A-	2 (4,8%)	3 (7,1%)
B+	1 (2,4%)	2 (4,8%)
B	2 (4,8%)	5 (11,9%)
B-	5 (11,9%)	2 (4,8%)
C+	11 (26,2%)	7 (16,7%)
C	12 (28,5%)	9 (21,4%)
D	2 (4,8%)	6 (14,3%)
E	4 (9,5%)	4 (9,5%)
Total	42 (100%)	42 (100%)

Based on table 1, in each class there are still 50% or more students who get a less good final grade of C +, C, D, or E. This indicates that the mastery or achievement

of student learning outcomes in the course IVPBC is still low. Then based on the initial analysis on the implementation of competency-based learning in IVPBC courses, it is obtained a conclusion that the Mathematics Education Study Program FKIP has a lack of literature or books in Indonesian language and the absence of competency-based teaching materials that are appropriate to the syllabus of IVPBC courses (Elfis Suanto 2015).

To make easily in mastery of mathematical material well, then at least it is needed two main competences in the form of ability of mathematical reasoning, and ability of mathematical connection. According to Sumarmo (2013) mathematical reasoning is the ability and activities in the brain that must be developed sustainably through a context. While the ability of mathematical connections include capabilities; (1) connecting a conceptual and procedural knowledge; (2) linking between mathematical topics; (3) using mathematics in other fields of study; (4) using mathematics in everyday life; (5) applying the ability to think mathematically and make models to solve problems in other lessons. So the ability of mathematical reasoning and mathematical connection as the main competence is very important to be built to the students.

Based on the problems above, to assist students and lecturers in learning and teaching IVPBC course, a research on the development of competence-based teaching materials on the subject of IVPBC in Mathematics Education program majoring in PMIPA FKIP Universitas Riau is necessary. While the competencies that are referred in this study is the ability of mathematical reasoning, and the ability of mathematical connections. Reasoning and mathematical connections are the two basic mathematical abilities that students must be persuaded (Sumarmo, 2013).

The PPPG mathematics team (2005) states that reasoning is a process or activity of thinking to draw conclusions or make a true new statement based on a statement that has been proved (assumed) to be true. According Awaludin (2007), the reasoning is the thought process to draw conclusions in the form of knowledge by using certain logic based on information provided.

Correspondingly, Sumarmo (2013) states that mathematical reasoning can be classified into two types: reasoning that is referred to inductive and reasoning that is referred to deductive. Inductive reasoning is defined as a general conclusion based on observed data (special). The value of truth in inductive reasoning can still be true or false. While deductive reasoning is a conclusion based on agreed rules. The value of truth in deductive reasoning is absolutely true or false and can not be occurs both at the same time. Inductive and deductive sharing, though opposite, but their use in mathematics are complementary.

According to Webb and Coxford (1993), students' abilities in mathematical connections include; (1) connecting conceptual and procedural knowledge, (2) using mathematics on other topics (3) using mathematics in life activities, (4) viewing mathematics as an integrated entity, (5) applying thinking and making models for solving problems in other subjects, such as engineering, arts, psychology, science, and business, (6) using and appreciating connections among topics in mathematics; and (7) recognize various representations for the same concept.

In line with Webb and Coxford, NCTM (2000) argues that meaningful learning is

the main foundation for mathematical connections, since mathematical connections aim to assist in the formation of student perceptions by viewing mathematics as integral parts of life. In the NCTM Standards (2000) it is explained that mathematics learning should be directed to the development of capabilities: (1) taking into account and using mathematical connections between various mathematical ideas, (2) understanding how mathematical ideas are interrelated so as to awaken a thorough understanding, and (3) consider and use mathematics in contexts of outside of mathematics.

Based on the description above, the mathematical reasoning capability referred to this study is an inductive reasoning (transductive and using relationship patterns to analyze situations, and construct conjectures) and deductive reasoning (drawing logical conclusions based on inference rules). While the connection is referred to a mathematical follow Webb and Coxford (1993).

The ultimate goal of this research is to produce competency-based teaching materials in the subject matter of initial values problem and boundary conditions. Teaching materials to be developed are expected to foster and build student competence. So that in the end it can improve student learning outcomes. The objective of this study is to recognize the aspect of the validity of competency-based teaching materials in the IVPBC course.

Methodology

The form of this research was a research and development. Research and development is a form of research used to produce a particular product and test the effectiveness of the product (Creswell 2009). This development research used ADDIE (Design, Development, Implementation and Evaluation) design instructional development model adopted from Branch (2009).

a. Analysis

Analysis was an initial activity to know the needs and goals of products to be developed. By assessing the needs, the researcher can know the existence of a situation that should exist and the real situation in the field. Researchers have conducted a preliminary study to see the existing gap that is the development of teaching materials in the form of textbook needed by students or lecturers.

b. Design

In the design stage the researcher collected the materials, prepared and designed the product to be developed. It begun by collecting reference books for the preparation of teaching materials and then proceeded to the preparation of the teaching materials itself based on a particular design. Subsequently was to looking for indicators that will serve as guidelines for making item statements about the validity of the resource. Based on the existing construction then the validation formats and statement items was made.

c. Development

In the development stage, the researcher validated the developed teaching materials. Validator consisted of two material experts and a learning expert. If according to the validator of the teaching materials, it was not yet suitable to be used then it will be revised to be re-validated. After the teaching materials were declared valid then the teaching materials were ready to be tested.

The validation of teaching materials in this research was a question or statement which consists of 35 adoption statements from Sa'dun Akbar (2016). It covered aspects: (1) relevance, (2) accuracy, (3) completeness of the presentation, (4) systematic, (5) presentation method, (7) Indonesian language compliance, and (8) legibility and communicativeness. Table 2 shows a splash of item statement items following the study construct.

Table 2. The questions

No.	Aspect	Item Number
1.	Relevance	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
2.	Accuracy	11, 12, 13, 14
3.	Completeness of presentation	15, 16, 17, 18
4.	Systematic Servings	19, 20
5.	Conformity of the presentation with the demands of student-centered learning	21, 22, 23, 24, 25
6.	Serving method	26, 27, 28
7.	Conformity with good and correct Indonesian language	29, 30, 31
8.	Readability and communicativeness	32, 33, 34, 35

d. Implementation

Teaching materials that have been valid were tested on a small scale product to determine the reliability.

e. Evaluation

From the instrument that has been implemented, it will be obtained a small-scale trial data and analyzed as a further improvement on the teaching materials that have been made.
In this study, due to limited time and cost, the development of teaching materials was only done until the development stage (Development) and it was tested it validities.

Results and Discussion

The result of this instructional material development is a set of a learning materials consisting of RPS, RP and teaching modules. The teaching module consists of four chapters namely Chapter I. Introduction; understanding the problem of IVPBC and solutions, understanding the problem of boundary conditions and solutions, chapter II. Orthogonal Function System, chapter III. Fourier series, and chapter IV. MSB on 1-Dimensional Waves. The teaching materials can be used by lecturers and students to support the lectures. The development process of this resource has followed the steps of the ADDIE model.

1. Needs Analysis (Analysis)

Based on the initial study by Elfis Suanto (2015), that the lecturers have not given considerable attention to the development of teaching materials, especially teaching modules. Besides, there is also the view of students who stated that there is still lack of literature or books in Indonesian language and the lack of competency-based teaching module that is really in accordance with the

syllabus of IVPBC courses applicable in Mathematics Education Study Program.

Based on this difficulty, the researchers took the initiative to float competence-based teaching materials with a particular design. This instructional material is expected to provide convenience to students and lecturers in studying and teaching courses of IVPBC.

2. Design of Teaching Materials (Design)

This instructional material is made based on constructivism learning theory and cognitive learning theory on the basis of its development is student competence. The student competence is mathematical reasoning and mathematical connection. Conceptual framework of development of this resource can be seen in Figure 1.

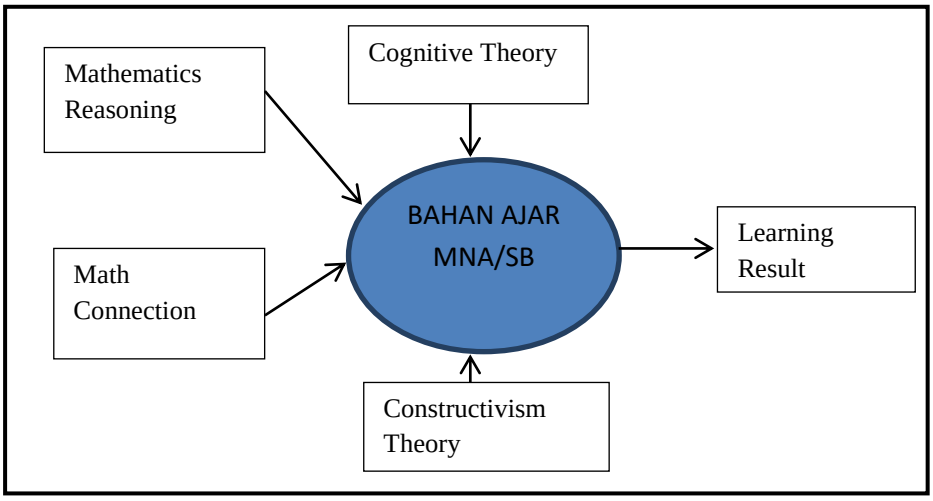

Figure 1. Conceptual Framework of IVPBC Teaching Material

According to Needham (1987) there are five phases of the learning process based on a constructivism theory. The five phases are orientation, idea generation, and reorganization of ideas, application ideas and reflection. The teaching materials consist of several chapters and sub chapters. Each chapter begins with a set of course targets that are made in detail about the competencies that must be achieved by the students. Competencies to be achieved by students are mathematical reasoning and mathematical connections. Each sub-chapter is written or made referring to the Needham's constructivism phases in order to achieve the competencies established at the beginning of the chapter.

Then the application of cognitive theory in teaching materials competence-based, is expected in every learning of social interaction, both between fellow students and between students and lecturers. It is through social interaction that the child's cognitive develops towards the better as caring for others, intelligent and effective in interacting, and fostering good attitudes in the student's daily life.

3. ***Development***

Formative assessment involves three experts namely two material experts and one expert learning. The expert involvement in this study refers to the

Kwanjai & Sumalee (2012), that study validates the building of learning materials. Descriptive analysis is conducted based on the discussion for each aspect that is assessed in the validation. After the first stages of validation, the researcher gets advice from experts on the weakness of teaching materials. The overall weakness of teaching materials and expert advice can be seen in table 3 below.

Table 3. Suggested improvement of teaching materials by experts

No.	Aspect	Suggestion improvement of teaching materials	Frequency
1	Relevance	Try more interesting and accordance with the level of student understanding.	2
2	Accuracy	In order to add the concept of the existence and unity of solutions of differential equations. In order to be added to the form of prove practice / prove or show / show that.	1
3	Presentation Completeness	A module should be added.	2
4	Presentation systematics	Presentation of teaching materials is structured in the form of definitions, theorem and new examples of its application.	1
5	Compatibility of Indonesian language	Use a better and standard language so it's easy to understand.	2

Based on table 3, it shows that there are 5 aspects that there are weaknesses according to the expert. There are one or two experts who advise or reserve. This suggestion becomes the basis for researchers to make improvements to the teaching materials. After the material is repaired, then the teaching materials are revalidated by the expert for every aspect of the assessment. The validation result per assessment by validator is as follows.

a. Relevance aspects

The following is a validator assessment of the relevance aspect of the developed teaching material

Table 4. Validator assessment results on relevance aspects

No	Assessment Aspect	VDA	DA	A	SA
1.	Material relevant to the competence that must be mastered by students.	0%	0%	0%	100%
2.	Exercise (the exercise of sub-chapters) is relevant to the competencies that must be mastered.	0%	0%	33.3%	66.7%
3.	Examples of explanations are relevant to the competencies that must be mastered.	0%	0%	0%	100%
4.	The task (the set of chapter problems) is relevant to the competence to be mastered.	0%	0%	0%	100%
5.	Depth of description is according to the level of	0%	0%	66.7%	33.3%

	student development.				
6.	Completeness of the material description is accordance with the level of student development.	0%	0%	33.3%	66.7%
7.	Material explanation is enough to meet the demands of the curriculum.	0%	0%	0%	100%
8.	The number of functional illustrations is adequate.	0%	0%	33.3%	66.7%
9.	The number of exercises and problems is adequate.	0%	0%	0%	100%
10.	The number of tasks is adequate.	0%	0%	0%	100%

Based on table 4, it can be seen that from 10 items statement, only 16.66% validator are agreed but 83, 34% validator stated strongly agree. It means that all validators have agreed and strongly agree about the relevance aspect of the developed teaching materials. But the statement of the depth of the material description associated with the level of student development is only 33.3% validators strongly agree. This may be due to the description or invention of a formula such as the problem of boundary conditions on 1-dimensional wave equations is very long and involves many mathematical concepts.

b. Accuracy aspects

Table 5. Validator assessment results on accuracy aspects

No	Assessment Aspect	VDA	DA	A	SA
1.	Presented material is accordance with scientific truth.	0%	0%	0%	100%
2.	The presented material is accordance with the latest developments.	0%	0%	66.7%	33.3%
3.	The presented material is accordance with daily life.	0%	0%	66.7%	33.3%
4.	Packaging material is accordance with the concerned scientific approach	0%	0%	0%	100%

When asked how the accuracy of teaching materials developed, from table 5 shows that 66.65% validator stated strongly agree, 33.35% agreed and there is no validator who stated disagree. It means that all validators have agreed and strongly agree on the accuracy aspects of the developed teaching materials.

c. Completeness of presentation aspect

Table 6. Validator assessment results on the completeness presentation aspect

No	Assessment Aspect	VDA	DA	A	SA
1.	Presenting the competencies that must be	0%	0%	0%	100%

	mastered by the students.				
2.	Presenting the benefits and importance of competency control for student life.	0%	0%	33.3%	66.7%
3.	Presenting a table of contents.	0%	0%	0%	100%
4.	Presenting a table of contents.	0%	0%	33.3%	66.7%

d. Presentation systematic aspects

Table 7. Validator assessment results on presentation systematic aspects

No	Assessment Aspect	VDA	DA	A	SA
1.	The description of the material adequate to the flow of thought from simple to complex.	0%	0%	0%	100%
2.	The description of the material adequate to the flow of thought from local to global scope.	0%	0%	66.7%	33.3%

Based on table 6, it turns out 83.35% validator strongly agree with the statement items given about the completeness of the presentation and the rest agree and there are no assessors who disagree. In table 7 all assessors agree and strongly agree on the systematic aspects of the presentation. Means that the system of teaching materials is good, although there are validators who suggest to be equipped with supporting theorems.

e. Compatibility of the presentation with the demands of student learning center aspect

In accordance with the demand for competency-based curriculum that refers to the Indonesian national qualification framework (KKNI), that a good learning is a learning that makes students as learning centers. So in the development of this teaching materials aspect of conformity of the serve with the demands of student-centered learning becomes one of the most important aspects to note. Here is a validator's assessment of the conformity aspects of the presentation.

Table 8. Validator assessment results on the conformity aspects of the presentation with the demands of student-centered learning

No	Assessment Aspect	VDA	DA	A	SA
1.	Encouraging student's curiosity.	0%	0%	0%	100%
2.	Encouraging student interaction with learning resources.	0%	0%	0%	100%
3.	Encouraging students to build their own knowledge.	0%	0%	0%	100%
4.	Encouraging students to study in groups.	0%	0%	0%	100%

Based on table 8, it turns out all validators / assessors are very aligned with all items of revelation about the aspect of conformity of the presentation with the demands of

learning centered on the students. Means teaching materials developed are enabling to students in the learning process on lectures.

f. The serving way Aspects

Table 9. Validator assessment results on the presentation aspect

No	Assessment Aspect	VDA	DA	A	SA
1.	Supporting the growth of students' metaphysical reasoning.	0%	0%	33.3%	66.7%
2.	Supporting the growth of students' critical thinking.	0%	0%	33.3%	66.7%
3.	Supporting student logical thinking.	0%	0%	0%	100%

g. Aspects of Language Compatibility

Table 10. Validator assessment results on language conformity aspects

No	Assessment Aspect	VDA	DA	A	SA
1.	The use of spelling accurately.	0%	0%	0%	100%
2.	Accuracy of term usage.	0%	0%	0%	100%
3.	The precision of the composition of sentence structure.	0%	0%	0%	100%

Based on table 9 and table 10, overall it can be seen that all validators have agreed and strongly agree the way of presentation and Indonesian language compliance aspects. On the aspect of the special presentation method, the item of the teaching material statement supports the logical thinking of the students, all validators strongly agree with the statement. While on the language suitability aspects, all validators strongly agree with all items statement although there are validators who still remind researchers to use good and standard Indonesian language

h. The legibility and communicativeness Aspects

Table 11. Validator assessment results on legibility and communicativeness aspects

No	Assessment Aspect	VDA	DA	A	SA
1.	The length of the sentence corresponds to the level of student understanding.	0%	0%	0%	100%
2.	The structure of the sentence corresponds to the level of student understanding.	0%	0%	0%	100%
3.	Making the jealous paragraphs.	0%	0%	0%	100%
4.	Language used is semi-formal (colloquial language in the class).	0%	0%	0%	100%

Then the latter is the aspect of legibility and communicativeness of developed teaching materials, then based on table 11 it turns out all the validators strongly agree with all items given statement. It means the aspects of the disclosure and the aspect of communicativeness of teaching materials is very good.

Conclusion

The development of competence-based instructional materials on the subject of initial value problem and boundary conditions has passed every stage of ADDIE model until final development stage. All validators have agreed on every aspect of the assessment that includes: (1) relevance, (2) the accuracy, (3) the completeness of the presentation, (4) the presentation system, (5) the appropriateness of the presentation with the demands of student-centered learning (6) the way of presentation, (7) Indonesian language compliance, and (8) legibility and communicativeness. It means that the developed teaching material is valid and ready to be tested to the real class teaching. Based on the results of this study it is suggested that this research can be continued in the implementation of a broader scale.

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