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Development of student worksheet based on collaborative learning model in learning course of numerical methods

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Abstract. Student worksheet is one of the learning media that lecturers can use to convey subject matter to students in the learning process. It provides an overview of the subject matter of the lecture and can assist students in preparing the material to be presented. The purpose of this research is to develop student worksheet based on collaborative learning model in learning course of numerical methods. This study uses a design of research and development that refers to the Plomp model which is consisting of three phases, i.e. preliminary research, prototyping phase, and assessment phase. Based on the validation results, it can be concluded that the developed student worksheet are worthy of use, but still need to be refined. The student's response to the use of worksheets in lectures is good.

1. Introduction

Learning is an interaction process between students and teachers and learning resources in a learning environment. Learning can run effectively if it is supported by an appropriate learning model. That means by using learning model can develop student's hard skills and soft skills. Hard skills are technical abilities related to the field of knowledge, while soft skills are a person's ability to organize themselves and interact with others. The existence of hard skills must be accompanied by the existence of soft skills because by having balanced hard skills and soft skills, someone become a competent and qualified person. The ability of hard skills and soft skills are very important to be developed in the learning process, especially learning at the college level. This ability is a learning outcomes that established in college level because this is very useful in the work environment that will be undertaken by students.

Regarding this ability, students in lectures not only master every subject but also able to develop existing soft skills, such as the ability to build communication with other people and the ability to work in a team. Therefore, a learner in the learning process is expected to be able to explain subjects orally not only writing. So the students can develop their ability to communicate and express opinions accompanied by appropriate arguments. In addition, students are also required to be able to cooperate and respect the opinions of others and be responsible for solving a problem.

Learning model that can be applied to support the achievement of learning outcomes is collaborative learning. The concept of collaborative learning is largely rooted in Vygotsky's social constructivism theory which views learning as a social process that is inherently activated through a zone of proximal development [1]. This view highlights how mediated learning is in accordance with



the context and experience with peers because when individuals work collaboratively with more capable peers, the level of potential development will increase.

A learning practice only qualifies as collaborative learning when these following elements are met, i.e. positive interdependence, considerable promotive interaction, individual accountability, social skills, and group processing [2]. Interaction among student are expected to occur, that would trigger other element of collaborative learning to occur. The ways to increase possibility of interaction can be done by designing an activity that can improve students' conceptual understanding. To create an effective activity requires the existence of resources that can be used to convey messages to students in the learning process. That resource is teaching material, one of which is a worksheet. According to Lee's study, worksheets are one of the most frequently used materials that play important roles in effective teaching practices [3].

Worksheets are written materials consisting of individual activities which the students will do while learning a topic and also will enable the students to take responsibility for their own learning with the given process steps related to these activities [4]. Worksheets facilitate the transfer of learning material and of course can also help in preparing the material to be presented. In addition, the use of worksheets can make learning more effective and will lead to interaction when the students solve the task.

The use of worksheets will be very useful in learning, especially in complex subjects and has a wide range of material as well as numerical method course. The numerical method is a subject that contains a fairly complex concept where numerical methods involve a variety of methods to solve a mathematical problem and each method has its own algorithm which requires many iterations. Therefore, it is necessary to have collaboration between students and students with lecturers to be able to understand the concepts in this course. Based on the benefits of using worksheets, it is necessary to develop an appropriate worksheets in order to support the implementation of collaborative learning in numerical method course. This study aims to develop a student worksheet and describe the quality of it.

2. Methods

The research design was development research which refers to the Plomp model which consists of three phases, i.e.: (1) Preliminary research which includes analysis of needs and context, theoretical and literary studies, and developing a conceptual framework; (2) Prototyping phase which includes design and development. In the design stage, the prototype was prepared. Then in the development phase, prototype development is carried out through formative evaluation; (3) Assessment phase which includes assessment to determine the feasibility, practicality, and effectiveness of worksheets based on the results of limited trials [5].

This research was conducted from January to August 2016, located at IKIP PGRI Bali, especially in the mathematics education department. Subjects in this study were students who followed numerical method course. The instrument used consisted of a validation sheet to measure the validity, a response questionnaire to measure the practicality, and a learning outcome test to measure the effectiveness.

3. Results and Discussion

The result of research on the development of student worksheet based on collaborative learning models in numerical method course:

3.1. Preliminary research

Needs and context analysis in the preliminary research shows that there are obstacles in lecturing numerical methods where the concept of numerical methods is quite complex involving various methods to solve a mathematical problem and each method has its own algorithm which requires many iterations, so students often get confuse in how to use the method. In addition, the source book used usually has a wide range of material so it is difficult to learn by students. Therefore, teaching materials are needed that can organize the activities of students in learning and to help students know

the scope and description of the material. The right teaching materials are student worksheet that has several benefits including being a learning guide, helping to find concepts, and helping to implement and integrate various concepts. The lack of available numerical method worksheet is one reason for the development of student worksheet.

Theory and literature study in the preliminary research was carried out to find out the scope of the material and the learning outcomes of the numerical method course. Learning outcomes of numerical method course, that is: (1) students are able to master the theoretical concepts of mathematics related to numerical methods; (2) students are able to apply logical, critical, and systematic thinking in understanding the theoretical concepts of numerical methods and their use in solving mathematical problems; (3) students are able to demonstrate independent performance and a sense of responsibility in applying theoretical concepts of numerical methods in solving problems. This learning outcomes was then revealed to be a sub learning outcomes contained in each topic of numerical methods. Some of the topics that will be developed in the worksheets are: (1) numerical methods to determine the solution of non-linear equations; (2) numerical method to determine the solution of a linear equation system; (3) interpolation method; (4) numerical integration methods; (5) numerical methods for determining the solution of differential equations; and (6) numerical method applications.

3.2. Prototyping phase

In the phase of making a prototype, the topics of worksheets were arranged in a structured and systematic. The worksheets were arranged by consider the components of the worksheets, i.e. the title, learning outcomes, instructions, and content. The display of title, learning outcomes, and instructions are presented in Figure 1.

PENDAHULUAN

Capaian Pembelajaran Mata Kuliah Metode Numerik:

- 1) Mahasiswa menguasai konsep teoritis matematika terkait materi metode numerik.
- 2) Mahasiswa mampu menerapkan pemikiran logis, kritis, dan sistematis dalam memahami konsep teoritis metode numerik dan penggunaannya dalam menyelesaikan permasalahan matematika.
- 3) Mahasiswa mampu menunjukkan kinerja mandiri dan rasa tanggung jawab dalam menerapkan konsep teoritis metode numerik dalam menyelesaikan soal.

Petunjuk Penggunaan Lembar Kerja Mahasiswa (LKM):

- 1) Kerjakan LKM dalam kelompok.
- 2) Pahami permasalahan pada LKM dengan baik.
- 3) Mahasiswa dalam kelompok menetapkan tujuan belajar berdasarkan permasalahan yang ada dan membagi tugas sendiri-sendiri.
- 4) Kelompok kolaboratif bekerja secara bersinergi mengidentifikasi, menganalisis, dan memformulasikan jawaban-jawaban dari permasalahan pada LKM.
- 5) Dosen menunjuk secara acak salah satu anggota dari setiap kelompok untuk mempresentasikan hasil diskusi kelompok kolaboratifnya di depan kelas (selanjutnya diupayakan agar semua mahasiswa dari setiap kelompok dapat giliran ke depan).

*"One we can do so little, together we can do so much."
(Hellen Keller)*

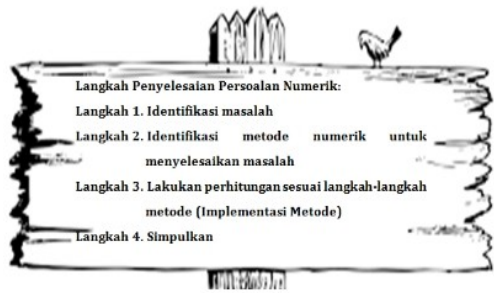
Figure 1. Numerical Methods Worksheet

The content section of the worksheets discusses the definition of numerical methods and errors, and the numerical method topics discussed in each chapter. Each chapter contains a summary of the material, exercises, and tasks that require students to collaborate with their colleagues and lecturers. In

addition, students are also required to be more active in reading book in supporting the explanation of each material. The appearance of the contents is presented in Figure 2.

PENGERTIAN METODE NUMERIK

Metode Numerik adalah teknik untuk menyelesaikan permasalahan-permasalahan yang diformulasikan secara matematik dengan cara operasi hitungan (aritmatika).



Penyelesaian secara numerik menghasilkan nilai hampiran/ aproksimasi yang mendekati nilai eksak (nilai yang sebenarnya). Berarti dalam penyelesaian numerik tersebut terdapat galat (error) terhadap nilai eksak yang disebut dengan galat numerik. Galat numerik adalah besaran yang merupakan selisih antara nilai hampiran dengan nilai eksak.

"Kesalahan bukanlah kegagalan tapi bukti bahwa seseorang telah melakukan sesuatu"
(Anonim)

LKM I. SOLUSI PERSAMAAN NON-LINIER

Tujuan:

- Mahasiswa mampu menerapkan pemikiran logis, kritis, dan sistematis dalam memahami konsep teoritis metode numerik yang terkait dengan penentuan solusi persamaan non-linier.
- Mahasiswa menunjukkan kinerja mandiri dan rasa tanggung jawab dalam menerapkan konsep teoritis metode numerik dalam menyelesaikan soal yang terkait dengan penentuan solusi persamaan non-linier.

MATERI

METODE PENCARIAN AKAR

Akar (pembuat nol) dari suatu fungsi adalah nilai-nilai dari variabel bebas yang membuat fungsi bernilai nol. Salah satu cara menentukan akar persamaan $f(x) = ax^2 + bx + c$ adalah dengan menggunakan rumus *abc*, yaitu: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Metode pencarian akar dalam metode numerik dikelompokkan menjadi dua, yakni:

1. Metode Pengurung

Tebakan akar dalam metode pengurung selalu berada "dalam kurung" atau berada pada kedua sisi dari nilai akar dan diperlukan dua tebakan awal untuk menentukan hampiran nilai akar persamaan fungsi. Metode pengurung ini memiliki keunggulan, yakni iterasi yang terjadi pasti konvergen (makin lama makin mendekati nilai sebenarnya). Akan tetapi hal ini juga menimbulkan adanya kelemahan, yakni kekonvergenan terjadi dalam proses iterasi relatif lambat.

Kekonvergenan pada metode pengurung pasti terjadi dikarenakan metode ini didasari oleh suatu teorema yang dapat menjadi filter dalam penentuan tebakan awal, sehingga tebakan awal tidak sembarangan ditentukan. Teorema yang dimaksud adalah: **Diketahui $f: [a, b] \rightarrow \mathbb{R}$ adalah kontinu, dimana $a, b \in \mathbb{R}$ dan $a < b$. Jika $f(a) \cdot f(b) < 0$, maka terdapat $c \in (a, b)$ sedemikian sehingga $f(c) = 0$.**

Beberapa metode numerik yang tergolong dalam metode pengurung adalah Metode Bagi Dua (*Bisection*) dan Metode Interpolasi Linear/ Posisi Palsu (*False Position*).

Figure 2. Content of Numerical Methods

The next step in the prototype phase is to do validation and revision. Validation and revision are carried out repeatedly to ensure that the worksheets is feasible to be tested. Validation was carried out by three validators by filling out a validation sheet. The validation sheet is used to measure the feasibility of worksheets component which includes the components of content eligibility, linguistic components, and presentation components. This research found that the average of each component has very valid criteria with total average is 4.48. This criteria based on the following categories [6]:

Very valid	: $4 \leq \text{component average} \leq 5$
Valid	: $3 \leq \text{component average} < 4$
Less valid	: $2 \leq \text{component average} < 3$
Invalid	: $1 \leq \text{component average} < 2$

In addition to validating based on three feasibility components, the validator also provides a general assessment of the worksheets. The general assessment given by the validator is criterion B, which is that the worksheets are worthy of use, but still need to be refined. Some suggestions for revisions given by the validator are: (1) The visualization of the image should have a little explanation, so that students can imagine the problems in the image; (2) An example of an application that can be equipped with a systematic problem solving stage; (3) A simple analogy can be given as an introduction in understanding a fairly complicated concept; (4) In the end of each chapter may completed with motivational sentences, to encouraging the interest and creativity of students. The display of the revised worksheets can be seen in Figures 1 and 2.

3.3. Assessment phase

Assessment phase conducted to assess the practicality and effectiveness. Prior to the practicality and effectiveness tests, the numerical method worksheet were tested on students who attended numerical

methods lectures. Learning is done by applying collaborative learning models and using worksheets as supporting teaching activities.

Practicality tests are carried out by giving questionnaires to students. This research was found that overall the numerical method worksheets received a good response from students. This shows that the worksheet developed is practical.

The effectiveness test is done by looking at learning outcomes in numerical method lecture. This research was found that the average score of learning outcomes was 72.53 which was good category. The data also shows that 76.7% of students get a B grade in the lecture of numerical methods that apply collaborative learning and use the worksheets as teaching materials for supporting activities. This shows that numerical methods worksheets are effective in learning.

3.4. Discussion

The numerical method worksheets developed in this study is based on collaborative learning. This worksheets contains instructions and tasks/ activities that must be carried out by students in order to create cooperation and interaction between students and between students and lecturers. Collaborative learning focuses on the development of meaningful activity and performance [7]. Therefore, worksheets developed must have valid, practical, and effective criteria to support the implementation of collaborative learning in numerical method course.

In this study, worksheets validation was stated to be very valid when viewed from the validator score average. In addition, the components of content eligibility, linguistic components, and presentation components are also stated to be very valid. The overall assessment of the validator states that the worksheets are worthy of use, but still need to be refined. This results are the results of the assessment after repeated revisions to the worksheets. Some suggestions have been given and improvements have been made so that the worksheets are feasible to be tested.

Practicality of worksheets is shown from the student's response where the overall aspects of the numerical method worksheets get a good response. This response is based on seven aspects, namely suitability with the syllabus/ curriculum, material coherence, material density, difficulty level, application, neatness of writing, and references used. Aspects of material coherence, difficulty level, application, neatness of writing, and references that are used each get a good response from students. Aspects of suitability with the syllabus/ curriculum get a pretty good response from students. Aspects of material density have a poor response from students. This is because students feel that the questions on the worksheets are too short so that the students do not catch the message conveyed, and there is an unclear statement. Therefore, it is necessary to revise some aspects of the worksheets.

The effectiveness of worksheets is shown by student learning outcomes where the average learning outcomes are categorized as good with details: 5.36% got an A, 76.79% got a B, 14.29% got a C, and 3.57% got a grade D. There is still C and D values indicates that the application of collaborative learning using worksheets as teaching materials in numerical method course needs to be further evaluated.

The result of this research presented that numerical method worksheet is effectively to be used to help students gain knowledge and allow students to be involved in active learning. This is because the material presented in the worksheets is in the form of a summary that includes material that will be done by students, and there are task and activities. Structure of these worksheets provide benefits in learning, i.e. facilitating teachers in managing the learning process, helping teachers in directing their students to be able to find concepts in the material, and developing scientific attitudes. This is as stated in Barniol's study that the students achieve their own understanding using the tutorial worksheet because the worksheets contain questions that break down the reasoning process into steps to guide students in using scientific reasoning to build conceptual understanding [8].

Numerical method worksheet based on collaborative learning were developed, received a good response from students. This is because worksheets can encourages students to interact, collaborate, share roles, tasks, and responsibilities in completing tasks or problems. As stated in Sulaiman's study, mathematics lessons can be designed by preparing teaching and learning activities that involve

collaboration through group work to the mathematical topics selected in the syllabus [9]. Activities that will be carried out in numerical methods learning are outlined in worksheets to direct students in understanding the concept and implementation of the method. The worksheets are given at the beginning of the lecture with prior instructions or explanations regarding the material in the worksheets. Concept discovery and method implementation are actively carried out by students.

4. Conclusions

Based on the research, it can be concluded that: (1) worksheets based on collaborative learning models in numerical method course meet very valid and worthy of use, but still need to be refined; (2) worksheets is practically to be used which are shown from student responses are good; (3) worksheets is effectively to be used which are shown from the average learning outcomes are good.

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