The Development of Student Worksheet Based on Realistic Mathematics Education in Ordinary Differential Equations of Order-1

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Abstract. Students' mathematical communication skills are still low and need to be improved. Learning tools do not support the student learning process. This study aims to produce a learning trajectory for 1st-order differential equations. This type of research is a Plomp type research design consisting of three phases: (1) preliminary phase (preliminary research phase), (2) prototyping phase (prototype development phase), and (3) assessment phase (assessment phase). This section reports the preliminary phase. The conclusion is that the device has not facilitated students to make their own strategies to find concepts. Students need teaching materials in the form of worksheets that contain contextual problems that are close to students and facilitate student learning flow in rediscovering the theoretical concept of Ordinary Differential Equations (ODE).

1. Introduction

Ordinary Differential Equations (ODE) is one of the branches of mathematics grouped in applied mathematics. This ODE has many applications in real life [1, 2, 3, 4]. In addition, the teaching method that is more often used is chalk and talk [5, 6]. As a result, most students think that the mathematical concepts studied in ODE are very difficult to understand because they are not related to real life. This contradicts Freudenthal's idea that mathematics is human activity and learning mathematics means doing mathematics [7,8].

Mathematical communication skills need to be the focus of attention in ODE learning, because through communication, students can organize and consolidate their mathematical thinking, and can also develop their mathematical ideas (NCTM). As part of mathematics, the material contained in ODE is closely related to symbols that make it a separate language. Students studying ODE must process communication skills using these symbols.

Several ways can be done to develop mathematical communication skills, including by getting students to communicate their ideas through representation, listening, discussing, reading, and writing. After that the lecturer must ask students to clarify their ideas either verbally or in writing.

Mathematical communication skills can be in the form of oral or written communication. The ability of verbal mathematical communication can be seen when students convey their mathematical ideas to their lecturers or friends during discussion activities. Meanwhile, written mathematical
Communication skills can be seen when students use models, tables, diagrams, or other mathematical symbols to solve a problem. This is because almost all mathematical material requires the use of models, tables, diagrams, or other symbols.

One of the innovations that can be done to stimulate an increase in mathematical communication through mathematical resilience is to use a learning approach that can provoke curiosity, confidence, and student persistence. The learning approach that can be used is a student centered learning approach. One is a realistic mathematics learning approach known as Realistic Mathematics Education (RME) to facilitate students in making discovery activities. In this case students are encouraged to solve the ODE problems given in their own way [9].

Observing the problems that occur, the researcher argues that the RME approach has the potential to overcome these problems, because RME aims to change mathematics education in such a way that most students will be able to do and enjoy mathematics (in this case ODE), solve math problems, and develop knowledge and math skills [10]. ODE learning with the RME approach is focused on how ODE is taught and how students learn ODE in class in a meaningful way. To achieve this goal, it is necessary to develop student worksheets (LKM) based on the RME approach.

2. Metode Penelitian
This type of research is design research which is divided into two types, namely development studies and validation studies [11]. This type of development studies is a systematic analysis, designing and evaluating educational interventions with the aim of building research based on solutions to complex problems in educational practice, and to increase knowledge of the characteristics of these interventions and the process of designing and developing them. The aim of these development studies is to develop relevant innovative interventions in educational practice.

Meanwhile, design type validation studies is a study of educational interventions (such as the learning process, learning environment, and the like). The focus of validation studies is to design a learning environment or hypothetical learning trajectory (HLT) with the aim of developing and validating theories about the learning process and how it can be designed. The purpose of validation studies is to develop learning and teaching theory, such as realistic mathematics education (RME).

This development is expected to produce a local instructional theory. Local instructional theory (LIT) is developed cyclically through the design of a hypothetical learning trajectory (HLT) which is manifested in the form of a lecturer work manual (BPKD) and a student work manual (BPKM). The development model used in this research is design research, namely the Plomp model design consists of three phases, namely (1) preliminary phase (preliminary research phase), (2) prototyping phase (prototype development phase), and (3) assessment phase (assessment phase).

3. Results and Discussion
3.1. Results of Needs Analysis
Based on the results of the needs analysis, it was obtained that the lecture design data made by the lecturers had not facilitated students to make their own strategies to find the concepts being studied, the learning flow used by the lecturers had not paid attention to the characteristics of the students as a whole. Lecturers in compiling lecture devices also have not paid attention to student learning flow, lecture devices are adjusted to the material in the reference book, so that it has not facilitated the development of mathematical communication skills and students' mathematical resilience abilities. ODE order-1 material is seen as material that is quite difficult for students to understand. Therefore, a learning path is needed that is designed according to student characteristics, is close to student life, and makes students discover the concept of ODE for themselves and makes mathematical communication skills and students' mathematical resilience abilities developing.

3.2. Results of Curriculum Analysis
Curriculum analysis is carried out on the syllabus of the ODE course. The analysis is carried out on learning objectives, materials and indicators to achieve basic competencies. From the results of the curriculum analysis, the ODE material contains many contextual problems. Therefore, in teaching ODE material it is very possible to start from things that are close to student life, so that students can rediscover the concepts that exist in ODE material. To achieve this goal, it is necessary to design ODE lectures that can guide and guide students to understand the concept well. Based on the analysis of basic competencies (KD) and indicators in the syllabus used, ODE material begins with the meaning of differential equations, 1st order ODE and its applications, high order ODE and its applications, as well as the linear PD system and its applications. In applying ODE order-1 to real problems, no more concrete steps are seen to form a mathematical model. For this reason, it is necessary to design more detailed stages that students will go through using RME-based HLT. This application is also not emphasized in any field, therefore this research is limited to five fields, namely biology, physics, chemistry, engineering and economics.

After students construct a mathematical model in the form of first-order ODE, it is expected that they can determine the classification of the first-order ODE which is formed to determine the solution. Then this solution will be interpreted according to the real conditions that occur. Changes in KD and indicators according to curriculum analysis for the topic of ODE order-1 above can be seen in Table 1.

| Basic Competence before analyzed | Basic Competence after analyzed | Indicators before analyzed | Indicators after analyzed |
|----------------------------------|---------------------------------|---------------------------|--------------------------|
| Students understand and are skilled at applying ODE order-1 to real problems | Skilled students create mathematical models in the form of first-order ODE from real problems and determine the solution. | a. Forming mathematical models of real problems in the form of 1st order PD. | a. Construct mathematical models of 1st-order ODE in real-world problems in biology, physics, chemistry, engineering, and economics. |
|                                  |                                 | b. Determine the solution of a mathematical model | b. Determines the classification of the resulting 1st-order ODE. |
|                                  |                                 | c. Interpret the solutions of the mathematical model | c. Determine the solution of the mathematical model |
|                                  |                                 |                           | d. Interpret the solution of a mathematical model |

3.3. Results of Concepts Analysis

Based on the results of concept analysis, the first concept that students must construct in the application material of Order-1 ODE is the concept of understanding differential equations, the order of a PD, the degree of a PD, the linearity of PD, and the solution of the 1st order ODE. Furthermore, students will study the basic theory / laws related to the field of science in which the mathematical model will be generated. Of the several fields that are the application of this 1st order ODE, students can present them in various conditions, for example registering or writing down what factors are contained in the field and the characteristics that represent them. This is useful for determining what variables are really involved directly related to the model to be produced. The essential concepts in learning ODE, the topic of real problem models in the form of ODE order-1 can be seen in Figure 1 below.
3.4. Results of Literature Review

Literature review was carried out on Differential Equation text books, and related research journals. The textbook was chosen which contained the topic of 1st order ordinary differential equations (ODE), namely: (1) Kartono [12], in Chapter 2, the material of first order ODE consists of: definition of 1st order PD, separate variable PD, PD Homogeneous, PD with linear coefficients, exact PD, linear PD, trajectory, power series method in 1st order, high order 1st degree PD and solving mathematical models. (2) Ross [13], in Chapters 2 and 3, the material of order-1 ODE consists of: exact PD and integration factors, separate and homogeneous variable PD, linear and Bernoulli PD, special integration and transformation factors, and the application of order-1 (trajectory, mechanical problems, and growth problems). (3) Sailah and Cekdin [14], in Chapters 2 and 3, the material of order-1 ODE consists of: separate variable PD, homogeneous PD, PD with linear coefficients, exact PD, PD with integration factor, linear PD, PD Bernoulli, and first-order ODE applications (temperature, growth and decay, and the electrical circuit RL). (4) Sugiyarto [15], in Chapter 1, the material of ODE order-1 consists of: introduction, classification, method of completion (separate and homogeneous variable PD, exact PD and integration factor, and linear PD and Bernoulli), and applied level PD. first (Newton's laws of temperature, circuit models, and motion along straight lines).

The results of the review of these textbooks show that in general these books are more concerned with the steps to resolve several types of ODE in the 1st order. Theories relating to first-order ODE are mostly presented in separate chapters, and it is not so clear how the real problem is related to the resulting model of first-order ODE. The learning flow shown in the textbook does not much facilitate students to retrace the stages of reinvention of theoretical concepts of first-order ODE.

Several journals related to learning design were analyzed, namely Andrews produced a learning design in the form of HLT, and resulted that HLT was able to support students in developing flexible ways of thinking in higher education. Apart from that Wilson et al, found that the learning trajectory can help educators in creating models of students 'thinking and restructuring educators' understanding of mathematics and reasoning.

Related to RME, research by Armanto [16] and Fauzan [5] found that RME is a promising approach to improve and increase students 'understanding of mathematical concepts and build
students' interest in learning mathematics. Apart from that Ruseffendi [17] found that RME can improve students' logical, critical, and creative thinking. Bonotto [18] found that RME can improve mathematical literacy skills, reasoning abilities, and problem solving abilities of students.

So, associated with theoretical studies, learning the topic of ordinary differential equations (ODE) will be more meaningful if the lecturer is able to design a learning trajectory that is adjusted to the development of students' thinking abilities. One way is to use a real context that is very close to the students. An approach that uses a real context to facilitate students to create their own models in finding the concept of ODE is RME. This is explained in several literatures, namely De Lange (1987), Gravemeijer

3.5. Results of Students’ Characteristic Analysis
The results of interviews with students and lecturers obtained information that students often forget the prerequisite material needed to learn the concept of ODE. The prerequisite material needed is in the form of material about derivatives and integrals. Therefore, students must prepare themselves in advance about the prerequisite material by repeating it, discussing with friends, or hoping that the lecturer will review the prerequisite material at the beginning of the lesson.

Students feel that the ODE material is difficult to understand because it requires the ability of the prerequisite material. For this reason, students prefer learning that invites students to reason with various activities to find theoretical concepts in lectures, compared to lecturers who directly explain the material in detail. This is because the characteristics of students are different. If learning is done classically by following the explanation given by the lecturer, of course not all students are able to study what the lecturer said. The theories directly explained by the lecturers did not last long in the minds of students.

The results of interviews with students indicated that besides using references from textbooks, students wanted teaching materials in the form of worksheets with the following characteristics: (1) containing contextual problems that were close to the students; (2) the language is easy to understand; (3) Facilitating student learning flow in rediscovering the theoretical concept of ODE.

4. Conclusion
Based on the description above, it can be concluded as follows:
1. The device does not yet facilitate students to create their own strategies to find concepts.
2. Students want teaching materials in the form of worksheets that contain contextual problems that are close to students and facilitate student learning flow in rediscovering the theoretical concept of ODE.

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