Didactital design of mathematics teaching in primary school

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Abstract. The fact that the low ability of geometrical understanding of primary school students is what triggers this study to be conducted. Thus, this research aimed to find out how to create a didactical design of students' mathematical understanding, particularly on one of geometry materials that is unit of length. A qualitative approach promoting Didactical Design Research (DDR) was administered in this study. Participants of the study were primary school students in Tasikmalaya, an city in West Java Province, Indonesia. The results show that there was a learning design based on learning obstacles found in the mathematics teaching and learning processes. The learning obstacles comprised students’ difficulties in memorizing, relating, and operating the standards of unit of lengths. It has been proven that the most influential factor in the success of mathematics teaching and learning processes is the use of creative media.

1. Introduction

Learning is the process of behavioral change to acquire knowledge, abilities, and something new and directed at a particular goal. Learning is also a process of doing things through various experiences by seeing, observing, and understanding something learned [1].

In the world of education, students who do the learning process do not perform it individually, but there are some components involved, such as educators or teachers, media and learning strategies, curriculum, and learning resources. There are many types of factors that influence learning which can be classified into two categories, namely, internal factors and external factors [2]. Attention is one factor that is included in the internal factors and teaching method is one factor that is included in the external factors. Both, of course, can affect students learning. In order to assure good learning outcomes, students should be concerned about a topic they are studying. If the subject matter does not attract students’ attention, then boredom arises so that they do not like learning anymore [2].

Mathematics is one of the subjects taught in primary school. Mathematics is known as deductive science because the process of seeking truth (generalization) in mathematics is different from natural science and other sciences. The method of finding the scientific truth used is a deductive method, not in an inductive way. Although in mathematics seeking the truth can begin in an inductive way, but the correct generalization for all circumstances must be proven in a deductive way. In mathematics, a generalization of nature, theory, or theorem is considered truth after it is proved deductively.

Mathematics learning is often considered as a more difficult learning activity than other subjects learning. However, mathematics is needed by every individual in his daily life. One of the teachers’ duties is to create an innovative and fun math lesson plan. It is because if a topic taught in learning which
is fun and interspersed with humor, it will quickly be absorbed by the brain and easily affect emotional intelligence.

Therefore, the process of learning mathematics should be interesting and fun so that students can easily absorb a topic and make it a meaningful learning. In primary school, one of the mathematics learning topics is the concept of the standard unit of length. This topic is the basis for understanding the concept of mathematical geometry.

Standardized measurements are measurements with fixed or standard results. There are two standard measurement systems, namely the British System and Metric System. At the primary school level in Indonesia, the standard unit of length is the metric system consisting of kilometers (km), hectometer (hm), decameter (dm), meter (m), decimeter (dm), centimeter (cm), millimeter (mm).

However, in reality, mathematics learning in primary schools is still less innovative and less attractive to students. This situation can be caused by several factors, one of which is the learning model used by teachers in the classroom. This is evidenced by some students' answers obtained in the preliminary study as shown in figure 1,2,3 following.

![Figure 1. Student’s learning obstacle in memorizing the standard unit of length](image1)

![Figure 2. Student’s learning obstacle in determining the relationships in the standard unit of length.](image2)

![Figure 3. Student’s learning obstacle in solving problems related to the standard unit of length](image3)

Based on the preliminary study, it can be concluded that the students had difficulties in memorizing the names and sequences of the standard unit of length, determining the relationships among the units in the standard unit of length and solving problems related to the standard unit of length. Based on the above description, this study question was, “How to develop the didactical design of student understanding on the standard unit of length?”
2. Methods
This research used Didactical Design Research (DDR) consisting of three stages, namely: (1) didactical situation analysis before learning process in the form of a didactical design hypothesis including ADP; (2) Metapedaddidactical analysis, and (3) Retrospective analysis relating to the outcome of didactical situation analysis hypothesis and metapedaddidactic analysis. Sugiyono [3] suggested that “the research method can be interpreted as a scientific way to get valid data to be found, developed and demonstrated that in turn can be used to understand, solve and anticipate a problem”.

This research took place in primary school located in Tasikmalaya. The participants of the research were composed of fourth grade students. We used a qualitative approach and we carried out the following activities: (1) The test of the preliminary study instrument; (2) The implementation of didactical design; (3) Observation; (4) Interview; (4) Questionnaire; and (5) Documentation.

3. Results and Discussion
Based on a preliminary study, each question generated different students’ responses and various learning obstacles. However, in this study, we selected some learning obstacles to become the focal points of this research. The research instrument, one of which in the form of questions, consists of 5 questions. The questions are arranged from the easiest to the most difficult and from the introduction of concepts, the planting of concepts, to the word (story) problems. This research focused on three types of learning obstacles are: (1) Memorization skills, (2) Deductive reasoning skills and (3) reasoning skills.

We created a learning design to was able to minimize or anticipate the emergence of learning obstacles. We took several steps to preparing the didactical design of the concept of the standard unit of length based on the students' understanding ability, namely: (1) prospective analysis, (2) teaching experiment, and (3) retrospective analysis.

3.1. Prospective Analysis
The first step in the preparation of learning activities was didactical situation analysis before the learning activities were performed in the form of HLT (Hypothetical Learning Trajectory) along with didactically-pedagogical anticipation. Before we developed the instructional design, we conducted curriculum analysis by choosing the standard of competence and basic competence in accordance with the concept of the standard unit of length in which we could implement the didactical design based on the improvement of students' understanding, set up the indicators, developed the learning objectives, described the learning activities to be carried out along with the didactical-pedagogical anticipation in HLT (Hypothetical Learning Trajectory), and created a didactical design.

The indicators and learning objectives were designed for two meetings with the time allocation of 2 x 35 minutes per meeting. The learning objectives were arranged to create teaching materials that will be implemented in the first and second meetings to overcome some learning obstacles revealed in the preliminary study of the concept of the standard unit of length. The development of this didactical design was implemented into two cycles. After determining the indicators and learning objectives, then we created the HLT (Hypothetical Learning Trajectory) and the didactical design which is divided into two meetings.

3.2. Learning Activities
Learning activities consisted of three student activities. The approach used in this research was a Realistic Mathematical Approach (RMA). This approach was chosen to form an understanding and development of ideas and concepts of mathematics that began from concrete mathematics to formal mathematics. This learning activity was assisted by student worksheet so that students could learn to observe the substitutitional words, which was related to the standard unit of length, that were easier to memorize. This was done as an effort to bridge the students to memorize the standard unit of length so
they cut and pasted the paper by themselves. The student worksheet in question is as shown in the following figure 4.

![Student Worksheet at the First Cycle](image)

**Figure 4.** Student Worksheet at the First Cycle

3.3. *Teaching Experiment*

The implementation of this initial didactical design was carried out in the fourth grade were composed of 30 students. Based on the implementation of didactical design of the standard unit of length, the following results were obtained. Learning was proceeded by giving the student worksheets. The student worksheet consisted of three activities. In the first activity, our purpose was to guide the students to attach the drawings related to the names of the standard unit of length through the practical activities. Thus, the students could memorize the names of the standard unit of length through observation activities and the students also could mention the names of the standard unit of length through observation activities.

To make the students memorize the order of the standard unit of length from kilometer to milimeter, in this activity, we distributed the learning design of the standard unit of length as shown in the following figure 5.
Students, who had been instructed to carry scissors for the learning process, immediately cut out seven paper that said "KUCING", "HITAM", "DI DALAM", "MOBIL", "DESI", "CENTIL", MONDAR MANDIR". After that, the students were instructed to fill in the second activity practice questions as shown in the following figure 6.

However, in this explanation, there were some students who answered incorrectly. When we asked if you go down a step we should multiply the number by 10, so if we go down two steps by what number should we multiply the number? They answered multiplied by 20. This is an imprecise concept. Therefore, we explained the material about the concept of the standard unit of length in a more detail way.

In the third activity, the objectives to be achieved by the researcher were the students could measure the tables in their classroom through the practice and students could solve the arithmetic operation problems about the standard unit of length through the activity that is measuring classroom table. This activity began by instructing the students to measure their classroom tables in centimeters and record them in the space provided as shown in the following figure 7.
Figure 7. Student Worksheet at the First Cycle

In the student worksheet, there was a short-answer question provided by us. The students were required to fill in the blanks in a paragraph such as shown in the following sample of student answers.

4. Conclusion
Based on the results and discussion of this research, it can be concluded that learning obstacles experienced by students related to the understanding of the standard length measuring unit are as follows: (1) the memorization of the names order of the standard unit of length, (2) the relationship among the units in the standard unit of length, (3) the operation of the standard unit of length.

The initial didactical design of mathematical connections on the concept of the standard unit of length was based on learning obstacles that emerged and reinforced with relevant learning theories. Furthermore, we created Hypothetical Learning Trajectory (HLT) that could guide us through the learning process. The implementation was carried out in fourth grade students. The results are most of the students’ responses matched with predictions, there were some unpredictable responses, and the available time was not enough to cover the entire contents of the didactical design that had been created.

Based on the above description, a revised didactical design was made. Implementation of revised didactical design was implemented again. There was a significant change in learning outcomes between the first and the second cycle learning process. Learning outcomes in the second cycle were more conducive and effective because some of the materials had been delivered in the first cycle.

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