Montessori learning: understanding the concept of early childhood mathematics

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Abstract. The development of understanding early childhood mathematics is very important to do through his playing experience. By using the Montessori method, understanding concepts about mathematics can be introduced and developed to children by involving all the senses they have; so that, children are able to develop optimally. This study aims to determine the extent of early childhood understanding of mathematical concepts using the Montessori method. Understanding children’s mathematical concepts include understanding in measuring length and weight, measuring the length of an object, measuring the weight of objects, sorting objects based on their size, and determining objects that have the same shape. This study employed quasi-experiment which is quantitative research and the design using time series. Data collection techniques used are observation and interviews. Based on the results of the study, obtained pretest data that out of 34 children, only 11 children were completely studied and 23 children had not yet finished learning. Whereas after treatment, the results showed that 28 children were thoroughly studied and there were only 6 children who did not complete learning. That is, learning by applying Montessori learning has an influence on increasing understanding of children’s mathematical concepts.

1. Introduction
Mathematics is one of the concepts that can be taught to early childhood in stimulating children’s mathematical-logical intelligence [1] - [5]. Mathematical logic intelligence requires children to think logically and process numbers. The ability to think logically and process these numbers can be seen through children’s play activities. In fact, there are still some people who think that playing is only important to fill the child’s free time [6]-[8]. This view is of course not true. This is because for children playing is a way for them to recognize themselves and the surrounding world through exploration and researching what they see, hear, and feel.

The child’s world is playing [9][10]. Therefore, in developing all aspects of child development can be done through fun play activities. Age from birth to 6 years is often referred to as the golden age (golden age) [11] - [13] is a period of development and growth that is very decisive for children in the future.

Efforts to optimize children’s development can be done through early childhood education (ECE). ECE is an effort to guide children born to 6 years old both physically and spiritually in stimulating children’s basic abilities which include moral, physical-motoric, cognitive, language,
social-emotional, and artistic religious values \[4\][14][15].

According to Piaget’s cognitive theory, children’s cognitive development is built on his understanding of the world and through four stages \[16\]. Children aged 4-6 years (kindergarten age) are included in the Preoperational Stage (2-7 years), i.e. children begin to explain the world with words and pictures. These words and images reflect increasing symbolic thinking and transcending the relationship between sensory information and physical action.

| Basic competencies | 4-5 years old | 5-6 years old |
|--------------------|---------------|---------------|
| 3.5 Know how to solve everyday problems and behave creatively | Able to solve simple problems faced by adults | Able to solve their own simple problems |
| 4.5 Get creative everyday problems | Continue the activity until it’s finished | Complete the task despite facing difficulties |
| 3.6 Get to know the objects around it (name, color, shape, size, pattern, nature, sound, texture, function, and other characteristics) | Do activities that show children are able to recognize objects by grouping various objects according to size (for example small, long-short nature, thick-thin, | Conduct activities that show children are able to recognize objects by grouping various objects in their environment based on size, pattern, function, lightweight) sound, texture, function, and other characteristics |
| 4.6 Delivering about what and how the objects around him are known (name, color, shape, size, pattern, nature, sound, texture, function, and other characteristics) through various works | Conduct activities that show children are able to recognize objects by pairing objects with their partners | Do activities that show children are able to recognize objects by connecting one object with another object |
| | | Conduct activities that show children are able to recognize objects by simple writing through various activities (for example, pairing, copying, imitating) |

Based on table 1, it show that children are equipped with simple problem-solving abilities and recognize their environment in children’s cognitive development. The mathematical concepts that are emphasized are the concepts of numbers, geometry, patterns, classifications, simple measurements and simple problem-solving. The introduction of understanding mathematical concepts is divided into 2 stages, namely under 3 years (0 - 3 years) and ages 3 - 6 years. The introduction of early childhood mathematical concepts includes the concept of numbers, the concept of patterns and relationships, the concept of geometric and spatial relations, the concept of selecting and grouping, concepts of measurement, collection, arrangement, and display of data \[17\].

Cognitive development can be developed using a variety of media and learning methods. The
media used can be in the form of visual media, audio or a combination of both. In addition, the media used can be natural or artificial materials. Corn is one of the natural media that can be used as a cheap and safe learning resource for children.

Corn is one of the many plants produced on Madura Island. Madura as one of the areas in East Java that has a large area of maize [18]. No stranger to children living on Madura Island. However, from the results of interviews with several guardians of students who are in fact corn farmers that children only know corn as a daily food. Children don’t understand what corn is, how to grow corn, and how to process corn. So far the corn yield has only been sold raw to consumers [19]. Even children do not want to become corn farmers later when they are adults with the reason that being a farmer is difficult.

Referring to these problems, it was found from the results of preliminary observations in one of the private Kindergarten in Madura with the average guardian of his students working as corn farmers that the child’s ability in mathematical process skills was still low. This can be seen when the learning process, the teacher only teaches mathematical concepts in the form of memorizing counting numbers 1-30. Teachers rarely use media from the surrounding environment. Children are only taught using the blackboard and notebook[20]. Children are only asked to imitate numbers and name their numbers. Although the conventional blackboard teaching method is not as vivid and diverse as multimedia teaching methods, blackboard writing is simple, convenient and time-efficient [16]. For early childhood, learning like this is deemed unsuitable. Learning with this approach makes students bored and the learning outcomes are less than optimal. Children are only like calculators and readers who do not understand the concept contextually. When a child is handed a ruler, the child does not know the name of the object, let alone how to use it. With the learning process like this, it has an impact on understanding the child’s mathematical concepts to be low. Therefore, innovation is needed in learning so that children have a meaningful understanding. One of the innovations that can be applied to optimize children’s mathematical understanding is the Montessori method. Montessori education is characterized by multi-age classrooms, special sets of educational materials, student-chosen work in long time blocks, collaboration, the absence of grades and tests, and individual and small group instruction in both academic and social skills. In this case, the age of children in the Montessori class is not specifically distinguished as that in Indonesia, namely early childhood grouped by age [15].

This Montessori method emphasizes student-centered learning. This Montessori method is suitable to be applied to children, in which children have the characteristics of the absorbent mind or better known as an easily absorbing mind. This means that this method is applied to early childhood which has the characteristics of a great imitator, explorer and likes new things. In its application emphasizes on 6 aspects of child development and involves all the senses that are owned by the child. The application of the Montessori method has five areas. In this study, the application of the Montessori method refers to a combination of three areas in the Montessori method, namely the practical life area, math area, and area culture. In applying this practical life area, children learn about things related to everyday life. Children in this area to introduce ways to care for the environment. In applying this math area, it is focused on introducing basic concepts related to the concept of numbers and numbers. In this area it aims to optimize children’s reasoning (thinking skills) on mathematical concepts. In this study the child learned the concept of measuring length and weight and grouping objects based on shape and size. In the application of the culture area the child learns to understand his role in the universe, fosters his love for the universe, and fosters his desire to contribute to preserving nature.
2. Methods
This study is aimed at determining the extent of early childhood understanding of mathematical concepts. This study employed quasi-experiment which is quantitative research and the design using time series.

\[
\begin{array}{cccccccc}
  O_1 & O_2 & O_3 & O_4 & X & O_5 & O_6 & O_7 & O_8 \\
\end{array}
\]

Figure 1. The Design Using Time Series

where:
- \( O_i \) : Observation with index-i
- \( X \) : Treatment (Montessori Learning by corn media)

This design was chosen because this study only involved one group (children aged 4-6 years old), so it did not require a control group. This is as characteristic of the application of the Montessori method that does not distinguish the age of the child (there are variations in the age of the child who is studying). In addition, the researcher cannot control the other factors that influence the group. In this design the group used is not randomly selected. Before being given treatment, the child is observed four times, then given treatment, and after the treatment is observed again four times.

This study only involved a group of children aged 4-6 years old at private kindergarten An Nash, Kamal District, Bangkalan, Madura - Indonesia. The population covers 24 students aging 4-5 years old and 13 students aging 5-6 years old. The sampling technique used in this study was purposive sampling. This technique was chosen because of consideration of the presence of children in school. There were 3 children who were never present at school during the study, so the 3 children were not used as research samples, so the samples used in this study were 21 children aged 4-5 years old and 13 children aged 5-6 years old.

The data excavated in this study are data about understanding children’s concepts of mathematics which include the concepts of numbers, geometry, and simple measurements. Data collection techniques used are observation and interviews. Participant observation was conducted by researchers to control the application of learning by using Montessori learning. Semi-structured interviews, researchers use by guiding the interview guidelines that refer to Montessori learning characteristics. The data obtained were analyzed by descriptive. The data obtained is described based on the graphs of observations in several sessions with the provisions for decision making of frequency, stability trends, and trends in the graph.

3. Result and Discussion
Before using the Montessori method, children’s understanding of mathematical concepts at An Nash Kindergarten was limited to recognizing the concept of numbers. In fact, children are taught to memorize the concept of numbers from 0 to 30. Every morning after the child marches and prays, the memorization of 1-30 numbers is done. This is because the learning method used by the teacher uses drill and paper and pencil based. Children are taught to write numerical concepts twice a week. Children are asked to write 5 numbers in their notebook as exemplified by the teacher on the board.

3.1. Result Before Using Montessori Learning
children aged 4-5 years old), the results showed that only 7 children from 21 children were able to write numerical symbols properly. In fact, there are 3 (three) children whose parents are still waiting. Not infrequently the parents take part in the work of their children. This causes the four children to still not be able to write numerical symbols properly. The other 14 children still experience misconceptions, for example in writing the numbers 5, 6 or 7, they are still written
facing upside down from their supposed position. In the initial observation (before using Montessori Learning) in group B (children aged 5-6 years old), learning to recognize the number concept showed that only 5 children from 13 children were enthusiastic in writing numbers in a notebook, the rest looked bored. This is reacted in the position they sit. The child puts his head/chin on the table and writes lazily. In fact, there are 3 children who disturb their friends who are writing. Children only recognize imitating numerical symbols but do not understand the basic concepts.

The details of the data on understanding the mathematical concepts of children from all children before treatment can be seen in the following figure.

Based on figure 2, it was obtained information that there were 17 children who received an average score of mathematical understanding with the No Developing category, 6 children with the Starting Developing criteria, 11 children with the Developing Criteria as Expected, and no children with the Very Good Developing criteria. This shows that out of 34 children, only 11 children were completely studied and 23 children had not yet finished learning. Based on these data the results of observations of the average mathematical understanding of children in each session before using Montessori learning were $O_1 = 1.88$, $O_2 = 1.94$, $O_3 = 1.97$, and $O_4 = 2.06$ ($O_1 \neq O_2 \neq O_3 \neq O_4$). This shows that the group is not stable. However, the results of the observations show that data is consistently up (continuing to increase from several observation sessions).

3.2. Using Montessori Learning

In learning activities, the teacher uses certain media/material as a tool in learning. Through the use of these materials, children prepare for success in school and life [17]. In learning using the Montessori method (treatment) this child is taught by using the help of corn media. Corn was chosen as a learning medium because in the environment around the child there were many corn fields and the average parent of the student was a corn farmer. Learning concepts in early childhood uses themes and sub-themes, which in this study the themes used are plants with sub-themes of corn plants. The learning consists of several types of activities, including the introduction of corn and its parts, measuring the length of corn and weighing corn, a collage of corn, planting corn in the garden, making food and drinks from processed corn. This learning involves all the five senses of a child, from the senses of sight, hearing, touch, smell, and feeling. This learning develops an understanding of mathematical concepts which include the concept of measurement of length and weight, as well as the concept of geometry[21].

On the first day when given treatment, that is by learning the introduction of corn and its parts. Children are introduced to science and math concepts. The mathematical concept developed is that children are able to sort objects according to their size and are able to determine objects that have the same shape. The child asks about the parts that corn has. The teachers
explanation starts from roots, stems, leaves, corn cobs and corn flowers. Children observe and identify their similarities and differences. Then the child cooperatively begins to peel the corn. Because of being overly enthusiastic, the child pulls one another to pull corn with his skin until it is released. In fact, there were children who fell down while peeling corn with their friends. Events like this make other children laugh, making learning fun. Children are not bored with the learning activities carried out. During this learning, the child is observed for his ability to understand mathematics. Initially, there were many children who still had difficulty sorting objects based on their size. Children are only able to show the size of objects, in this case, corn is used. Children understand that corn is held in large or small size, but children are still having difficulty if asked to sort the corn from the smallest to the largest.

In the second lesson, children were invited to learn by measuring the length of corn, weighing corn, and corn collage. At the apperception stage, the teacher shows the ruler and the cake scales. Through this Montessori learning, children are interested in the measuring instruments carried by the teacher. The next child actively asks, Mom, what is this name? What is the use for? The teacher does not directly answer the question. The teacher explains the rules for playing in class and gives the tools and materials used. Children ask each other questions with group members and then observe the measuring instruments given. There are some children who say, Mom, how come there are numbers (while pointing to the ruler) and this one also has numbers and needles (pointing to the scales). Then the new teacher explained that the name of the measuring instrument in front of them was called a ruler and a scale. Because the experience of the day is their first experience of knowing the measuring instrument, they are very enthusiastic in learning. After knowing the name of each measuring instrument, the child begins to observe the given corn and then tries to measure the length. Each team member helps, some hold the corn, some hold a ruler, and together look at the length of the corn. While discussing, children try to determine the results. Then they write the results of the measurements on the sheets that have been provided according to the numbers printed on the ruler as a measure of their length. Finally, each team demonstrated how they determined the length of the corn and reported the results to the teacher.

Moving on to the next activity is to weigh corn. Children and their team weighed corn kernels. Children carry out activities to weigh corn seeds together. The child independently takes a few handfuls of corn and then puts it into the scales to the brim. The child then observes the changing position of the needle on the scale. Then they hypothesize simply that if they put more corn, then the needle will move down and go to a number that is greater in value. Therefore, several groups included corn kernels until the scales were full. After being observed, they deformed the results of the process of weighing the corn kernels on a piece of paper provided by the teacher. They record the results according to the numbers designated by the jar.

3.3. After Using Montessori Learning

After being given treatment, the researcher made a re-observation of children’s mathematical understanding. Figure 3 below presents data on the average ability of children in understanding mathematics, especially in the concept of measuring length and weight and grouping objects based on shape and size.

Based on the figure 4, information was obtained that there were 6 children with the criteria for Developing and 28 children with the criteria for Developing as Expected. There are no children with criteria that have not yet developed and developed according to expectations. This means that 28 children are thoroughly studied and there are only 6 children who do not complete learning.
Figure 3. Understanding the Concept of Early Childhood Mathematics after Using Montessori Learning

Based on these data the results of the observation of the average mathematical understanding of children in each session were $O_5 = 2.88$, $O_6 = 3.18$, $O_7 = 3.41$, $O_8 = 3.74$ ($O_5 \neq O_6 \neq O_7 \neq O_8$). This shows that the group is not stable. However, the results of the observations show that data is consistently up (continuing to increase from several observation sessions). The magnitude of the effect of treatment using Montessori learning can be determined by calculation $= (O_1 + O_2 + O_3 + O_4) - (O_1 + O_2 + O_3 + O_4) = (2.88 + 3.18 + 3.41 + 3.74) - (1.88 + 1.94 + 1.97 + 2.06) = 13.21 - 7.85 = 5.36$. The graph of trend direction from the data can be seen in the figure 4.

Figure 4. Trends in Understanding Child Mathematics Charts Using Montessori Learning with Time Series Design

3.4. Discussion

Making fun of learning mathematics in school is the hope of every child. In essence, early childhood learns while playing, not monotonous with the drill system and uses student worksheet as already in school. Monotonous learning and emphasizing reading, writing and arithmetic in ECE such as the demands of parents can have a negative impact on children.

Based on the results of observations before treatment using Montessori learning illustrates that the children in the group are still largely incomplete learning. This is because the teacher does not apply learning as the principle of early childhood learning namely children as active learners, Children Learn Through Sensory and Five Senses, Children Build Knowledge Alone, Children Think Through Concrete Objects, Children Learn From the Environment.

Using Montessori learning, children are not directly taught mathematical concepts. However, children are invited to play and do activities in stages as the children’s work cycle in the Montessori Method. So, children are more enthusiastic in participating in a series of learning activities. If the child learns not in accordance with the child’s work cycle, the child will easily feel bored and not ready to learn, which will cause disruption in the child’s work cycle and have an impact on children’s learning outcomes that are less than optimal. Disorders in a child’s
work cycle can be a level 1 disorder or a level 2 disorder. Level 1 disorders can occur with a marked condition of the child disturbing his friend and unplanned interference. While level 2 disorders are characterized by the condition of the child intentionally disturbing his friend, the child does not concentrate, and the emergence of deviant behavior.

After treatment using Montessori learning, it was obtained an illustration that starting from the 1st observation to the 8th observation the condition of the group of children was unstable. This is because $O_1 \neq O_2 \neq O_3 \neq O_4$ and $O_5 \neq O_6 \neq O_7 \neq O_8$. When viewed from figure 3, the graph shown by the tendency of the direction of the monotonic chart continues to rise gives an overview of the influence of external factors that are more instrumental than the effect of treatment. That is, learning by applying Montessori learning has an influence on increasing understanding of children’s mathematical concepts, but there are other factors that also provide a role in improving children’s understanding.

This research is expected to be able to contribute to the teacher so that the teacher can increase his professionalism in designing learning and determine the right media in accordance with the conditions of the school, especially in stimulating children’s thinking skills. In addition, the limited media owned does not make the reason for teachers not to innovate in learning. For teachers, in determining alternative media used in learning can use corn plants. This is because corn, especially in Madura, is a natural media that is easily available and relatively inexpensive.

This study can also contribute to parents that stimulating children’s understanding of mathematics can be done not only through student worksheets (at school). However, children’s mathematical understanding can be given through fun learning at home using Montessori Learning by utilizing environmental media (such as corn) and through daily activities (planting corn) because of the environment in which children live around the corn fields.

For further researchers, through the results of this study can provide input in the application of the Montessori method can use other media adapted to local wisdom to stimulate understanding of the concept of early childhood mathematics.

In addition to finding information related to understanding the concept of early childhood mathematics, through learning Montessori learning information was found on several things including: children become more happy to be in school all the time of school; children feel more excited when going to school; the classroom learning atmosphere is more alive when group A (children aged 4-5 years old) and group B (children aged 5-6 years old) are combined; children are free to express themselves in learning activities; children are more confident; children can explore the environment assisted by corn media; children are able to solve simple problems independently; children are not easily bored because of variations in learning activities; children are able to work with corn media, and assessment of children is faster.

4. Conclusion
After reviewing and analyzing, this study can be concluded that through Montessori learning, early childhood understanding of mathematics can increase significantly. This understanding includes understanding children in recognizing length and weight measuring instruments, measuring the length of an object, measuring the weight of objects, sorting objects based on their size, and determining objects that have the same shape. Based on the results of the study obtained pretest data that of 34 children, only 11 children were completely studied and 23 children had not yet finished learning. Whereas after treatment, the results showed that 28 children were thoroughly studied and there were only 6 children who did not complete learning. That is, learning by applying Montessori learning has an influence on increasing understanding child mathematical concepts.
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