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Development of teaching materials in numerical methods

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Abstract
This research is aimed to develop teaching material in numerical methods in the faculty of teaching and education, Batanghari University (Jambi, Indonesia). The Research and Development (R&D) approach was used in the study. The development model used in the research is the instructional development model. After being developed, validation is done by design experts, material experts, and media experts. Then one to one learning, learning in small groups, and field trial trials were conducted. The results of the study based on validation by experts were categorized as feasible with a feasibility percentage for design validation of 90%, media validation of 87.7% and material expertise of 90.1%. On the basis of validation results and tests it is concluded that the teaching materials for learning mathematics are efficient to use.
Keywords: teaching material; instructional development model; numerical methods.

INTRODUCTION

The learning process in the college based on the curriculum has been prepared by each university because it is an autonomous right to higher education. This will impact on the lecture system that refers to a paradigm shift that is centered on students. But it still appears in the field that there are still lessons that still use the old paradigm that is centered on the teacher (lecturer). This is based on the observation results in the field showing that in learning lecturers deliver the material and students listen and understand the material presented. In addition, the teaching material still uses several books which material is still separate from one another, so it is necessary to combine material with one another to be studied. This has an impact on the student financial side to buy those books that relevant with any material in the syllabus. Moreover, the results of interviews with students showed a lot of numerical methods materials were difficult to understand relatively to the methods that require iteration. This is one of reasons students are not interested in learning.

Based on the fact revealed above, it gives a chance to do a Research of Development Teaching Material in Numerical Methods in the Faculty of

Teaching and Education at Batanghari University, Jambi. For the research it is necessary to study: 1) what is the learning process and what teaching materials are used for teaching Numerical Methods at Batanghari University Jambi; 2) How to develop numerical methods teaching materials at Batanghari Jambi?

Development concepts

According to Ali and Asrori in the field of education, development is a process of developing educational aids carried out through a series of research using various methods in cycles that go through various stages (Ali, & Asrori, 2014). Then according to Borg and Gall that quoted from *English Educational Journal* by Abdillah and Rukmini (Abdillah, & Rukmini, 2013), it is defined as "*research and development as a process used to develop and validate an educational product*". The research and development are the process that is used to create and validate an educational product.

Instructional development models (IDM)

Instructional development models (*IDM*) are models used in development design of the learning system in the numeric methods subject for students of the College because IDM have clear relevance for the development of learning. Besides these instructional development models are simple and easy to understand, it is expected this *output* model later will meet the criteria: (1) there is a clear analysis of general instructional needs and objectives; (2) the content corresponds to the specific objectives of learning; (3) the order is correct; (4) there are instructions for the use of teaching materials; (5) there are practical questions; (6) there are training examples; (7) there are performance tests; (8) there are instructions for the student progress; and (9) there are instructions for students towards their next activities.

Development of teaching materials uses the system approach, because it is important to create the connection between components. The system approach is also able to increase the opportunities for integrating of all variables that influence the learning in design learning. All steps of instructional development models and the structure of the development model are presented in Fig. 1.

Teaching materials

Based on (Depdiknas, 2008) teaching materials are any forms of materials that are used to help the teacher/instructor carry out teaching and learning activities. While teaching materials according to (Lestari, 2013) are a set of objectives or learning tools that contain learning materials, methods, boundaries and ways of evaluating that are designed systematically and attractively in order to achieve the expected goals, namely achieving competence or subcompetence with all its complexity. According to (Majid, 2007) teaching materials are any forms that use of teaching materials used to help teacher/instructor in carrying out teaching and learning activities in the

class. The indented materials can be the form of written material or unwritten teaching materials. According to (Hamdani, 2011) teaching materials or learning materials (*instructional materials*) in the broad sense consist of knowledge, skills and attitudes that students must learn in order to achieve predetermined competency goals.

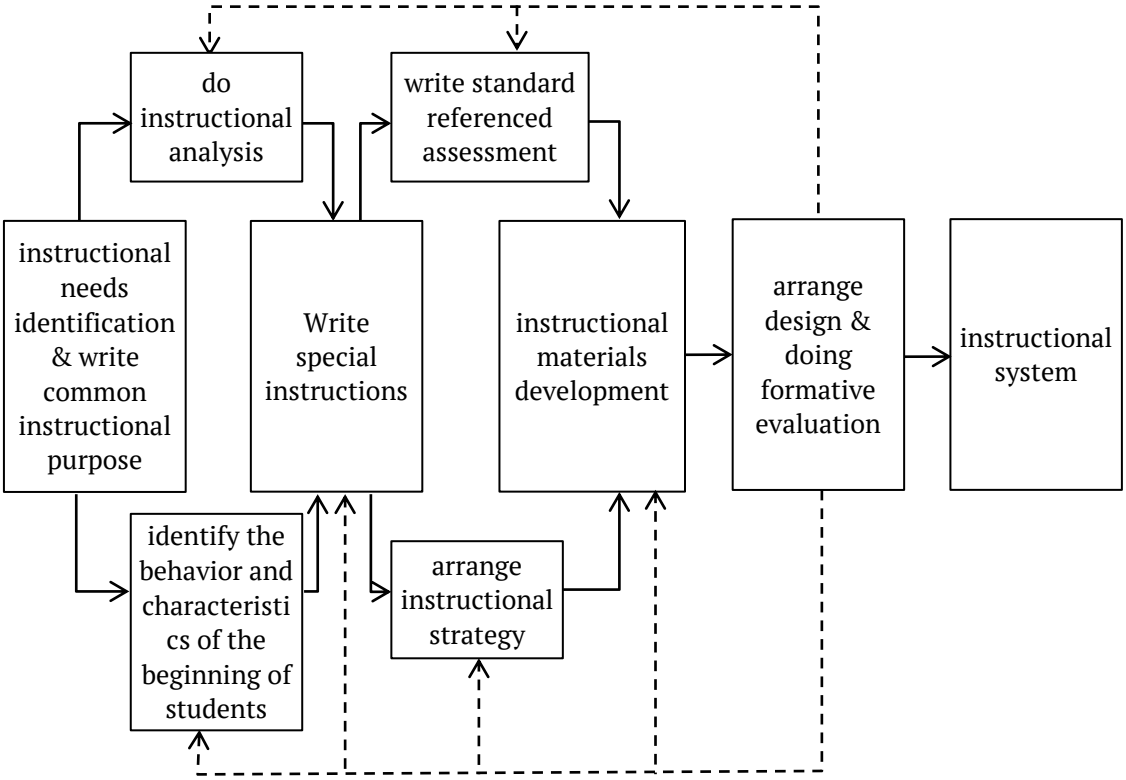

Fig. 1. **Instructional development models (IDM) (Suparman, 2004)**

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From some of the theories mentioned above it can be concluded that teaching materials have all forms of learning materials or resources that contain subject matters, methods, evaluation that are used by educators in

implementing learning, both in electronic form, hand outs, books, modules, student worksheets, brochures, and so on.

Numerical methods

The characteristics of many mathematical materials are abstract, but abstract materials must be studied and it is important to know numerical methods. According to (Chapra, 2012) numeric methods is using a technique that is applied to formulate the mathematical problems so they can be solved by arithmetic and logical operations. The same idea was expressed by (Triatmodjo, 2002) who stated that numeric methods are a step or a technique to solve mathematic tasks by arithmetic operations.

The ability of using the step or the technique for the mathematic problem can be solved with arithmetic operations (Chapra, & Canale, 2010). The numeric ability has one general characteristic – it always involves and uses arithmetic calculations. This means that the numerical ability is closely related to arithmetic and has a large role in learning mathematics materials so that the numerical ability is one that influences mathematics learning outcomes.

RESEARCH METHODS

This research uses the system approach. The system approach is a series of problem solving stages, each step is understood and produces an alternative solution. The approach is adjusted to development models that used IDMs. The method used in this research is the research and development (R&D) method, a research method used to produce a product or test the effectiveness of a particular product.

The subjects of this study were students enrolled in the numerical methods subject of the even semester of 2018/2019 of the Mathematics Study Program, the Teaching and Education Faculty, Batanghari University, Jambi. Development of teaching materials is carried out in several stages, namely: 1) a preliminary study, 2) development planning, 3) validation, evaluation and revision, 4) and implementation. Formative evaluations carried out: (1) *one to one expertise* (material expert, instructional design expert and media expert), (2) *one to one learning* (individual trials of subjects consisting of three students), (3) *learning in small groups*, namely a small group trial consisting of 9 students, and (4) *field trials*.

DISCUSSION AND RESULTS

Preliminary studies

Preliminary research is conducted to determine the real situation and to analyze the needs related to the problem and the solution offered as a solution to the problem so that it is necessary to carry out the user needs analysis. The results of the research based on lecturer interviews showed that currently

lecturers in teaching are still using references or teaching materials that are still separate from one book to another so it is necessary to adjust some teaching materials to the syllabus that has been set.

Development steps

a. Identification of instructional needs and formulation of general instructional objectives

1. Instructional needs identification.
   The instructional needs identification confirms that for many students it is difficult to find the teaching materials that match with the materials compiled in the numerical method syllabus and books are relatively expensive. So that when offered to students as product users to use numerical method teaching materials that are in accordance with the materials compiled in the syllabus, students strongly agree to get them. Several technological facilities support student learning activities such as work in the internet network and other facilities that support numerical methods learning.
2. Formulating general instructional purpose.
   In general, after numeric methods courses, students are expected to understand the methods that were learned in numerical methods.

b. Instructional analysis

The instructional analysis result is 1) understanding the introduction to numerical methods and errors in computing; 2) understanding solving nonlinear equations with the bisection method, the fixed point iteration method, the Newton Raphson method, the secant method and modification of the Newton Raphson method; 3) understanding solving system equations with the matrix notation and matrix inverse, Gaussian elimination, the iteration method, the Jacobi method, the Gauss–Seidel Method; 4) understanding interpolations: linear interpolation, quadrant interpolation, interpolation of difference divided by Newton, Lagrange interpolation and spline interpolation; 5) understanding differentiation and integrations consisting of derivative formula, numeric integration, and the Simpson method.

c. Identification of early behavior and characteristics

1. Initial behavior
   The target group or students can be participants in the numerical methods subject registered at Batanghari University (UNBARI) in even semester 2018/2019.
2. Initial characteristics
   The results of data collection are based on the characteristics of students who use teaching materials and students who have high motivation and willingness to learn numerical methods, these students are of heterogeneous educational backgrounds, for example high school, vocational school, and Islamic Senior High School students.

d. Formulation of special instructional purposes

From the general instructional purpose above, so it is possible to describe specific instructional objectives as follows: 1) students understand introduction to numerical methods and errors in computing; 2) students understand resolving nonlinear equations with the bisection method, the fixed point iteration method, the Newton Raphson method, the secant method, and the modification of the Newton Raphson method; 3) understanding solving system equations with matrix notation and matrix inverse, Gaussian elimination, the iteration method, the Jacobi method, the Gauss–Seidel method; 4) understanding interpolations consisting of linear interpolation, quadrant interpolation, interpolation of difference divided by Newton, Lagrange interpolation and spline interpolation; 5) understanding differentiation and integration consisting of derivative formula, numeric integration, and the Simpson Method.

e. Assessment tools

Assessment tools are tests that consist of middle semester tests, semester tests, tasks, and a competency test.

f. Arrangement of the learning strategy

The learning strategy which uses teaching materials in the numerical methods courses consists of three main activities: introduction, core activities, and closing. In addition, the method uses media and tools, and also an ability test.

g. Development of teaching materials

Development of teaching materials is carried out in the form of creating textbooks consisting of 5 chapters. The results of eligibility consist of validation and formative evaluation:

a. Expert test (one to one expert)

1. Learning design expertise
   This expert validation is carried out to determine the product feasibility and the results of the validation can be seen in Fig. 2.
2. Material expertise
   The feasibility test by the material expert was carried out earlier than the feasibility test for the learning design expert. The results of the validation by the material expert of the numerical methods teaching materials are presented in Fig. 3.
3. Media expertise
   The validation was carried out by media experts together with learning design validation and material expert validation. The results of the validation by media experts are presented in Fig. 4.
4. Revision and suggestions from experts
   a) Learning design expert revision
      The revision of the design expert is that the benchmark reference test is in accordance with ICT, so that the ICT will be measured. This aspect has been improved and recommended to be used.

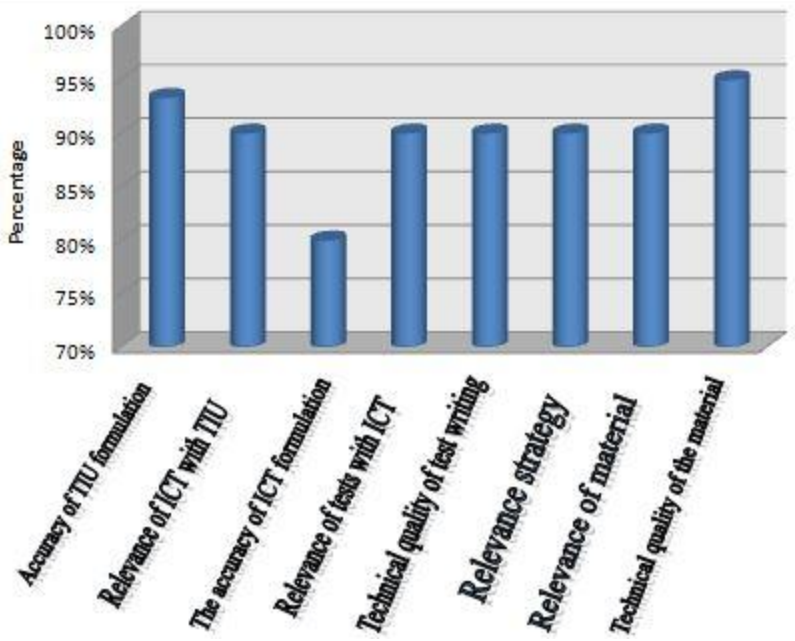

Fig. 2. **Results of expert learning design validation 1**

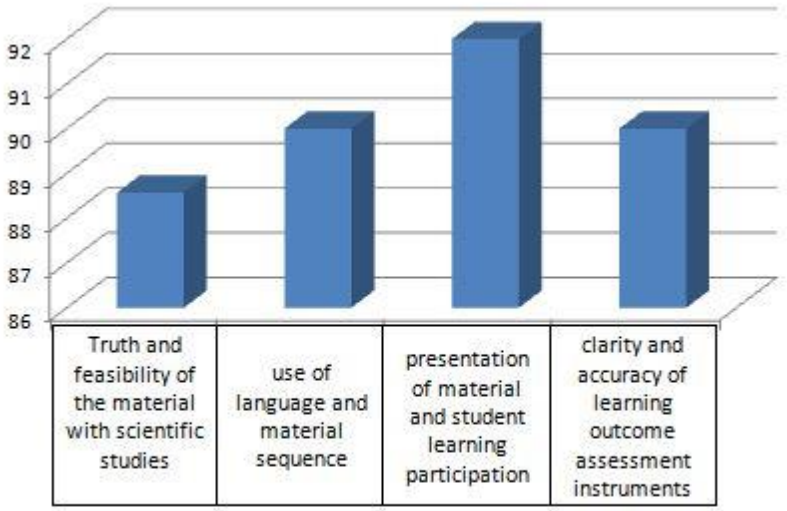

Fig. 3. **Expert validation results**

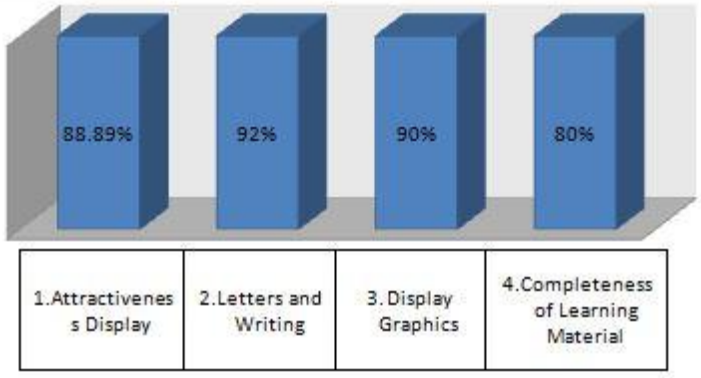

Fig. 4. **Results of media expert validation**

b) Material expert revision
The revision from the material expert on learning materials confirms that a lot of typing mistakes are made teaching materials so it is necessary to proofread the materials. Those parts that have been already corrected and agreed with the material expert are recommended to be used.

c) Learning media expert revision
The media expert suggests that the book size requires correction. The suggestion has been already fixed and the book is recommended to be used.

b. Individual test (one to one learner)

Individual test results (one to one learner) consist of two indicators which are the quality of product appearance, and the quality of product presentation. Subject responses to individual trials (one to one learners) can be presented in Fig. 5.

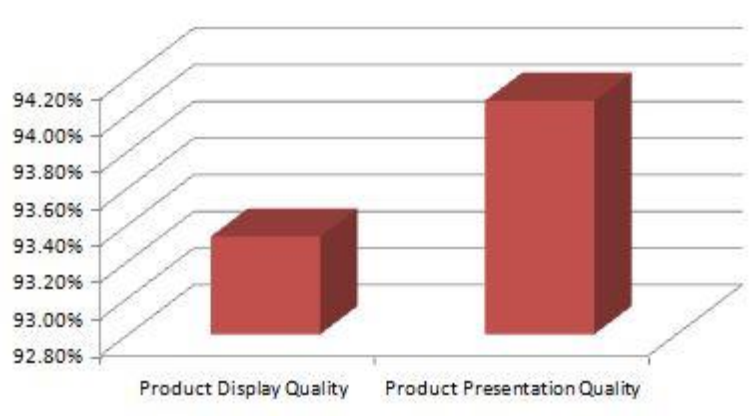

Fig. 5. **Individual trial results (one to one learner**)

c. Small group test (small group)

Subject responses to small group trials can be presented in Fig. 6.

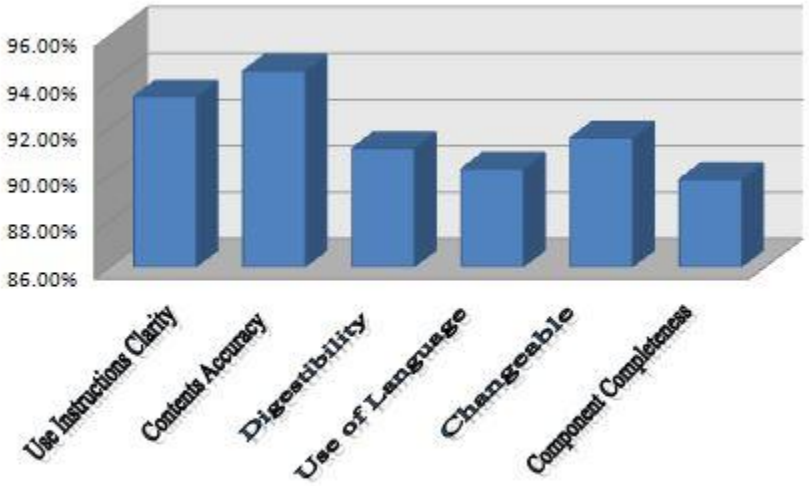

Fig. 6. **Responses of small group trial subjects**

d. Field group trial test

Field trial results are demonstrated in Fig. 7.

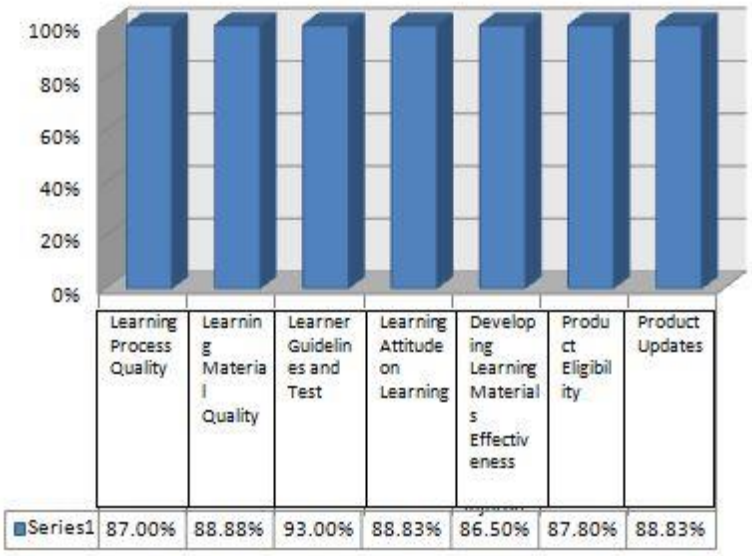

Fig. 7. **Responses to field trials**

DISCUSSION

1. Role of learning materials in numerical methods in learning

In the Faculty of Teaching and Education at Batanghari University Jambi, there are several mathematics study programs. In mathematics study programs there are compulsory courses, namely, numerical methods. In numerical methods learning, a lecture does not yet use sorting and choosing from several materials that fit the syllabus being studied. This makes student find references and needs extra expenses. Responding to this, innovative new breakthroughs become necessary that allow teachers to make teaching materials in accordance with the syllabus. Teaching materials contain materials that correspond to the syllabus. Those things will facilitate students in learning the provided materials. In accordance with the function of learning materials or information submitted so that it can be studied effectively and efficiently to achieve instructional goals.

However, in arranging teaching materials it is necessary to study aspects of needs, users (students), materials, learning strategies and evaluation. Because in the implementation of teaching and learning the ongoing learning process has an important role. In addition, teaching materials become tools or means to achieve instructional goals that have been set.

2. Procedure for development of numerical methods teaching materials

Development procedure refers to the steps that must be followed in developing teaching materials that will be created. Teaching material development in numerical methods is guided by the design of instructional systems using instructional development models (IDM). Instructional

development models are one of the learning models in accordance with the conditions that exist in the regions of Indonesia because this model is a modification of the Dick and Carey model.

Instructional development models are initially identified according to instructional needs and then the general instructional purpose is formulated. Identification of needs is the first step requiring special attention because this will determine whether the developed teaching materials are needed by the user or not. After, the researchers chose the form of development and formulated general instructional goals which became the final goals of teaching materials. Then it was continued with attitude identification and the initial characteristics of the student goals to understand the student behavior before development is carried out in order to compare with student behavior after instructional development occurred. Then the competency analysis was carried out to describe changes of general behavior into specific behavior that were arranged logically and systematically. Then the basic competency was formulated to get basic written tests and the instructional strategy. And then a benchmark reference test was developed to measure the level of success of students in achieving instructional goals. And the instructional strategy and development of instructional materials carried on. At this step the necessity of compiling teaching materials was discussed. After this, formative evaluations were continued to be designed and carried out. This stage discussed how to carry out formative evaluations of instructional materials that had been produced by researchers in the form of learning and how to get the desired instructional system.

CONCLUSIONS AND PERSPECTIVES FOR FURTHER STUDIES

1. In the implementation of numerical methods lecturers have still used conventional learning. Presentation of materials using the lecture method and using teaching materials are different from one book to another. The books that are already used are very good, but the material studied is not in accordance with the syllabus to be studied, therefore we need the teaching materials that contain materials that correspond to the syllabus so that teaching materials which are the product of ordinary results are used easily by users because all materials in the syllabus are included.

2. Procedures for designing and developing teaching materials on numerical methods use instructional development models. These models are developed to design teaching materials in the form of books. To get good results, a formative evaluation was carried out. Formative evaluation results from some validation experts prove that the developed model is feasible to use. On the basis of validation results and one to one, small group and field trial tests it is concluded that the teaching materials for learning mathematics are efficient to use.

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