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DEVELOPING SCALES BASED ON MONTESSORI METHOD AS A LEARNING MEDIA OF MATHEMATICS FOR PRIMARY SCHOOL

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ABSTRACT:

This study aims to develop, analyze the feasibility and effectiveness of learning with scales media based on Montessori methods. The type of this study was Research and Development with ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). The techniques of data collection employed observation, interview, test, questionnaire, and documents. The techniques of data analysis were product data analysis, test of learning accomplishment, t-test, and N gain test. The results of the study indicated that the feasibility test of the materials was 3.29 and the media was 3.76 in very feasible criteria. In the learning accomplishment test, the z count (2.04124) > z table (1.64) which indicated that the learning outcomes passed the learning accomplishment criteria more than 75%. T-test showed that t count (7.229) > t table (2.660) which indicated that the average learning outcomes in posttest were higher than the average learning outcomes in pretest. The improvement was 0.754 with high criteria. The conclusion of this study is implementing scales based on Montessori methods is valid and feasible in decimal rounding learning. Moreover, mathematics learning is effective by using scales based on Montessori methods.

KEYWORDS: Learning media, mathematics, Montessori methods, scales

INTRODUCTION:

Mathematics is always used in everyday life (Surya 2017:85-94), this demands students to understand concepts in mathematics. Failure to understand the concepts makes it difficult for students to understand the development of materials in higher grades (Pilomonu, 2014). Based on the study conducted by (Aris, Ilma, Putri, & Susanti, 2017), the use of media can help students understand the concepts being studied. In addition, based on the study by (Kaune, Nowinska, Paetau, & Griep, 2013),

games can also be used to develop the concept of materials that the students are learning.

However, in fact, mathematics is also not an exciting subject for students (Sujiati, 2016) even most of the students find mathematics difficult. The students also get unsatisfactory learning results. This results in low student learning outcomes.

The fact about low mathematical abilities of Indonesian students is indicated from the results of PISA 2018 (OECD, 2018) that the average mathematics score was 379, below the average score of 489. In line with this, the researchers revealed that the mathematics scores of grade 4 students at Jatisari Public Elementary School, Semarang were the lowest compared to other subjects. The low learning outcomes of mathematics in grade 4 were caused by several factors both from the teachers and students. The teacher factor was the limited learning media, while the student factor was lack of enthusiasm, only smart students in mathematics who were eager to follow the learning.

On the other hand, learning arithmetic operation is quite important, as it exists in almost all topics of mathematics (Ahmad & Sivasubramaniam, 2010; Hendriana, Charitas, Prahmana, & Hidayat, 2019). This is because learning arithmetic operations on numbers means learning about numbers, symbols and notations (NCTM, 2000), and it plays an important role in student performance in other mathematical topics.

Failure to implant the concepts will make it difficult for students to understand the development of material in higher grades (Pilomonu, 2014). In fact, students still memorize what they get from the teacher, not understanding the concepts given by the teacher although mathematics is closely related to daily life. Many life problems require the ability to calculate, measure, and convey information in mathematical language (Ullya, Zulkardi, & Putri, 2010).

The level of mathematics knowledge and skills directly affects the quality of individual's life of our and our society (Mutlu, 2019). Besides mathematics is considered important, it is widely used in all aspects of life. For example, when we want to buy goods online with a weight of 0.69 kg, 1.27 kg, and 2.89 kg, the weight of the item purchased will be carried out to calculate the shipping costs. This is considered abstract for students if the students are not directly involved.

Involving students directly is useful to enhance students' understanding of the concepts. Direct involvement of the students is needed in mathematics learning. Mathematics is the study of patterns and relations of analytical thinking to solve the abstract and practical problems (NCTM, 2000). Development of education demands student-centered learning, where students are active and free to learn the materials, while the teacher acts as a facilitator (Amir, Mufarikhah, Wahyuni, Nasrun, & Rudyanto, 2019). Mathematics learning is more into participating instead of like watching a match. Directly involving students requires interactive learning media.

Based on the aforementioned background, the researchers limit the development of scales based on Montessori methods to the media of mathematics learning for grade 4 students at Jatisari Public Elementary School, Semarang. Learning media is anything that can convey messages from a source to create a conducive learning environment so that efficient and effective learning can be achieved. Montessori method is a method invented by Maria Montessori that emphasizes the concept of student-centered learning and learning while playing for children (Montessori & Gutek, 2004).

In general, this study aims to describe the development of the scales design, test the

feasibility of the scales, and test the effectiveness of learning using the scales based on the Montessori Method.

METHODS:

They type of this study was Research and Development with ADDIE model. The steps in ADDIE model included Analysis, Design, Development, Implementation, Evaluation (Aldoobie, 2015).

The research subject was 40 students in grade 4A of Public Elementary School Jatisari. The product trial of scales media based on Montessori methods was conducted to 8 students, and the other 32 students were involved in the trial of using this product.

In this study, the independent variable was the development of scales based on Montessori methods, while the dependent variable was mathematics learning outcomes of grade 4A students at Jatisari Public Elementary School. The techniques of data collection employed observation, interview, test, questionnaire, and documents. The techniques of data analysis were product data analysis, test of learning accomplishment, t-test, and N gain test.

RESULTS:

The results of the research and development of scales based on Montessori method evaluated several things including: (1) the development of scales based on Montessori method; (2) the feasibility of scales based on the Montessori method; and (3) the effectiveness of mathematics learning using scales based on the Montessori method.

3.1 Developing Scales based on Montessori Method

Scales based on the Montessori method were adapted from number scales. The scales were used as learning media for estimating decimal fractions. The scales were developed based on the student needs analysis, teacher needs analysis, and Montessori methods. Montessori is a learning method proposed by Maria Montessori who believed that students must be the center of learning (Shivakumara, J, & O, 2016). Following are the development results of scales based on the Montessori method.

Figure 1 Scales

Figure 2 Puzzle Cover Display

The product of this development was the media consisting of scales and puzzles. The scales were developed from number scales. Number scales are mathematical teaching aids consisting of Cuisenaire rods as scale hands, weight, poles, and legs (Puspita, Usada, Istiyati, & Kamsiyati, 2016). Based on the study by (Fadillah, Susiaty, & Ardiawan, 2017), number scales were used to teach the concepts of addition, subtraction, multiplication, and division operations on round numbers. There are many reasons why puzzles are used in informal and formal education (Maric, Haan, Hogendoorn, Wolters, & Huizenga, 2014). There are many reasons why puzzles are used in informal and formal education (Moursund, 2007). Puzzle is used by arranging pieces of the

picture into a unified whole. The developed puzzles consisted of 2 sides, if all answers are correct, the puzzle will create a complete butterfly picture.

3.2 The Feasibility of Scales based on Montessori Method:

The scales media based on Montessori method were evaluated for its feasibility by material and media experts. The results of the material expert's evaluation of the scales media based on Montessori method by Dr. Nuriana Rachmani Dewi, S.Pd., M.Pd, obtained a mean score of 3.29 in the "very good" criteria. Meanwhile, the results of the media expert's evaluation conducted by Heri Triluqman BS, S.Pd, M.Kom, obtained a mean score of 3.76 in the "very good" criteria.

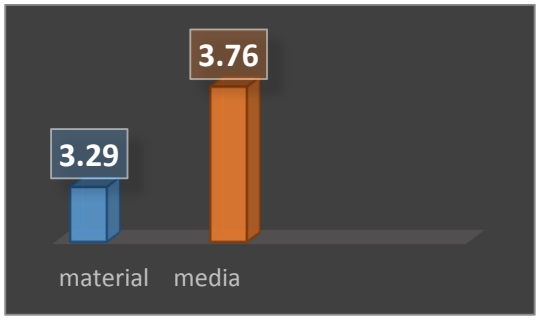

Figure 3 Diagram of material and media experts' evaluation

The conformity of material in Scales based on the Montessori method media with basic competencies and curriculum is very good. While material conformity with the indicator of learning and learning needs, clarity and sequence of material presentation in the media is assessed well. The material expert provided suggestions for improving the answer key in the questions. Moreover, the media expert suggested several improvements, including: (1) making a container (2) increasing the puzzle size (3) changing the shape of the scales load (4) changing the puzzle picture.

3.3 The Effectiveness of Mathematics Learning using Scales based on Montessori Methods:

The effectiveness of mathematics learning using scales based on the Montessori method was obtained from cognitive learning outcomes through formative tests in the form of pretest and posttest. Effective in Kamus Besar Bahasa Indonesia (Indonesian Dictionary) means there is an effect, there is an implication. The effectiveness of learning using the media can be seen from student learning outcomes through product trials and usage. The product trial was conducted to 8 students in grade 4 of Jatisari Public Elementary School, and the usage trial was carried out to 32 students in grade 4 of Jatisari Public Elementary School. The activities accomplished by the students in the product usage were the same as those in product trials in small groups. To investigate the effectiveness of learning, the researcher conducted learning accomplishment test, t-test, and N gain test.

3.3.1 Learning Accomplishment Test:

Learning accomplishment test was used to test whether the test results using the scales media based on Montessori method can achieve learning accomplishment. Below are the hypotheses tested.

Ho : $\pi \leq 0.75$ (the percentage of classical learning accomplishment of the students is less than or equal to than 75%)

Ha : $\pi > 0.75$ (the percentage of classical learning accomplishment of the students is more than 75%)

Table 1 Results of learning accomplishment test in product trial and usage

Class	Z_{count}	Z_{table}	Criteria
Product Trial	1.85058	1.64	Ha is accepted
Usage	2.04124	1.64	Ha is accepted

It indicated that 75% students passed the learning accomplishment with the score above the minimum accomplishment criteria.

3.3.2 T-Test:

T-test was used to investigate the difference in the students' average scores in pretest and posttest. Below are the tested hypothesis.

Ho : μpost ≤ μpre (the average posttest score is less than or equal to the average pretest scores)

Ha : μpost ≥ μpre (the average posttest score is more than the average pretest scores)

Table 2 T-Test results of product trial and usage

Class	Average Pretest Score	Average Posttest Score	N	t_{count}	t_{table}
Product Trial	3.646	8.96	8	13.129	2.977
Usage	3.751	8.464	32	7.229	2.660

From the comparison of t count to t table, it can be concluded that both at the product trials and usage, the average score of learning outcomes is higher after learning using the Scales media based on the Montessori Method.

3.3.3 N gain Test:

N-gain test was conducted to investigate the improvement in student learning outcomes after using the Scales media based on Montessori method.

Table 3 Results of n-gain test

Class	Average Pretest Score	Average Posttest Score	N-gain	Criteria
Product Trial	3.646	8.96	0.836	High
Usage	3.751	8.464	0.754	High

Based on Table 3, it can be seen that the learning outcomes in product trials and in usage trials increased with high criteria.

DISCUSSION:

Based on the results and discussion of the study, it was concluded that mathematics learning of estimating decimal fraction using Scales based on the Montessori method consists of effective scales and puzzles. The effectiveness of learning can be seen from the improvements after using the Scales media based on the Montessori method. This is in line with the study by (Nugrahanta, Rismiati, Anugrahana, & Kurniastuti, 2016), the results of the study showed that the learning outcomes of elementary students improved by using teaching aids dakon board based on the Montessori method. Another study conducted by (Sujiati, 2016) concluded that the average student learning outcomes increased after using Montessori teaching aids. Another study by (Sari, 2014) revealed that puzzle media are effective in increasing students' ability to understand fraction concepts. Furthermore, the media used in groups also makes learning more effective. This is in line with the research by (Arsaythamby & Zubainur, 2014) that mathematics learning in elementary schools is more effective through group activities. A study by (Yurniwati & Hanum, 2017) indicated that students prefer to move, play in groups rather than having to sit quietly and merely listening to the teacher's explanation. By playing, children will practice balance, both gross and fine motorize, controlling limbs, agility and eye and hand coordination(Amir et al., 2019). The role of a Montessori educator is to creating a cooperative and supportive setting that is organized and seems pleasing to the learners (Shivakumara et al., 2016). This can be realized when the student uses the scales to practice the estimation process.

Basic competencies related to developed media are 3.3 explains and performs the estimation of addition, subtraction, multiplication and division results for the two integers, fractions or decimals and 4.3 solving

estimation problems of addition, subtraction, multiplication and division results for the two integers, fractions or decimals. Computational estimation is seen as an important topic in primary mathematics education and also a frequently employed skill in everyday life (Sekeris, Verschaffel, & Luwel, 2019).

CONCLUSIONS:

This study is a Research and Development (R&D). The product is the Scales based on Montessori method adapted from the existing number scales. Creating the Scales media takes into account the problems, potential, needs, and characteristics of number scales and the characteristics of Montessori method. The products developed in this study are scales and puzzles which are put into containers. Because of the limitation of researchers, this media is designed and focused on the concept of estimating the addition and subtraction of decimal fractions for grade 4 students.

The feasibility of this Montessori-based media is based on the evaluation of the material expert and the media expert. The score from material expert is 3.29 with very good criteria. The score from media expert was 3.76 with very good criteria. Therefore, the learning media is feasible to be used in mathematics learning for estimating decimal fractions for grade 4 students.

The Scales based on Montessori method is effective in improving mathematics learning outcomes for estimating decimal fractions of grade 4 students at Jatisari Public Elementary School. The feasibility test in product trials obtained z_{count} = 1.8506 and z_{table} = 1.64 with classical accomplishment criteria. Furthermore, the accomplishment in usage trials obtained z_{count} = 2.0412 and z_{table} = 1.64 with classical accomplishment criteria. The results of the product trial t-test obtained t_{count} = 13.129 and t_{table} = 2.997, while the t-test in the usage trials obtained t_{count} = 7.229 and t_{table} = 2.660. Therefore, it can be concluded that $t_{count} > t_{table}$, then Ha is accepted so that the average posttest score is higher than the average pretest score. N-gain test was conducted to determine the increase in students' learning ability during the pretest and posttest. The N-gain score in product trials was 0.836 with high criteria and in usage trial was 0.754 with high criteria. It can be concluded that mathematics learning in decimal fraction estimation using Scales media based on the Montessori method is effective so that learning outcomes increase.

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