Developing Teaching Material Software Assisted for Numerical Methods

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Abstract. The NCTM vision shows the importance of two things in school mathematics, which is knowing the mathematics of the 21st century and the need to continue to improve mathematics education to answer the challenges of a changing world. One of the competencies associated with the great challenges of the 21st century is the use of help and tools (including IT), such as: knowing the existence of various tools for mathematical activity [1]. In the era of technological advances such as today's graphics software support is very abundant and can be utilized as an effort to improve students' mathematical learning outcomes. In addition, students of Mathematics Education program as a prospective teaching

1. Introduction
The NCTM vision shows the importance of two things in school mathematics, which is knowing the mathematics of the 21st century and the need to continue to improve mathematics education to answer the challenges of a changing world. One of the competencies associated with the great challenges of the 21st century is the use of help and tools (including IT), such as: knowing the existence of various tools for mathematical activity [1]. In the era of technological advances such as today's graphics software support is very abundant and can be utilized as an effort to improve students' mathematical learning outcomes. In addition, students of Mathematics Education program as a prospective teaching
staff need to get the fullest extent in the mastery or skills utilizing computer software, in order to meet the demands on the job.

Many researchers are discussing and do the research about the use of software in education, especially in mathematics teaching and learning. A computer algebra system is a tool not a self-contained learning package or encyclopaedia of mathematical knowledge. It is the way in which it is presented to and used by students that determines its ability to influence learning. CAS are computer tools which are easy to use and useful in both pure and applied mathematics courses. Use of CAS in the teaching of Mathematics should be channelized to maximize [2].

With the traditional undergraduate curriculum, students do not often regard themselves as active participants in mathematical exploration. Rather they are passive recipients of a body of knowledge, comprising definitions, rules and algorithms. Computers offer a number of didactic advantages that can be exploited to promote a more active approach to learning. Students can become involved in the discovery and understanding process, no longer viewing mathematics as simply receiving and remembering algorithms and formulae [1]. Computers help in differentiating the roles of students and teachers, applying the same standards in learning[3]. Educational software can also equate and encourage students' understanding and meaningful learning for all students in a constructivist approach. The teacher-centered learning spontaneously becomes student-centered when multiple intelligence situations are implemented in educational activities through the use of computer [4].

The concepts that can be integrating with mathematics software is Numerical Methods. Numerical methods are a technique for solving effective and efficient math problems. With the help of computers is able to deal with complex problems and involves extensive calculations, for example to solve the problem of solution of a nonlinear equation, a system of great equations, and other problems including in engineering and social. Problems that are often difficult or even impossible can be solved analytically can be solved by numerical methods.

Currently there are various packages of computer programs (eg exel, maple, matlab, or other package programs). The software that can be use to help lecture to teach numerical methods is maple and Matlab. Maple is one of the most popular Software because it is perfect for helping students learn math through the verification of calculations and plotting complex graphics, and also combines mathematical skills with a text editor. Matlab has numerical advantage. Users can do calculations looking for equation roots, graphs etc. It is a high level programming language devoted to the needs of technical computing, visualization and programming such as mathematical computation, data analysis, algorithm development, simulation and modeling and graphics calculations. In numerical Methods, Student can create the algorithm to get the solution or they also can make the graph of the function as a visualization. Matlab is a high-level software package with many built-in function that make the learning of numerical methods much easier and more interesting[5].

One of the significant challenges in mathematical learning is how to teach students about abstract concepts [3]. In this case, the technology in the form of mathematics learning software can be used more widely to instill abstract concept in mathematics. With the existence of math software some of the material that is difficult to explain, can be more easily conveyed to the students. In addition, according to [6], technology can also be used for problem solving, for example in advanced calculus courses, students often have difficulty in determining the integral region of the integral fold. With the use of Mathematica software in learning, the students' difficulties can be overcome, so that students can more easily determine sketches, integration areas and integration functions.

A common problem encountered in engineering and mathematical analysis is this[7]: given a function \( f(x) \), determine the values of \( x \) for which \( f(x) = 0 \). The solutions (values of \( x \)) are known as the roots of the equation \( f(x) = 0 \), or the zeroes of the function \( f(x) \). Before proceeding further, it might be helpful to review the concept of a function. The equation \( y = f(x) \) contains three elements: an input value \( x \), an output value \( y \) and the rule \( f \) for computing \( y \). The function is said to be given if the rule \( f \) is specified. In numerical computing the rule is invariably a computer algorithm There are several methods to find the roots of non linear equation, those are Bisection Method, Regula Falsi and Secant Methods, and Newton-Raphson Method.
One of the first numerical methods developed to find the root of a nonlinear equation \( f(x) = 0 \) was the bisection method (also called Binary-Search method) [8]. Bisection methods based on the formula: an equation \( f(x) = 0 \), where \( f(x) \) is a real continuous function, has at least one root between \( x_i \) and \( x_u \) if \( f(x_i) \cdot f(x_u) < 0 \). Note that if \( f(x_i) \cdot f(x_u) > 0 \), there may or may not be any root between \( x_i \) and \( x_u \). If \( f(x_i) \cdot f(x_u) < 0 \), then there may be more than one root between \( x_i \) and \( x_u \). So the theorem only guarantees one root between \( x_i \) and \( x_u \) The steps to apply the bisection method to find the root of the equation \( f(x) = 0 \) are:

1. Choose \( x_i \) and \( x_u \) as two guesses for the root such that \( f(x_i) \cdot f(x_u) < 0 \), or in other words, \( f(x) \) changes sign between \( x_i \) and \( x_u \).
2. Estimate the root, \( x_m \) of the equation \( f(x) = 0 \) as the mid-point between \( x_i \) and \( x_u \) as
   \[
   x_m = \frac{x_i + x_u}{2}
   \]
3. Now check the following
   a. If \( f(x_i) \cdot f(x_m) < 0 \), then the root lies between \( x_i \) and \( x_m \); then \( x_i = x_i \) and \( x_u = x_m \).
   b. If \( f(x_i) \cdot f(x_m) > 0 \), then the root lies between \( x_m \) and \( x_u \); then \( x_i = x_m \) and \( x_u = x_u \).
   c. If \( f(x_i) \cdot f(x_m) = 0 \); then the root is \( x_m \). Stop the algorithm if this is true.
4. Find the new estimate of the root
   \[
   x_m = \frac{x_i + x_u}{2}
   \]

Find the absolute approximate relative error as
   \[
   |\varepsilon_a| = \left| \frac{x_m^{\text{new}} - x_m^{\text{old}}}{x_m^{\text{new}}} \right| \times 100
   \]
where
   \[
   x_m^{\text{new}} = \text{estimated root from present iteration}
   \]
   \[
   x_m^{\text{old}} = \text{estimated root from previous iteration}
   \]
5. Compare the absolute relative approximate error \( |\varepsilon_a| \) with the pre-specified relative error tolerance \( \varepsilon_i \). If \( |\varepsilon_a| > \varepsilon_i \), then go to Step 3, else stop the algorithm. Note one should also check whether the number of iterations is more than the maximum number of iterations allowed. If so, one needs to terminate the algorithm and notify the user about it.

A shortcoming of the bisection method is that in dividing the interval from \( x_i \) to \( x_u \) into equal halves, no account is taken of the magnitude of \( f(x_i) \) and \( f(x_u) \). Indeed, if \( f(x_i) \) is close to zero, the root is more close to \( x_i \) than \( x_u \). The false position method uses the property that is a straight line joins \( f(x_i) \) and \( f(x_u) \). The intersection of this line with the x-axis represents an improvement estimate of the root. This new root can be computed as: \( \frac{f(x_i)}{x_i - x_f} = \frac{f(x_u)}{x_u - x_i} \). So, \( x_r = \frac{f(x_i)(x_u - x_i) - f(x_u)(x_i - x_u)}{f(x_i) - f(x_u)} \). Then, \( x_r \) replaces the initial guess for which the function value has the same sign as \( f(x_i) \) [7].

The difference between bisection method and false-position method is that in bisection method, both limits of the interval have to change. This is not the case for false position method, where one limit may stay fixed throughout the computation while the other guess converges on the root [8].
2. Experimental Method
This research is a type of research development. The procedure of development in this study is 4-D (Four D model). The development of learning media of numerical methods using Matlab consists of four steps [9], namely (1) Define include early analysis, learner analysis, material analysis, task analysis and specification of learning objectives; (2) The design includes the selection of media, the selection of formats and the initial planning of learning media based on mobile learning mathematics with a scientific approach; (3) Development and (4) Distribution

The developed instrument consists of validation sheet of teaching material software assisted for numerical methods. Validator in this research is divided into two kind, namely software media validator and material validator. Validation of media experts assess the quality of the product in terms of media aspects are: ease of program start, logic thinking, interaction with users, the clarity of usage instructions, use of text format language, presentation sequence, and program appearance. While the validation of material experts assess the quality of the product in terms of the content of the content, namely: conformity with learning objectives, relevance to student skills, clarity of learning topics, material demands, material coverage, material completeness, image relevance and illustration with the material, ease of use, and ease of understanding material.

3. Result and Discussion
From the research that has been done, from the preparation, the making of teaching materials, instruments and validation, then obtained the following results

3.1. Development Process
In the development process consist of Defining Steps, ie: Preliminary analysis. In this era of educational advancement, many teachers and lecturers are incorporating technology into classroom learning. In mathematics learning, the use of technology in the classroom makes high-level math activities more accessible to students. In this case, technology can strengthen the learning process of students, by presenting numerical, graphic, and symbolic content without spending the time to calculate complex computing problems manually. Technology can also help to encourage students to acquire the ability and skills to make connections between concepts so as to find the solution and prove the process[10]. The next is analysis of learners. With the method of documentation and literature study results obtained analysis of learners that the undergraduate students are now already familiar with technology like software for mathematics. In the previous courses they was studied about several mathematics Software. The third, we do the material analysis. Based on discussions with lecturer Numerical Methods at a university in Kediri, the lectures on numerical methods never integrate the software. Although many calculations are done in this course, but the calculations used still use the calculator and do not use the software. In fact, according to theoretical studies conducted by researchers, numerical methods often require a long calculation, so that learning if the calculation is only done with a calculator. Based on this, the researcher developed the teaching materials software assisted for numerical method. As an example material that the teaching material developed with software assisted is how to find the root of equation by using bisection method and regula falsi method. On next step is task analysis. Analysis of tasks done after knowing the material to be taught, such as finding the root of the equation with bisection and regula falsi method so that students will be able to know the tasks that must be completed. The last is specification of learning objectives. Based on the material analysis and task analysis that has been done is expected to be able to produce special learning objectives which is the basis for preparing the test and designing teaching materials software assisted for numerical method.

3.2. Design Steps
After analyzed at the definition stage, then compiled instructional software materials in the form of syllabus, Lesson plan, student activity sheet, student response questionnaire. The first step is selection of media. This instructional material is made with attention to the steps of learning mathematics so that still allows learners explore their ability. The second, we do selection of formats. Activities at this step include selection of formats for designing or designing instructional content, strategy selection,
approaches, learning methods and learning resources. The third is initial design. This activity is a
learning plan, which includes: (1) syllabus, (2) lesson plan, (3) student activity sheet, (4) student
response questionnaire, (6) teaching material software-assisted for numerical methods

3.3. Development Steps
Expert assessment includes product validation, which includes all instructional materials of software-
assisted numerical methods developed at the design stage. The results of the revisions based on the
validator's assessment resulted in draft II. For this study we limit until the validation of experts and not
until the trial is limited

Based on the results of expert validation of the teaching and learning material obtained the
validation of teaching and learning material of numerical methods is well designed. Thus the result is
learning material in numerical methods is in accordance with the criteria specified valid.
The average value of the media validator is 91.56% and the average value of the material validator is
92.67%.

Generally the validator declares good in teaching and learning material and can be used with a little
revision. Based on the results of expert validation, some revisions made to the media can be seen in
Table 1.

| Revision from Validator | Follow up revision |
|-------------------------|--------------------|
| Incomplete teaching materials, need to be | The teaching materials are equipped with other |
| equipped with root search method equations | root search methods, such as Newton-Raphson |
|                                        | method, the Secant method, etc |
| Learning steps and teaching materials are adapted | The learning steps are adjusted to the steps of |
| to the inquiry learning method to suit the | inquiry learning |
| objectives of developing the teaching materials |

At the design stage aims to design the instructional materials software assisted numerical method.
In designing the researcher consult with the media expert in the making so that it can design and
design the instruction of software assisted numerical method. Activities undertaken at this stage are:
(1) selection of software (2) format selection and (3) initial planning of instructional materials of
software assisted numerical method.

At the development stage produces draft teaching materials software assisted for numerical
method. Activities undertaken at this stage are expert judgment and legibility test. Teaching materials
that have been designed to be validated by a media expert to obtain input and suggestions are also
done test legibility from the side of the sentence and language.

Based on the results of the validation of media experts say the instructional materials are designed
is good, and innovative. This teaching material can be a new innovation for the campus where the
research to use as a teaching tool numerical method. The use of integrated software in the study of
numerical methods will enable the learning of numerical methods to be more effective. Assessment of
validator to the average teaching material is good and can be used with little revision. Learning
material is feasible to be used in the field in accordance with the curriculum and hope when tested gets
good enthusiasm by students and lecturers.

By those result, we can say that computers were a support tool in learning as well as screen
subjects, slides or televisions. But, it must be remember, in the initial computer applications were used
only to present electronic pages with color images and simple calculations compared to the role of
computers in guiding students in constructing their own knowledge [3]. If the computer is only used
traditionally, suppose for a simple calculation, then this will have a negative impact on the results to
be achieved in learning. The traditional use of computers, for example, when computers are used as
calculators in algebra learning, where students can only see results with simple calculations [7]. The
results show that students lose their ability in algebraic calculations when they only use the computer as a simple calculation tool.

4. Conclusion
The process of developing the teaching material starts from the defining step, the process of designing the learning material developed based on information obtained from the step of early analysis, learners, materials, tasks that support then done the design step or design, then the last step is the development step. The development of teaching materials software assisted for numerical methods is valid in content. While validator assessment for teaching material in numerical methods is good and can be used with little revision.

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