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Obstacle to Learning Algebra in Elementary Schools

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ABSTRACT

This research is based on the results of a preliminary study which identified students' learning barriers in algebraic multiplication and division material in elementary schools. Students do not fully understand the concept of algebraic multiplication and division due to learning obstacles related to limited didactic designs made by teachers. Learning obstacles experienced by students must be anticipated through a learning process that is able to overcome these problems. The researcher developed a didactic learning design using a Realistic Mathematics Education (PMR) approach. The aim of this research is to determine the learning obstacles experienced by students, develop didactical designs for algebraic multiplication and division, describe, test, and describe the designs that have been created. The research method used in this research is Didactical Design Research (DDR). This method consists of three stages, namely didactic situation analysis before learning in the form of Hypothetical Learning Trajectory (HLT) and Pedagogical Didactic Anticipation (ADP), metapedadidactic analysis and retrospective analysis. The data collection technique used is triangulation which combines observation, interviews and documentation. The design development process was carried out in class V with a total of 18 students, and the preliminary study stage was carried out in class IV at SDN 1 Sukamanah with a total of 22 students, and class IV at SDN Sukamulya with a total of 16 students. This research produces data regarding student barriers to multiplication and division material, didactical design in the form of teaching materials, student worksheets (LKPD), to minimize students' learning barriers to multiplication and division material in algebra.

Keywords: Realistic Mathematical Approach, Algebra, Elementary School

ABSTRAK

Penelitian ini didasarkan pada hasil studi pendahuluan yang mengidentifikasi adanya hambatan belajar peserta didik dalam materi perkalian dan pembagian aljabar di Sekolah Dasar. Peserta didik tidak memahami secara utuh konsep perkalian dan pembagian aljabar dikarenakan adanya hambatan belajar terkait keterbatasan desain didaktis yang dibuat guru. Hambatan belajar yang dialami peserta didik harus diantisipasi melalui proses pembelajaran yang mampu mengatasi permasalahan tersebut. Peneliti menyusun desain didaktis pembelajaran dengan pendekatan Pendidikan Matematika Realistik (PMR). Tujuan dari penelitian ini adalah untuk mengetahui learning obstacle yang dialami oleh peserta didik, mengembangkan desain didaktis perkalian dan pembagian aljabar, mendeskripsikan, menguji cobakan, dan mendeskripsikan desain yang telah dibuat. Metode penelitian yang digunakan dalam penelitian ini adalah Didactical Desain Research (DDR). Metode ini terdiri dari tiga tahap, yaitu analisis situasi didaktis sebelum pembelajaran yang berupa Hypothetical Learning Trajectory (HLT) dan Antisipasi Didaktis Pedagogis (ADP), analisis metapedadidaktik dan analisis retrospektive. Teknik pengumpulan data yang digunakan adalah triangulasi yang menggabungkan antara observasi, wawancara dan dokumentasi. Proses pengembangan desain dilaksanakan di kelas V dengan jumlah 18 peserta didik, dan tahap studi pendahuluan dilaksanakan di kelas IV SDN 1 Sukamanah dengan jumlah 22 peserta didik, dan kelas IV SDN Sukamulya dengan jumlah 16 peserta didik. Penelitian ini menghasilkan data mengenai hambatan peserta didik pada materi perkalian dan pembagian, desain didaktis berupa bahan ajar, lembar kerja peserta didik (LKPD), untuk meminimalisir hambatan belajar peserta didik pada materi perkalian dan pembagian dalam aljabar.

Kata kunci: Pendekatan Matematika Realistik, Aljabar, Sekolah Dasar

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Introduction

The industrial era 4.0 is here to replace the old order which does not follow the demands of technological developments. These changes occur in every field, be it business, education, social, transportation to education. Education in the era of the industrial revolution 4.0 is

considered as the development of three major competencies in the 21st century. These three competencies are the competence to think, act and live in the world. Critical thinking skills and the ability to solve problems are closely related to mathematical literacy skills (Pratiwi et al., 2019). Good literacy is literacy that can make skills that can help students to think critically and solve problems found in everyday life (Halidi et al., 2015).

Thinking algebraically is different from thinking about algebraically. According to experts, the problem is that algebra is learned after arithmetic at the junior high school level, in contrast to algebraic thinking which is not the case (Siew et al., 2016). Various previous studies have revealed that algebra is one of the most difficult materials to learn in junior high school and high school (Jupri et al., 2014). One of the facts is that a study conducted in California stated that only 22% of eighth graders demonstrated proficiency in an equivalent algebra course (Setyawati et al., 2017).

The study of algebraic thinking in elementary schools, especially in the upper grades, is very important for making learning designs that are in line with the curriculum. Therefore, educators and prospective elementary school educators must pay more attention to this problem. In research it was found that the average algebraic thinking ability of students in algebraic thinking was 55% (Pratiwi et al., 2017), meaning that based on indicators of algebraic thinking, the ability to think algebra in upper grade students in elementary schools was not good.

Algebraic thinking in elementary schools is simple, namely, it includes generalizations based on patterns, facts, phenomena, or existing data and solving problems in everyday life (Hadi, 2021). The development of algebraic thinking skills is strongly influenced by mathematical activities in class (Mirza et al., 2020). This is a role that must be considered by the teacher, where the teacher is expected to be able to determine effective learning activities and can facilitate students to develop algebraic thinking skills.

One of the algebraic materials that will be implemented in elementary schools, especially in grade IV. Based on the Independent Curriculum with Learning Outcomes (CP), students can fill in unknown values in a correct mathematical sentence, students can solve simple equations using multiplication and division and students can find simple equation relationships using multiplication and division. Based on the Learning Outcome (CP) analysis, student understanding can be said to be achieved if students understand the basic algebraic concepts in elementary schools so that students are able to define and explain algebraic concepts. besides that, students are able to perform and complete algebra in multiplication and division.

Facts in the field found that many students still had difficulty understanding completion and division in elementary schools. This happens because when teachers deliver material, they only provide subject matter without paying attention to the level of student understanding. As a result, students are less involved in concrete learning. That many schools and teachers treat students as containers that are ready to receive knowledge. Not only that, the hereditary tradition of copying what the teacher writes onto the student's blackboard and the lack of student participation in class are two habits that cannot be abandoned.

Results of interviews with teachers of class V SDN Sukamanah during the preliminary study. Based on the results of interviews conducted on April 1, 2023, data was obtained that in delivering mathematics material, teachers were more fixated on teacher guide books and student books and focused more on activities that did not hone students' creativity in understanding a

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material. Not only that, the implementation of the dominant learning system with material reasoning causes a lack of understanding of students when the material is presented in a slightly different form than usual.

The results of the preliminary study show that there are still many students who experience learning obstacles in solving algebra problems in elementary schools. Learning Obstcles experienced by students include, there are still students who have not been able to determine unknown numbers from mathematical equations, students have difficulty completing multiplication and division operations. And students have not been able to determine the relationship between multiplication and division operations.

Learning Obstcle is a learning obstacle experienced by students during the implementation of learning takes place. The cause of the occurrence of Learning Obstcle in students can be caused by the students' internal and external environment. This is detailed who states that there are 3 factors that cause learning obstacles, namely mental readiness (ontogenic obstacle), didactical condition (didactical obstacle) and limited understanding (epistemological obstacle) (Brousseau, 1997). Ontogenic obstacle is a learning obstacle caused by the mentality of the students themselves. Didactical obstacles are obstacles caused by the teacher's method or approach when learning takes place, and epistemological obstacles are learning obstacles caused by the limited knowledge of students in certain contexts.

Learning obstacles in algebra material experienced by students can be anticipated and minimized by developing didactic design teaching materials. This is in line opinionstating that didactic design is a teaching material design that is compiled based on research on student learning obstacles in a lesson (Suryadi, 2010). The didactic design that always pays attention to the relationship between the teacher and students, students and material, and teacher and material. The preparation of this didactical design was carried out in 3 stages of analysis, namely: 1) analysis of the didactical situation before learning, 2) metapedidactic analysis and 3) retrospective analysis (Suryadi, 2010).

Research Methods

The type of research used in this research is the Didactical Design Research. This research was conducted to compile and develop students' worksheets in learning algebraic concepts for class V in elementary schools. In Didactic Design research there are 3 stages that must be passed: (1) analysis of the didactic situation before learning in the form of a Didactic Hypothesis Design including ADP, (2) metapedadidactic analysis, and (3) retroactive analysis which links the results of metapedadidactic analysis (Pratiwi et al., 2019).

The DDR research procedure is carried out in 3 stages, including:

Didactical situation analysis (Prospective analysis)

At this stage the researcher makes a hypothetical learning trajectory based on the analysis of student response predictions which is planned pedagogically, the description of the research consists of: reviewing the literature, determining the material, and analyzing the material, discussing with lecturers who understand and are experienced in this field, and as well as preparing the initial instruments that will be used to uncover learning obstacles.

Experiment

At this stage it was carried out by collecting data in the field which included: instrument testing, dedactic design implementation, and field documentation (photos, student response sheets and

interview results). The description of the activity at this stage is the basis for redesigning or modifying the next didactic design.

Review analysis (Retrospective analysis)
At this stage, the researcher analyzes the relationship between the results of the prospective analysis stage and the experimental data, including: analyzing student responses based on instrument testing and interviews discussed with the supervisor and analyzing learning obstacles that arise. The results of these associations will be the basis for designing the next learning cycle. Of the three stages, described into research steps which include:

The prospective analysis stage includes: analysis of the elementary school curriculum, choose and determine the material under study, develop preliminary study instruments to determine learning obstacles experienced by students, conduct a preliminary study, formulate learning obstacle experienced by students, designing and compiling didactic designs to overcome learning obstacles experienced by students, including compiling HLT and ADP.

The metapedidactic stage includes: implementing a didactic design accompanied by HLT and ADP, conduct interviews with observers, and collect data on the results of the didactic design implementation. The retrospective stage includes: processing and analyzing the results of the implementation of the didactic design, make improvements to the first didactic design, and compile a revised didactic design.

Result and Discussions

In this section, the researcher will present a discussion of the findings based on the questions contained in the problem formulation in chapter 1. The results of the findings are presented systematically based on the problem formulation that has been prepared.

Learning Obstacles related to Algebra Learning material in Multiplication and Division
Based on the analysis of the results of preliminary research related to algebra learning, learning barriers or learning obstacles experienced by students were found. Researchers conducted a preliminary study in class V study group B at SDN 1 Sukamana. Cipedes District, Tasikmalaya City. The learning objectives found based on preliminary studies are as follows:

Type 1:
Learning obstacles relate to the activity of determining unknown numbers from a mathematical equation that involves adding and subtracting whole numbers. Type 1 learning barriers arise when students mistakenly determine the value of an unknown number. This happens because students do not understand the concept of addition and subtraction let alone the concept of multiplication and division.

Type 2:
Learning barriers related to completing multiplication and division operations. Learning Obstacle type 2 arises when students have difficulty solving problems repeatedly involving multiplication and division equations. Students only multiply the existing numbers without answering correctly. This is because students do not understand the concept of multiplication as repeated addition and subtraction as repeated subtraction.

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Type 3:
Learning barriers related to finding the relationship between multiplication and division operations. Type 3 learning barriers arise when students cannot understand the meaning of the story questions that have been provided. Students have difficulty finding unknown values which are usually replaced with variable values in different terms simple in the form of dots, mathematical symbols and so on. This is because students have not mastered the essence of story questions and the relationship between multiplication and division operations.

Didactical Design for Algebra Learning in Multiplication and Division
The initial didactic design was prepared based on learning obstacles that emerged during the preliminary study and was reinforced by relevant theories. The theories used in this preparation include Realistic Mathematics Education (PMR) which presents the initial context for learning. Cognitive development theories, namely Piaget's theory and Brunner's theory. In preparing the didactic design, Hypothetical Learning Trajectory (HLT) is also prepared, in which there are learning objectives, learning activities to be carried out, predictions of student responses and anticipation of peagogical designs (ADP) which are prepared with the aim of minimizing learning obstacles or learning barriers that will be experienced by participants. students in the implementation of learning. Not only that, the researchers also developed a scheme or learning flow for algebra learning in multiplication and division.

The learning activities which are arranged in an algebra learning scheme in multiplication and division originate from everyday life regarding window panes which have several columns and rows. This is in line with Realistic Mathematics Education which departs from the real world so that students can be involved in a meaningful learning process. The learning design continues by providing examples of contextual problems by presenting window glass problems in the classroom that are related to everyday life. Furthermore, the learning design is designed so that students gain experience in learning activities by arranging the colored tiles that have been provided. After students are able to arrange these color tiles into several patterns, students are guided to describe the patterns on the graph paper provided in the LKPD. Then, students will be directed again to be able to write down the number patterns obtained from arranging the color tiles.

The activity of writing multiplication number patterns is an activity that bridges (Bridge) students to arrive at the formal stage, namely the stage of applying multiplication and division to questions where one of the numbers is omitted, with the aim of students being able to answer the correct number to fill in the multiplication and division number equations. that has been provided.

After testing the initial didactic design. The researcher analyzed the results of the trial with the aim of knowing whether the didactic design was feasible or needed to be improved. Taking into account the responses of the students and discussions with the class teacher the researcher then compiled a revised didactic design with the sequence of concepts in the revised design basically still the same as the initial didactic design except that a number of things were revised including time allocation, student worksheets (LKPD) and ADP.

Trial of Didactical Design for Algebra Learning in Multiplication and Distribution
The didactic design that had been prepared by the researcher was then tested in class IV elementary school. The initial didactic design trial was carried out in class IV study group B at

SDN 1 Sukamanah with 22 students as respondents. Learning is carried out in one meeting with a time allocation of 4 x 35 minutes.

During its implementation, there were several events that matched the predictions and several events that did not match the previous predictions. By understanding the terms column and row, students can respond well based on initial predictions. Apart from that, in this section there are also unexpected responses when students encounter problems in the LKPD. The students had difficulty counting the number of window panes. However, after explaining the characteristics of columns and rows, students are no longer confused. Their understanding of the objects around them now increases into meaningful learning, they will be more enthusiastic if they learn from the objects around it. This is in line with the PMR theory (Realistic Mathematics Education) which holds that "mathematics is human activity". Learning mathematics must start from problems in everyday life (Suherman, 2003).

Even though some student responses cannot be predicted in advance during the implementation of the initial learning design, this is a normal thing in the learning process. This is in accordance with the component of metapedagogical theory that teachers must master, namely flexibility. Not only that, the overall implementation of learning runs effectively because the supporting media in the form of colored tiles in completing the LKPD helps students to play an active role in the learning process. This is in line with Piaget's theory which states that the importance of using objects in learning will make it easier to achieve a learning goal (Rohmah et al., 2022).

The next stage is preparing a revised didactic design. This revised didactic design was prepared based on the analysis of the initial didactic design trials. The learning objectives of this revised didactic design are the same as the initial didactic design. In implementing this revised didactic design, it was carried out in class IV study group B at SDN Sukamulya with a total of 16 students as respondents. The time allocation for implementing the revised didactic design is 4 x 35 minutes.

The learning activities in this revised didactic design are not much different from the initial didactic design trial. Likewise with student responses. In implementing this revised didactic design, the researcher asked more stimulating questions that were able to make students think critically so that learning was made more active and effective. The students' responses and anticipations of the pedagogical didactic design during implementation were in accordance with the predictions of the students' responses and anticipations that had been previously designed. This didactic design for algebra learning, which has been tested, has provided many changes to students' learning outcomes, especially in algebra multiplication and division material. Many of those who are enthusiastic about learning even ask for the colored tiles used as learning media to take home so they can study at home. The use of colored tiles during learning is in accordance with Brunner's theory which states that meaningful learning that can make it easier for students to understand and will always be remembered is learning that goes through three stages, enactive, iconic and symbolic (Tampubolon, 2018).

In implementing learning, researchers also pay attention to the characteristics and needs of students according to the age of the students. This is done as an effort to empower students so that they can optimize their abilities in elementary school. This is in line with the opinion of Jean Piaget (Kholiq, 2020) who holds the view that every individual has a level of intellectual development if the teacher is able to understand and meet the students' needs.

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Mathematics learning in lower grades generally discusses and masters addition and subtraction. Therefore, learning in higher classes will begin to discuss multiplication and division material. Multiplication is defined as repeated addition and division is repeated subtraction (Purwandari & Wahyuningtyas, 2017). The multiplication and division material is mentioned as a prerequisite material for understanding the following numeracy material (Aswarliansyah & Febriandi, 2021).

In the independent curriculum, multiplication and division material is discussed in the algebra domain in elementary schools. In the description of the independent curriculum, algebra material in multiplication and division has learning outcomes "finding the relationship between multiplication and division operations, solving simple equations for multiplication and division operations and determining missing values in multiplication and division operations. In this way, this didactic design can become a learning alternative that will achieve learning goals for students.

Conclusion

Based on the findings and discussion in this study, the researchers draw the following conclusions. Learning obstacles or learning obstacles that occur to students regarding algebraic material are as follows: Type 1: Learning obstacle relates to the activity of determining unknown numbers from a mathematical equation that involves adding and subtracting whole numbers. Type 2: Learning obstacles related to completing multiplication and division operations. And Type 3: Learning obstacle with regard to finding the relationship between multiplication and division operations.

The results of the researcher's analysis of the preliminary study carried out yielded data that students experienced learning obstacles (learning obstacles) that were epistemological obstacles, where these learning obstacles were learning obstacle that occurred due to students' limitations in certain learning contexts. This causes, when students are faced with questions in other forms given by researchers, students experience difficulties because the understanding of the concept of learning algebra in multiplication and division has not been understood and has not been mastered by students as a whole.

The Didactic Design of Algebra Learning was designed and compiled by researchers based on the learning obstacles found during the preliminary study. The development of didactic design is supported by relevant theory. This was manifested in the preparation of the HLT. Preparation of HLT (Hypoctical Learning Trajectoral) in didactic design, compiling learning schemes that describe learning activities, and equipped with didactical pedagogical anticipation (ADP), which can minimize students experiencing learning difficulties (learning obstacles).

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