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Development of mathematics manipulative for slow learner and dyscalculia student in elementary school by using Montessori's characteristic

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Abstract. Mathematics has an abstract object of study. That's why many students have difficulty understanding Mathematics, especially for slow learners or dyscalculia. This research was conducted based on the needs analysis results at SD N Mertelu and SD Muhammadiyah Sagan Yogyakarta. This study aims to develop and determine the quality of mathematics teaching aids for slow learners and dyscalculia using Montessori media principles. This research method is research and development with research subjects, namely 4 grade III students with the characteristics of slow learner or dyscalculia. The instruments used in this study were questionnaires, interview guides, and observation guidelines. The results showed that mathematics teaching aids have the characteristics of Montessori manipulative, namely attractive, gradation, auto-education, auto-correction, contextual, and have a "very good" quality and suitable for use.

1. Introduction

Mathematics is one of the compulsory subjects that students take from elementary to middle school age. Beth & Piaget [1] say that what is meant by Mathematics is the knowledge that is related to various abstract structures and relationships between these structures so that they are well organized. While Kline [1] is more likely to say that Mathematics is the knowledge that does not stand alone, but can help humans understand and solve social, economic, and natural problems. On the other hand, Reys [1] says that Mathematics is the study of patterns and relationships, ways of thinking with organizational strategies, analysis, and synthesis, art, language, and tools for solving theoretical problems and practical.

Mathematics has an abstract object of study. That's why it causes many students to have difficulty understanding Mathematics. In the process of learning the underlying mathematics concepts in children, children do not always develop as they should because each child experiences further growth and development. Some children are fast, and some are slow or have difficulty understanding the underlying mathematics concepts, especially for students with special needs, namely dyscalculia or slow learner. Developmental dyscalculia is a structural disorder of mathematical abilities with its origin in a genetic or congenital disorder of those parts of the brain that are the direct anatomical-physiological substrate maturation of mathematical skills adequate to age, without a simultaneous disorder of general mental functions [2]. Mathematics learning difficulties are also called Dyscalculia



(Dyscalculia) [3]. The term dyscalculia has medical connotations, which see a connection with central nervous system disorders. Heavy difficulties in learning mathematics called dyscalculia [3]. Academic learning difficulties in counting were called dyscalculia [1]. From the opinion of some experts, it can be concluded that the challenge of learning Mathematics is the inability of children to learn Mathematics, also called dyscalculia. Characteristics of Dyscalculia are 1) disturbances in spatial relationships, 2) visual perception abnormalities, 3) visual-motor associations, 4) perseverance, 5) difficulty recognizing and understanding symbols, 6) impaired body understanding, 7)) difficulty in language and reading, and 8) Performance IQ is much lower than Verbal IQ score. In comparison, the slow learner is A child of below-average intelligence, whose thinking skills have developed significantly more slowly than the norm for his/her age.

According to Desinigrum [4], children who are slow to learn are those who have low learning achievement (below the average child in general). IQ test scores show scores between 70-90 [4]. According to the Indonesian dictionary [5], significant words slow means not agile, not handy at work. Hence, children who are hesitant to learn are delayed in the learning process, requiring a longer time to complete the task [6]. Children who are slow to learn are children who have low or slightly below average learning achievement in children in one or all academic areas [7].

Based on the interviews with students at SD Mertelu and Muhammadiyah Sagan with the suspicion of dyscalculia, it was found that Mathematics was considered the most challenging subject. For children with a slow learner and/or dyscalculia, it takes a longer time to understand Mathematical concepts than children in general. Division and multiplication materials are often considered one of the most challenging elements for students to understand, and the teaching rarely uses teaching aids.

Though Mathematics manipulative can be used to help student's difficulties in understanding certain materials, especially in Mathematics learning, not only that teaching aids can also help teachers in delivering content to children who have special needs. The limitation of teaching aids provided by schools is an obstacle for teachers in providing material to children. Therefore, these problems are worthy of being addressed immediately. Mathematics manipulative are learning aids and all kinds of objects used to demonstrate learning material [8]. In the Indonesian Dictionary [5] explained that teaching aids are a tool in teaching to describe something so that what is taught is easily understood by students. In line with this understanding, Prastowo [9] provides an understanding of teaching aids as media that illustrate or illustrate concepts or material taught so that children are more comfortable to learn the material being taught. Thus, it can be concluded that Mathematics manipulative is objects used in determining to help children understand the material being taught. Mathematics manipulative has a function to explain or demonstrate a subject in teaching and learning activities [10].

Learning in the classroom where the teacher explains, and students pay attention, makes the child less interested and will feel easily bored. The learning strategy is not suitable for children with special needs because children with special needs cannot concentrate properly. They need assistance and special treatment to balance their academic abilities with ordinary children in general. The lack of attention and the school's handling towards children with special needs makes the child's condition worse. Schools do not carry out psychological tests to strengthen the types of children with special needs found in schools. It is compounded by the relationship between teachers and parents who are less open to children's conditions in school. The teacher does not inform parents of the psychological health of their child. So, there is no specific strategy to deal with problems faced by children, both at home and at school.

Technology can be used to help people with disabilities who are mild or severe in many ways, for example, to communicate, access learning, complete assignments, and participate fully in school and also in society [11]. Students with disabilities are allowed to use assistive technology that suits their needs. Auxiliary technology refers to any device, be it a tool, product, or another item that can be used to raise, maintain, or improve the functional abilities of individuals with disabilities. Children with special needs need concrete objects to help understand a learning material. The lack of use of real objects in each learning makes it a teacher's obstacle in delivering content. The teacher only explained until they felt they could understand a material. Based on the need's analysis in the field, the teacher

often complains about the child's condition, who is challenging to understand the content. Limitations of Mathematics teaching aids in schools are the main obstacles for teachers to convey and embed a Mathematical concept. Therefore, the use of Mathematics teaching aids for children with special needs (Slow Learner and Dyscalculia) is the best solution for the problems found in the field.

Mathematics manipulative can help children with special needs (Slow Learner and Dyscalculia) develop the ability to learn Mathematics. Mathematics manipulative can make it easier for children to understand a mathematical concept to positively impact children's ability to solve math and numeracy problems. From the research conducted by Dewi [12] entitled, it is explained that props can help in understanding the concept of multiplication and division. Also, teaching aids can improve student learning outcomes. From the pre-test to post-test results showed a difference of 90.4%. It confirms that Mathematics teaching aids about division are needed to help Dyscalculia children understand the division's concept. Montessori [13] mentions five characteristics of Montessori Mathematics manipulative that are 1) attractive, the first feature is exciting; learning for children is directed at developing the senses. These Mathematics manipulatives are made interesting by paying attention to the color, the soft contour of the surface, and the weight, so that the child is interested in touching, touching, and holding it; 2) graded, gradation of mathematics manipulative is related to the color, shape, and age of the child. This mathematics manipulative allows being used involving the five senses of the child. Also, it can be used for children of various ages and concept. 3) auto-education, mathematics manipulative develops the ability of children to learn independently. 4) auto-correction, the mathematics manipulative made have error control so that the child will know if they made a mistake when using the Mathematics manipulative, 5) contextual, In the principle of Montessori education, learning should also be adapted to the context [14]. The meaning in question is following the environment around the child. Also, mathematics manipulative is made by surrounding environment material. Hopefully, new mathematics manipulative can arouse children's learning interest, so children are not easily bored. Besides, these teaching aids can shape children's independence in learning because children can find their knowledge and mistakes. If teachers using manipulatives in the classroom, they help students understand key mathematics concepts, gain mathematical knowledge abstractly, and increase test scores [15]. This result in line with Danner and Flower [16] that say another difference was the range of disability types and the number of children with disabilities in Montessori and non-Montessori classrooms. Also, the necessary environment is made available for children so they can pick the activity they want to engage in [17].

Based on the explanation above, the authors are interested in developing mathematics manipulative for Slow Learner and Dyscalculia with Montessori manipulative characteristics. The purpose of the discussion is to describe teaching aids and their quality to develop the ability to learn mathematics in children with special needs (Slow Learner and Dyscalculia). This article themed mathematics manipulative to develop manipulative Mathematics in children with special needs (Slow Learner and Dyscalculia).

2. Methods

The type of research used in this research is research and development, commonly referred to as Research and Development (R). This research adopts 7 of the ten steps of Research and Development (R&D) that mentions the ten steps carried out including 1) potential and problems, 2) data collection, 3) product design, 4) design validation, 5) design revision, 6) product testing, 7) product revision, 8) usage trial, 9) product revision and 10) mass production.

The subjects in this study were two students with special needs, slow learning class III SD Muhammadiyah Sagan Yogyakarta and SD N Mertelu. The considerations in choosing students who are reluctant to learn or dyscalculia as research subjects are based on interviews with the principal and teachers and making observations. The data collection technique is done by interview, observation, and questionnaire. The instruments used were interview guidelines, observation guidelines, and questionnaire sheets. The data analysis technique was carried out as a qualitative method by looking at

the results of observations and interviews and a quantitative approach by seeing the props' quality through expert judgment.

3. Results and discussion

The results of the development of mathematic manipulative could increase the mathematical ability of slow learners. The quality of the media was classified as an “excellent” category with a score of 3.6. It will be explained in two parts below.

3.1. Results

Media development begins with a needs analysis to see potential and problems through observation and interviews with students and teachers in the classroom. The results of the need analysis step are children with special needs need concrete media to develop their mathematical ability. The researcher designed mathematics teaching aids for slow learners and dyscalculia students based on the discussions' results and observations. Furthermore, at the product design stage, starting with making an initial sketch using images and determining the color to design based on the characteristics of Montessori media. The next step is to validate the design. The result of validation is the design can continue with revision. The expert gives a suggestion to change the multiplication box. From 3 expert opinions, an average rating of 3.6 from a scale of 4 is obtained, classified as “very good.” After the product is revised, conducted product trials on these students with special needs, the result increases the understanding of the multiplication and division material. During the testing process, it was difficult to remove the box. Figure 1 below is the result of developing the mathematics manipulatives.

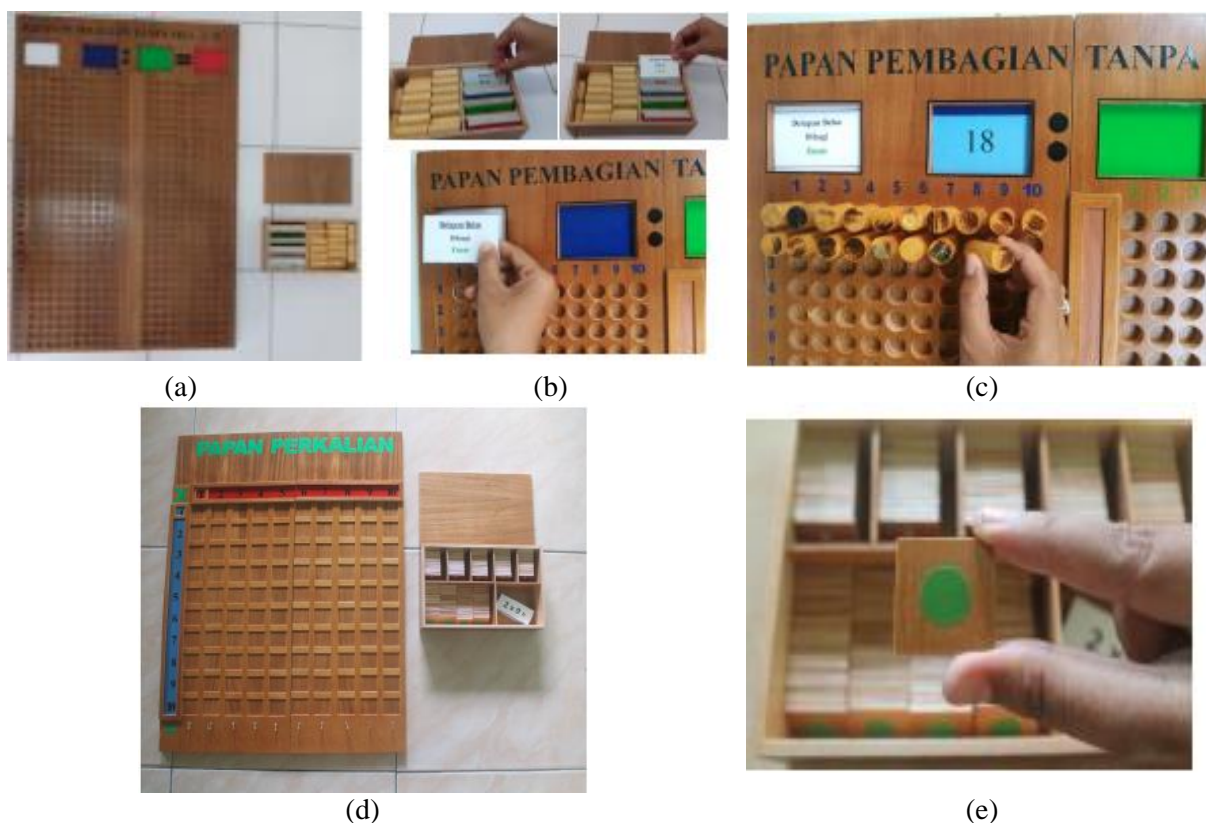


Figure 1. The result of developing the mathematics manipulative with (a) division board, (b) question card, (c) cylinder of division board, (d) multiplication board, and (e) bean of multiplication board.

3.2. Discussion

In research conducted by Shabiralyani [17], there are several conclusions drawn. One of the findings is that using teaching aids in learning methods at school can help improve children in understanding learning. This case also for children with special needs. Children with special needs need concrete objects to help understand a learning material. The lack of use of real objects in each learning makes it a teacher's obstacle in delivering content. Limitations of Mathematics teaching aids in schools are the main obstacles for teachers to convey and embed a Mathematical concept. Therefore, the use of Mathematics teaching aids for children with special needs (Slow Learner and Dyscalculia) is the best solution for the problems found in the field. Mathematics manipulative can help children with special needs (Slow Learner and Dyscalculia) develop the ability to learn Mathematics. Mathematics manipulative can make it easier for children to understand a mathematical concept so that it will positively impact children's ability to solve math and numeracy problems. Manipulatives are ubiquitous in early childhood classrooms; yet, findings regarding their efficacy for learning mathematics concepts are inconsistent [18].

Pandey and Agarwal [19] state that to help children with dyscalculia understand mathematics, an appropriate intervention program is needed to get satisfactory results. In line with this, Farooq and Aslam [20] examined the problems experienced by slow learner children in learning mathematics provide recommendations. One thing that was expressed was better learning strategies where schools need to arrange and deliver essential materials. Learning for children with (Slow Learner and Dyscalculia) requires tools that can attract children's interest and attention. Malik, Rehman, and Hanif [21] revealed this intervention in learning to improve children's skills. The choice of principle in developing this teaching aid is because, in addition to the Mathematics manipulative that is interesting, the Mathematics manipulative must have a broad scope. Error control will make it easier for teachers and children to know if there are errors when counting. As explained before, a child with dyscalculia has difficulties in mathematics learning [3] and counting [1]. Contextual teaching aids will be closer to students (Slow Learner and Dyscalculia) because the materials used in making teaching aids are in the environment around the child. Malik, Rehman, and Hanif [21] in online research wrote down some of the problems of slow learner children, one of which is that they need more stimulation to be able to do simple tasks. Even research from Butterworth and Laurillard [22] also tries to strengthen numeracy skills in children with dyscalculia. Thus, the development of teaching aids uses the principle of Montessori Mathematics manipulative. Same with Faryadi [23] said the Montessori method of learning helped kindergarten pupils improve their mathematical proficiency, critical thinking, and problem-solving skills, besides training them to be responsible learners. First, that is interesting. It can be seen from the color variations on the Multiplication Board, namely the green title, red numbering row, multiplier series blue, the circle color in the Multiplication Granules Box is light green, and the Results Box is blue. Second, namely graded. This tool has the right weight for students to learn slowly and can be seen giving numbers and marks on the Multiplication Board. Third, that can be used for learning (auto-education). It can be seen from the increase in students' understanding after using the Multiplication Board Mathematics manipulative. Fourth, which is useful as an error controller (auto-correction). It can be seen from the back of the Question Card, which lists the correct answers to the multiplication problems that exist on other surfaces. Fifth, it called contextually. It can be shown from the easy-to-obtain Multiplication Teaching Aid material in the surrounding environment, and students recognize the contents. The multiplication board is for students with Slow Learner. Those who use Montessori characteristics are proven to have excellent quality. It is because there are five characteristics of Montessori Mathematics manipulative are attractive, graded, auto-education, and contextual auto-correction [13][14].

The use of division board Mathematics manipulative with dyscalculia can help students calculate division 1-30. At the same time, the use of multiplication board Mathematics manipulative for students with Slow Learner can help students calculate multiplication 1-10. Prastowo [9] provides an understanding of teaching aids as media that illustrate or illustrate concepts or material taught so that children are more comfortable to learn the material being taught. When testing multiplication and

Mathematics manipulative division, students are asked to solve the problems found on the available card. Students can find their own mistakes by looking at the control of errors behind the question card. There is the correct answer too. In the distribution board Mathematics manipulative, there is two control of errors, namely in the control wood and behind the question card. While on the multiplication board, there is only one control of error behind the question card. It encourages children to learn independently in understanding the concepts of division and multiplication. Learning mathematics is not only a teaching concept from teacher to student, but also student participation is needed [24]. It is in line with using this teaching aid, where students play an active role in learning mathematics.

4. Conclusion

The development of mathematics manipulative for children with mathematical difficulties (Dyscalculia) adopted the characteristics of teaching aids in Montessori education. These characteristics are auto-education, auto-corrected, graded, attractive, and contextual. The teaching aids validation results, it was obtained a mean of 3.6 in the category of "excellent." While the Mathematics manipulative album validation results got a way of 3.6, too, with the grade "excellent." This mathematics manipulative can help students, in general, learn about basic multiplication concepts for children with special needs, especially dyscalculia or slow learners.

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