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Design of Realistic Mathematics Education on Elementary School Students

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Abstract. This study focuses on developing learning design based on realistic mathematics education. The learning design developed related to the real life of students, so students are expected to enjoy and tend to like mathematics. The results showed that the realistic mathematics education design consisting of a lesson plan, a teachers guide, a student book, a student worksheet, and mathematics achievement test are in good quality, which meet the criteria of validity, practicality, and effectiveness. Mathematics achievement test as a research instrument meets the criteria of validity, sensitivity, and reliability. In learning process by using realistic mathematics education, the students are more active, have an energy and motivation to learn, so there is a good impact on the improvement of students learning achievement.

1. Introduction

Mathematics has an important role in science and technology, both as a tool in the application of other fields and in the development of mathematics itself. The role is written in the Content Standards for Primary and Highs School Education [1] that mathematics underpins the development of technological progress, plays an important role in various disciplines, and advances human thinking. Mathematics is given early in school to equip children with logical, analytical, systematic, critical, and creative thinking, and cooperative skills. They are important that children need for challenging and changing future life.

Unfortunately, today many students have difficulty in learning mathematics. Students do not have the desire to try and think a high level to find solution for difficulties found in learning mathematics. Instead, they always avoid the difficulties experienced. It results student learning achievement in mathematics is relatively low

The low learning achievement of students not only because mathematics is difficult, but also the learning process implemented. The importance of this learning process is underlined by Soedjadi [2] which states that however appropriate and well-defined mathematics teaching materials, they are not guaranteed to achieve the desired mathematical education objectives. One of the important factors to achieve the goal is the learning process undertaken.

In line with an effort to change the learning paradigm from teacher-centered to students-centered, mathematics learning which is more abstract requires a meaningful learning so the students can understand the mathematical concepts well. Tiro [3] argue that mathematics serves as a vehicle for achieving educational goals. However, a meaningful learning expected in mathematics is very rare. The learning so far is still dominated by teachers. Most teachers use conventional methods in one

direction, teacher to students. In addition, the class is only filled with talks, while students are forced to listen and memorize. The students less involved in learning activities. Therefore, the learning is monotonous and they tend to be passive in following the class.

In an effort to improve learning achievement, it needs a learning process that can foster students' activeness. The Students are required to be actively involved in the process of learning physically, intellectually and emotionally [4]. The students does not only take for granted what they have just got, but they also think first and they are expected to ask questions, propose opinions, and generate discussion lead by the teacher.

However, the development of mathematics in Primary Schools, especially in SD Inpress Mallengkeri Bertingkat is upset. There is an indication for a lack of attention, interest, willingness and achievements of students. The problem basically arises that the teachers who are less innovative. The instructional sequences described by the teacher in teaching mathematics are: introduction, explaining, giving practice, examining the exercises, and assigning tasks. Students are not given an opportunity to express their opinions, give reasons, or discuss difference of answers among students. As a result, the learning is only memorizing and not trained the students' thinking. Thus, the learning achievement also tend to be low.

In this study, the researcher tries to solve an education case which basically still needs improvement. The case is experienced by elementary school students in the city of Makassar which is the low achievement in the topic of arithmetic operation on integer.

In general, the topic of arithmetic operation on integer for primary students is given abstractly. The students are asked to memorize how the formulas are written in a textbook along with the examples. The teacher finds a difficulty to concrete the integer operations, especially negative integers. Indeed in everyday life, there is no concrete example describes a negative integer. Most of the teachers in SD Inpres Mallengkeri Bertingkat used number lines. For positive numbers there is no problem. But once the operation of the negative numbers, the students struggle and the teacher finds a difficult to give a concrete explanation.

There is a considerable gap between the expectations of mathematics learning and the reality in the classroom. To achieve the improved quality of education as expected, teachers need to improve the learning patterns and pursue an innovation in learning activities.

Therefore, the orientation of the learning process should be changed. The role of teacher who during this time dominate the learning activities should be reduced and provide greater opportunities for students to actively participate in the learning process. Teacher-centered learning is naturally modified to be student-centered

The learning model should be chosen and designed to be more emphasis on student's activity. Therefore, it is necessary to design a teaching that gives the widest opportunity to the students to learn by improving their own knowledge. By this learning, it is expected to obtain a better learning achievement.

One approach fits with the expectation is that a realistic mathematics education approach. Realistic mathematics education approach uses realistic problems, using models, using students' contributions, interacting in the learning process, using various relevant learning theories, and so on. Therfore, this study investigates the process and results of the development of realistic mathematics education design at Primary School (SD) Negeri in Makassar City.

2. Literature Review

2.1 Realistic Mathematics Education

Soedjadi [5] states that realistic mathematics Education focuses on the students' potential to be developed. The potential effect on how the teacher should manage the learning. In addition, it also encourage to familiarize expected students' perform activities for them. Both will influence the way teacher teaches and the way students learn. Thus, realistic mathematics education is not only enable

the alteration of the mathematical material concept map and its relationship, but also to change the culture towards a more dynamic, yet still in the corridor of the educational process.

Therefore, realistic mathematics education is an innovative learning approach that emphasizes on mathematics as a human activity that must be associated with real-life using the real-world context as the starting point of learning. The students have the opportunity to rediscover and construct mathematical concepts or formal mathematical knowledge through horizontal and vertical mathematization

2.2 The nature of Realistic Mathematics Education

Gravemeijer [6] states the principles of realistic mathematics education, namely: (1) the use of context; (2) the use of models, bridging by vertical instrument; (3) student contribution; (4) Interactivity process; and (5) Integrated with other topics (intertwining).

2.3 Development of learning Instructional system and design

Thiagarajan, et.al., (1974) introduces a model of developing a learning instructional system called "4D Model" through four stages: (1) define, (2) design, (3)) the development, and (4) disseminate. Based on the above description, the development of realistic mathematics education design involving students' metacognition in this study is based on "4-D Model". The stages of development of learning instructional system "4-D Model" are as follows:

Stage 1: Define

The defining stage aims to define requirements in the lesson. To define these terms, a goal analysis is conducted within the boundaries of the subject matter to be developed by the design. At this stage there are five main steps that must be done as follows

1. Front-end analysis
   Preliminary analysis is used to determine the underlying problems faced by teachers in an effort to improve student learning achievement. Important terms in the analysis are the recent curriculum, materials, learning methods, media used, relevant learning theory, challenges and future demands.
2. Students analysis
   Student analysis is used to examine the characteristics of students in accordance with the design and development of instructional design. Student analysis is done by taking into account: students' knowledge background, student cognitive development, and student learning experience.
3. Concept analysis
   Concept analysis identifies key concepts to be taught, systematically arrange, and break down relevant concepts.
4. Task analysis
   Task analysis identifies the key skills needed in the learning process and analyze them into a framework.
5. Specifying instructional objectives
   convert the results of task analysis and concept analysis into learning objectives (indicators of learning). The learning objective (learning indicator), is the basis for preparing test results and design the learning.

Stage 2: Design

The design stage aims to design a prototype of learning. Activities undertaken at this stage, namely: preparing tests, selecting instructional media, selecting format, and initial design.

1. Constructing criterion-referenced tests
   Criterion-references test is based on the task analysis and concept analysis described into the specifications of the learning objectives.

2. Media selection
   Media selection is to determine the appropriate media to be used in presenting the topic during learning process. The media selection process is based on task analysis, concept analysis, and facilities available at school.
3. Format selection
   Format selection includes formatting for designing content, selection of learning strategies, and learning resources
4. Initial design
   The main activity in this step is the initial design of the learning prototype.

Stage 3: Develop

The development stage aims to produce a learning design. It should meets valid and reliable requirements. There are two key steps at this stage, namely expert and practitioner validation and development testing. The two steps are as follows.

1. Expert appraisal
   Expert and practitioners validation includes content and construct validity of instructional design that has been prepared at the design stage. Expert and practitioner validation results are used as a basis for revision of instructional design.
2. Developmental testing
   A development test is carried out to obtain a direct response from the field towards the instructional design. The responses based on reactions and comments from students, observers, and teachers as a basis for revising the learning designs. Testing, revising, and experimenting are carried out continuously until a consistent and effective learning design obtained.

Stage 4: Disseminate

This stage aims to test the effectiveness of the design. In this stage, the instructional design is implemented on a wider scale. For example in a class or in other schools, and other teachers. This stage consists of three main steps as follows.

1) Validation test. The learning design is implemented in replicable conditions..
2) Packaging. Selected producers and distributors who will package the learning design that is acceptable to the user.
3) Diffusion and adoption. The design of learning is disseminated and adopted by the user

2.4 Mathematics Realistic Education Design

A learning design is a collection of learning resources that enable students and teachers to do learning activities. Ibrahim [7] illustrates an instructional design as an army that will fight, they need logistics. Similarly, teachers also need logistics in the form of an instructional design help and facilitate teaching and learning process in the classroom. Therefore, the design of realistic mathematics education is absolutely needed by a teacher.

The design of realistic mathematics education consists of various components depending on the needs of each realistic mathematics activity to be performed by the teacher. For example, lesson plans, a teacher guide a student book, a student worksheet, and mathematics learning achievement test. In order to produce a good quality of realistic mathematics education design, it is necessary to follow a certain procedure which refers to the model of learning design development by taking into account the principles and characteristics of realistic mathematics education.

The design of realistic mathematics learning in this study is a collection of learning resources, namely: lesson plans, a teacher guide a student book, a student worksheet, and a mathematics learning achievement test used by teachers and students as a guide to realize the process of realistic mathematics to achieve the learning objectives. The design involve students' metacognition means the metacognition aspects (metacognitive knowledge skills) are involved in the design, namely: lesson plans, a teacher guide, a student book, and a student worksheet.

2.4.1 Criteria for Quality of the Design. Nieveen [8] states that development of educational products needs three aspects of quality; validity, practicality, and effectiveness. Furthermore, Nieveen explains that a valid learning material should meet the following characteristics: (1) The learning material developed based on a strong theoretical rationale, and (2) There is an internal consistency between the components of the developed learning material. The practical aspect satisfies the following: (1) Do experts and practitioners state that the developed learning materials can be implemented?; and (2) On the field, do the developed learning materials can be applied. The aspect of effectiveness based on: (1) Experts and practitioners based on their experience state that the learning materials are effective; and (2) Operationally in the field the material gives results as expected.

Kemp [9] suggests a way to measure the effectiveness of learning by asking a question, "what has been achieved by students?" Therefore, to answer the question, it must be known how many students achieve their learning objectives within a given time. Eggen & Kauchak [10] states that a learning is effective if students are actively involved in organizing and discovery of information (knowledge). Students not only passively receive the knowledge provided by the teacher. Thus, in learning it is necessary to consider how the involvement of students in organizing lessons and knowledge so that the criteria of learning completeness is fulfilled, more effective also the learning. Slavin [11] states that effectiveness in learning can be reviewed from four aspects: quality of instruction, instruction level, incentive, and time. The quality of learning refers to the degree of information or skill presented, so that students can learn it easily or students are at a small error level. The instructional level is the extent to which teachers can ascertain the degree of readiness of the students having the knowledge and skills to learn new material. In another words, the learning materials provided are not too difficult or too easy for students. Incentives are how much teachers motivate students to do the tasks assigned by teachers to students. This means that the greater the motivation given, the greater the student activities, the learning will be effective.

Based on the description, the quality of learning design criteria is said in a good quality if it meets aspects of validity, practicality, and effectiveness. While the test of mathematics learning achievement are said to be of a good quality if they meet the following criteria: (1) The correlation coefficient of validity of the test is minimum in a category high; (2) The sensitivity of each test item is greater than or equal to 0.30; and (3) The reliability coefficient of the test is minimum at high category. The indicator of design learning quality as follows:

a. The learning design validity

Instructional design is valid, if the assessment of experts and practitioners of mathematics education states that the design of learning is developed based on a strong theoretical rational and has an internal consistency between the components of the design. The practitioner refers to a mathematics teacher who meets at least three criteria: (1) the teaching experience long enough; (2) followed upgrading and workshop on learning mathematics at least three times; or (3) Upgrading and workshop instructor team of mathematics education.

b. Practicality ofthe learning design

The design is practical, if the assessment of experts and practitioners of mathematics education states that the design can be implemented. Therefore, the learning design is said to meet the criteria of practicality, if: (1) The assessment of experts and practitioners of mathematics education states that the design of learning can be implemented with minimum at small revision; and (2) the teacher can implement and manage the class using realistic mathematics education for all observed aspects which are in at least the category of good.

The ability of teacher to manage realistic mathematics education is refers to the quality of a teacher implement the approach of realistic mathematics education by using the learning design. It is shown by the average score obtained from all learning activities at each meeting.

c. Effectiveness of the learning design

The design is effective, if the results of the implementation of the learning design in classroom meet: (1) Percentage of all students' activity indicators meet the ideal time limit with tolerance of 5%; (2) the students' learning mastery in a classical way; and (3) 80% of students who say: happy, new, can

clearly understand the language used, and interested in the appearance of the design. Students' activities in realistic mathematics education consists of two components: (1) Students activities are not related to metacognitive; and (2) students' activity are related to metacognitive. The Components are as follows.

1) Students' activities in realistic mathematics education.
2) Classically Student's learning completeness.
3) Student response to instructional design.

3. Research Method

Metacognition This is a quantitative research that is intended to develop the design of realistic mathematics education. It is the development of product-oriented learning design, because the development process is described clear and detail through the development phases until obtained the a good quality design of realistic mathematics education. Furthermore, the resulting product will be disseminated to elementary school students in Makassar City. The dissemination means implementing the design to teachers and students as users in the form of a collection of learning resources used by teachers and students as guidelines for realizing the process of realistic mathematics education, so the learning objectives are achieved.

Development of instructional design in this study is guided by the development model instructional system of learning developed by Thiagarajan, et.al., (1974) covering the defining, designing, and development stages. Data analysis conducted in the development of realistic mathematics education design, namely: (1) Analysis of validation results data of realistic mathematics education design; (2) analysis of students' activities data in realistic mathematics education; (3) analysis of teacher ability data in managing realistic mathematics education; (4) Analysis of student responses data on realistic mathematics education design; and (5) Analysis of test of mathematics learning achievement data.

4. Result and Discussion

The development of realistic mathematics education design is adapted to the principles and characteristics of realistic mathematics education and merge with metacognition (metacognitive knowledge and metacognitive skills) into the design. Based on the results of the validity test, the design of realistic mathematics learning, including: lesson plans, a teacher guide, a student book, a student worksheet, and test of mathematics learning achievement meet the criteria of validity. This result in line with Nieveen [8] which states that a learning material (in this case the design of realistic mathematics education is said to be valid, if it meets: (1) Learning materials developed based on strong theoretical rationale; and (2) There is an internal consistency between the components of the developed learning material. Therefore, the design of realistic mathematics education developed based on the principles and characteristics of realistic mathematical education involving metacognition aspects; and there is an internal consistency of the design of realistic mathematical education developed.

The test of mathematics learning achievement in its function as a research instrument has met the criteria of validity, sensitivity, and reliability. The validity of each item of mathematics learning achievement test is in the category of very high and high. These results indicate that each item of mathematics learning achievement test can measure students' mastery on the topic of arithmetic operation on integer in Primary School (SD). The test also has a sensitivity. This means that each item of mathematics achievement test can distinguish students who have not learnt and who have learnt the topic. The reliability of the test is very high. This result indicate that the mathematics learning achievement test provide highly consistent measurement results.

Theoretically and empirically the design of realistic mathematics education meets the criteria of practicality. Theoretically, the result of the assessment of experts and practitioners of mathematics education states that the design can be implemented in the classroom. Empirically, the test results meet the criteria of practicality for indicators of the teacher ability in managing realistic mathematics education class. However, indicators of teachers' ability to manage realistic mathematics education

class are interesting to discuss. The mathematics teacher at SD Negeri in Makassar has never implemented a realistic mathematics education approach. The teacher used to a conventional learning approach that is more dominated by the teacher. The students only listen and record what is delivered by the teacher. Less students are given the opportunity to develop their own abilities. This learning process lead students to become passive; not familiar to construct their mathematical knowledge or his own way of solving problem; when there is a topic that they has not understood, they did not ask a question; and less expressed his way of thinking or his own opinion to the topic. To overcome these factors, the researcher discussed with the teacher about realistic mathematics education approach, then asked the teacher to do realistic mathematics education activity by using the design in parallel class which is not experiment class. Consequently, the practicality criteria of realistic mathematics education design based on teacher's ability indicators in managing realistic mathematics education is in category of good. These results in line with Nieveen [8] which states that practicality is associated with two things, namely: (1) experts and practitioners state that the developed learning design can be applied; and (2) the developed learning design in the field can be implemented [12]. In addition, this result also disagree with the statement that the ability of teachers to teach mathematics in Indonesia is very limited [13].

The effectiveness of realistic mathematics education design is determined by three indicators: students' activities in realistic mathematics education, student's learning completeness classically, and student's response to realistic mathematics education design. In the experiment class, the indicators of students' learning completeness classically and students' responses indicators on the design meet the criteria of effectiveness. Oppositely, the indicator of students' activities in realistic mathematics education has not fulfilled the criteria of effectiveness. On the second experiment, the student activity indicators in realistic mathematics education and students' responses indicators on the design meet the criteria of effectiveness. Meanwhile, the students' learning achievement indicators have not fulfilled the criteria of effectiveness. Furthermore, in the third experiment, the students' activities indicators in realistic mathematics education, student's learning completeness classically, and student's response to the design meet the criteria of effectiveness.

Basically, the learning is effective if the learning objectives are achieved. According to the constructivist view the purpose of learning will be achieved if students actively build knowledge in learning. Therefore, effectiveness is also influenced by students' activity in realistic mathematics education. This is in line with Eggen & Kauchak (1988) which states that learning is said to be effective if students are actively involved in organizing and finding information (knowledge) and linkage of information provided. Students not only passively receive the knowledge provided by the teacher. The learning does not only improve students' understanding and engagement, but also improve their thinking skills. Thus, the learning should concern on how the involvement of students in organizing lessons and knowledge. The more active students, the learning achievement is greater, the more effective the learning. In addition, a learning is said to be effective when achieving the desired goals, both in terms of learning objectives and student learning achievement.

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