How to develop primary school mathematics learning media

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Abstract. Development of mathematics learning media is needed in order to obtain representative mathematics learning media so students can learn mathematical concepts and procedures correctly, easily, interestingly, and fun. Therefore, it is necessary to develop mathematics learning media in order to create representative mathematics learning media so that students can learn mathematics correctly, easily, interestingly, and fun. For this reason, this study was conducted by using a qualitative approach with the model Educational Design Research based on Mc Kenney's research design. There are three main stages in his research, namely, (a) needs and context analysis, (b) design, development and formative evaluation, and (c) semi-summative evaluation. This study was started with the findings of theoretically measured aspects and indicators which were then developed by using EDR. The study resulted in four representative media about (a) the place value for first and second-grade students, (b) multiplication for second-grade students, (c) fractions for third-grade students, and (d) LCM, GCF and decimal fractions for fourth-grade students.

1. Introduction
Elementary school students (first and second grade) have already had the proper math learning experience. It is proven by the fact that they do not complain when learning mathematics, and their average learning outcomes are above the standard. However, we discover the fact that the math learning outcomes in the following years do not increase; instead, it declines. This fact certainly has to do with the experience of learning mathematics in previous years. We know that mathematics learning is structured and systematic learning [1-3]. Therefore, there is an assumption that mathematics learning in the first two years in elementary school does not begin with structured and systematic learning resulting in a decrease in learning activities and learning outcomes in the following years [4].

Learning mathematics means learn about the abstract material. Creating abstract, structured, and systematic mathematics learning in elementary school students requires the right method so that students can obtain the mathematical knowledge and skills that they can utilize in mathematics learning at a later stage and in daily life. Elementary students learn to understand things by using concrete mindsets and fiddling with things. Everything they learn will be understood easily if they are assisted by manipulative visualization, which is a medium that provides meaningful learning experiences [5-9].

Media for mathematics learning is widely available but still needs to be improved so that it can convey the concepts and procedures of mathematics correctly. It is still necessary to create more mathematics learning media to overcome learning difficulties, such as understanding the place value, multiplication, fractions, Lowest Common Multiple (LCM), Greatest Common Factor (GCF), and decimal fractions. Thus, it is essential to provide representative media to facilitate the process of learning.
the material. The mathematics learning media must provide ease of mathematics learning and support the process of obtaining the correct mathematical conceptual and procedural [10-12].

To realize this idea, the step that must be taken is identifying how to design, create, and mass produces representative mathematics learning media about place value, multiplication, fractions, LCM, and GCF. Hence, the right action is needed through a series of stages in research to create the media that are in accordance with the needs of students in understanding elementary mathematics concepts and procedures.

2. Method
This study was conducted by utilizing McKenney's Educational Design Research (EDR) model. McKenney's EDR model is carried out in three stages as shown in Figure 1.

![Figure 1. Educational Design Research (EDR) model. McKenney's.](image)

The first stage was the needs and context analysis by analyzing and finding the context of the problems of the existing media and then creating a plan to overcome the problems so that they become representative media. The context of the problem found was the media regarding place value, multiplication, fractions, LCM, GCF, and decimal fractions. The second stage was improving the media through the stages of design, development and formative evaluation repeatedly performed to find representative media. The final step was the semi-summative evaluation phase by testing and evaluating the media that had been developed through the use of classroom learning.

3. Results and discussion
3.1. Needs and context analysis
One of the learning outcomes of students of elementary school teacher education or Pendidikan Guru Sekolah Dasar (PGSD) in the Mathematics Education subject is to have an understanding and skills in providing mathematics learning facilities for elementary school students. Every PGSD student must understand how to guide elementary school students to learn mathematics and must know the target of learning mathematics that is in accordance with educational programs in the education system in Indonesia. Accordingly, PGSD students must understand the concepts and learning process of mathematics that are in accordance with students' cognitive readiness. The PGSD students also must realize that the process of mathematics learning in elementary school level requires representative media to help students to learn mathematical concepts and procedures.
There were six topics and mathematics learning media identified as difficult to be learnt, namely place value, multiplication, fractions, LCM, GCF, and decimal fractions. Based on the learning media used in the mathematics learning topics shown by PGSD students, several aspects that must be improved regarding physical aspects and benefits were identified. The physical aspects and benefits in question are shown in Table 1 as follows.

| ASPECTS                  | INDICATORS                                      |
|--------------------------|-------------------------------------------------|
| Physical Form            | Generally attractive                             |
|                          | Interesting colour selection                     |
|                          | Easy to manipulate                               |
|                          | Durable                                          |
|                          | Visible by students sitting in the back rows     |
|                          | Novel                                            |
|                          | Simple, systematic, and easy to understand       |
|                          | Does not require special treatment               |
| Benefits of Learning Media | Helping students to understand math concepts easily |
|                          | Encouraging students to be more active in learning process |
|                          | Easy and feasible to use                         |
|                          | Easy and feasible to store                       |
|                          | Supporting teachers in conveying concepts clearly |
|                          | Suitable with learning topics explained          |
|                          | The selection of media form is accurate          |
|                          | Suitable with elementary school student development |
|                          | Reducing time needed for delivering learning materials |
|                          | Can be used repeatedly                           |

3.2. Design, development and formative evaluation

3.2.1. Design. Designing improvements to learning media about place value, multiplication, fractions, LCM, GCF, and decimal fractions that PGSD students had made to overcome the difficulties of students in learning mathematics both conceptually and procedurally, was carried out after students had simulated the media during the lecture. During the simulation, several indicators did not meet the standard of representative media that is regarding aspects of physical form and benefits. Therefore, some improvements were needed to make media feasible to use in providing conceptual and procedural mathematics learning facilities for elementary school students. The design of media improvement was performed according to several aspects and indicators of multimedia measuring instruments [13].

3.2.2. Development. Based on hypothetical learning trajectory of the learning media about place value, multiplication, fractions, LCM, GCF, and decimal fractions, it is necessary to make some improvements to create representative learning media to facilitate students in learning mathematics. Representative media test was started with determining learning objectives, namely, understanding the concept, and being able to solve questions about the material of place value, multiplication, fractions, LCM, GCF, and decimal fractions based on learning experience supported by using the media. Therefore, a development plan of the learning media about place value, multiplication, fractions, LCM, GCF, and decimal fractions was created and shown below.
Table 2. Development of PGSD student-made mathematical learning media.

| The focus of the Development | Aspects and Indicators Developed | Indicators of the Development |
|-----------------------------|----------------------------------|-------------------------------|
| 1. Physical Form            | Generally attractive             | Represent objects with representative images, typography, and layout |
|                             | Interesting colour selection     | Selection of appropriate colors |
|                             | Easy to manipulate               | Simple, Unity                 |
|                             | Durable                         | Navigation                    |
|                             | Visible by students sitting in the back rows | Communicative, Typography |
|                             | Novel                           | Creative                      |
|                             | Simple, systematic, and easy to understand | Communicative, Simple, Unity |
|                             | Does not require special treatment | Simple, Navigation |
| 2. Benefits                 | Helping students to understand math concepts easily | Communicative |
|                             | Encouraging students to be more active in the learning process | Represent object in the form of a representative image |
|                             | Easy and feasible to use and store | Simple |
|                             | Supporting teachers in conveying concepts clearly | Communicative, Unity |
|                             | Suitable with learning topics explained | Creativity, Unity |
|                             | Suitable with elementary school student development | Communicative, Simple |
|                             | Reducing time needed for delivering learning materials | Simple, Unity |
|                             | Can be used repeatedly           | Navigation                   |

3.2.3. **Formative evaluation.** The assessment of the improvement of learning media on place value, multiplication, fractions, LCM, GCF, and decimal fractions was performed by using the instruments as shown in the development indicators in Table 2. Based on several indicators that must be improved and developed, further simulation of media use was needed. This simulation aimed to measure the achievement of media information resulting from the improvement and development. The measurement results showed that there was an increase in each development indicator.

3.3. **Semi summative evaluation**

The final step in developing elementary school mathematics learning media was to test the readability and communicative of mathematics learning media in conveying mathematical concepts and procedures to elementary students. Tests are carried out in two parallel classes. Judging from the learning outcomes measured from the pre-test and post-test, there was a significant change in scores. The scores show better than those who do not use the media. Responses from teachers and students that the media used has an attractive and easy way for teachers to provide facilities and motivation to learn. Similarly, students feel happy and easily learn mathematical concepts and procedures by using the media provided.
4. Conclusion
Based on the results of the analysis, it can be concluded that designing and developing elementary mathematics learning media required systematic work based on aspects of the physical form and benefits of the media. Findings of flaws in the physical form and benefits of media became the focus of development. Aspects and indicators of the development were elements that must be improved or developed. The feasibility of the media to be used in facilitating student learning must also pass the test of experts and teachers who want to realize a meaningful learning atmosphere as well as learning outcomes of students who used the media demonstrated better scores.

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