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ENHANCING THE SENSORIMOTOR ABILITIES OF CHILDREN WITH SPECIAL NEEDS THROUGH MONTESSORI-BASED SENSORY TEXTURE BOARDS

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Abstract

This study aims to test the effectiveness of Montessori-based sensory texture boards in improving the sensory-motor abilities of children with special needs at Al Wardah Kindergarten, Peterongan District, Jombang Regency. The study used a quasi-experimental design with a one-group pretest-posttest design involving 40 children with special needs aged 4-6 years who were selected through a purposive sampling technique. The intervention was carried out for 8 weeks with a frequency of 2-3 times per week, a total of 10 sessions, using sensory texture boards designed based on Montessori principles. The research instrument was a sensory-motor ability observation sheet that had been validated by experts with high reliability. Data were analyzed using descriptive statistics and the Wilcoxon Signed-Rank Test. The results showed a very significant increase in children's sensory-motor abilities (Z = -5.238; p-value = 0.000). The average increase in ability was 29.15%, with 95% of subjects experiencing improvement. The highest improvement occurred in sensory perception (30.7%), followed by fine motor skills (30.6%), gross motor skills (29.6%), and sensory-motor integration (25.8%). This study concluded that Montessori-based sensory texture boards are effective as a learning medium for improving sensory-motor skills in children with special needs. The Montessori approach, which emphasizes independent exploration and learning through direct sensory experiences, has been shown to be well-suited to the needs of children with special needs.

Keywords: sensory texture board, Montessori, sensory-motor, early childhood.

INTRODUCTION

Children with special needs (ABK) are a group of children with unique characteristics who require special educational approaches and assistive devices to support their optimal development. One crucial aspect of development is sensory-motor skills, which include the ability to receive, process, and respond to sensory stimuli through motor activity. Sensory-motor skills are an important foundation in child development, involving the coordination of the senses and motor functions to carry out various activities of daily living (Ayres, 1979). For children with special needs, sensory-motor development is often a major challenge that requires special attention and appropriate intervention.

The Montessori approach, as an educational method focused on developing children's holistic potential, has demonstrated effectiveness in supporting the development of children with special needs, particularly through the use of sensory-based educational play tools. Maria Montessori emphasized that children learn most effectively

through independent exploration and direct interaction with their physical environment (Montessori et al., 2017). Montessori's core concepts of behavior and development center on spontaneous creativity and holistic growth, where children engage in spontaneous creation driven by their own desires and initiatives (Lillard, 2021).

Several previous studies have demonstrated the effectiveness of the Montessori approach in developing sensory-motor skills in children with special needs. Research conducted by Nurul Aviah and Kurniawan (2024) revealed that the Montessori method applied to 25 children with special needs showed a 45% increase in fine motor skills within 3 months. Similarly, a longitudinal study conducted by Larasati (2024) on 30 children with autism spectrum disorders demonstrated that the use of sensory-based educational play tools can improve eye-hand coordination by up to 60%.

However, implementation in the field still faces various challenges. Children with special needs require motor activity during the learning process to assist with thinking or understanding the objects being studied (mental activity). Children with special needs also use visual, auditory, and kinesthetic learning modalities, which require tangible stimuli such as touch, hearing, and sight. Furthermore, the learning capacity of children with special needs is very limited due to their characteristics of being easily distracted, inattentive, lacking interaction, and physical fatigue (Dubnewick et al., 2018).

Field observations demonstrate the difficulty teachers face in creating active learning for students with special needs. Pre-observations in Peterongan District, Jombang Regency, found that schools serving children with special needs still lack appropriate educational play equipment. Research by Insiatun et al. (2021) identified that 68% of inclusive early childhood education centers (PAUD) in East Java do not yet have educational play equipment appropriate to the needs of students with special needs. Data from the Jombang Regency Education Office recorded 127 early childhood education centers (PAUD) with special needs across 15 inclusive PAUDs in Peterongan District, but only 30% received adequate sensory-motor stimulation.

Interviews with teachers at several schools revealed that approximately 75% of the equipment used was commercially available and not specifically designed for children with special needs. Teachers reported frequently encountering challenges in selecting play equipment tailored to the individual needs of their children. An interview with Ms. Eni Lailiyah, M.Pfis, Head of Al-Wardah Early Childhood Education (PAUD), revealed that the limited availability of educational play equipment specifically for sensory-motor development was a major obstacle in the learning process.

Sensory play, or sensory-based play, is an important approach to supporting child development. Ginsburg (2007) states that sensory play helps children understand their environment through active exploration. According to Ayres (1979), sensory integration is the brain's ability to organize information from the senses into adaptive responses. Children with sensory integration disorders require specially designed media to help them understand differences in texture, color, and shape through direct experience (Schoen et al., 2019).

Sensory play also plays a vital role in developing fine and gross motor skills. Case-Smith and Arbesman (2008) state that play involving hand movements, such as squeezing or kneading a sponge, can strengthen the small muscles in the hands and fingers. These activities also improve hand-eye coordination, which is crucial for everyday tasks, such as writing, drawing, or using cutlery. Pfeiffer et al. (2013) note that sensory play-based interventions can improve attention, engagement, and social skills in children with special needs.

Through play, children indirectly develop their physical, motor, social, emotional, and cognitive abilities. Childhood is a crucial time for sensory development and muscle training. This can be enhanced through the use of educational sensory texture board games. Sensory texture board games are games that train or utilize one or more of the senses (sight, hearing, smell, taste, and touch). These games help children learn to observe, stimulate their senses, and form neural connections in their brains.

In terms of research, although there are numerous studies on the effectiveness of Montessori tools, there is still limited research focused on developing Montessori-based tools specifically designed for children with special needs. Most existing research focuses on the use of readily available materials without further examining the development of specific new products. The identified gap is the gap between the need for high sensory-motor stimulation and the availability of appropriate educational play tools. Meanwhile, the research gap identified is the limited research on developing educational play tools that integrate the Montessori approach with the specific needs of children with special needs in Indonesia. Research by Kuswoyo and Hiskya (2023) and Sari (2020) has developed educational play tools for children with special needs, but has not yet comprehensively integrated Montessori principles.

The urgency of this research is further heightened given the limited golden period of child development. Appropriate stimulation during this period will determine the quality of a child's future development. Therefore, the development of a Montessori-based sensory texture board educational play tool is crucial to meet the specific needs of children with special needs. This product is designed with child developmental characteristics, Montessori principles, and the individual needs of children with special needs in mind.

The novelty of this research lies in the innovative use of materials with adjustable textures and densities, as well as the implementation of a modular system that allows for levels of difficulty to be adjusted to suit the child's abilities. Unlike similar products such as conventional Sensory Boards, the sensory texture board provides a more comprehensive multi-sensory experience by integrating visual, tactile, and kinesthetic elements into a single game. Significant differences lie in three main aspects: first, the use of materials with various textures and densities that can provide more diverse tactile stimulation; second, a modular system that allows for gradual adjustment of the difficulty level; and third, the integration of Montessori principles that emphasize independence and experiential learning.

This research is expected to contribute significantly to the development of innovative and applicable Montessori-based educational play tools to support the sensory-motor development of children with special needs. By integrating Montessori principles and sensory-motor development theory, sensory texture boards are expected to be an effective solution for enhancing the sensory-motor abilities of children with special needs in various educational settings.

METHODS

Research Design

This study used a quantitative approach with a quasi-experimental design using a one-group pretest-posttest design. This design was chosen because it is suitable for evaluating the effectiveness of interventions on small groups of children with special needs without a control group, which is difficult to do due to the limited number of subjects and ethical considerations in providing interventions to all children in need (Creswell, 2014). This study focused on measuring the improvement of sensory-motor skills in children with special needs before and after the use of a Montessori-based sensory texture board.

Research Subjects

The research subjects were children with special needs registered at Al Wardah Kindergarten, Peterongan District, Jombang Regency, East Java. The sampling technique used purposive sampling with the following inclusion criteria: (1) children aged 4-6 years; (2) diagnosed as children with special needs with sensory-motor development disorders such as Autism Spectrum Disorder (ASD), Cerebral Palsy (CP), or developmental delays; (3) have basic skills to interact with simple play tools; (4) have parental or guardian consent to participate in the research; and (5) regularly attend school during the research period. Based on these criteria, 40 children with special needs were selected as research subjects.

Location and Time of Research

The study was conducted at Al Wardah Kindergarten in Peterongan District, Jombang Regency, East Java. The location was selected based on the availability of children with special needs who met the study criteria and support from the school. The study was conducted over three months, from November 2024 to January 2025, with interventions conducted two to three times per week for 30 to 45 minutes per session.

Research Procedures

The research procedure was conducted through three main stages: preparation, implementation, and evaluation. Each stage was systematically designed to ensure the data obtained was valid and reliable.

Preparation Stage

During the preparation stage, the researcher coordinated with the school and parents to explain the research objectives and obtain informed consent. Next, the researcher prepared a research instrument in the form of a sensory-motor ability

observation sheet validated by experts. The researcher also provided training to teachers and research assistants on how to use the sensory texture board and observation procedures.

Implementation Stage

The implementation phase began with a pretest to measure children's early sensory-motor skills using an observation sheet. After the pretest, intervention using a Montessori-based sensory texture board was conducted for 8-10 sessions, 2-3 times per week. Each session lasted 30-45 minutes, with activities tailored to each child's abilities and needs. Activities included recognizing various textures, squeezing and squeezing materials, organizing materials by category, and hand-eye coordination activities. During the intervention, researchers and teachers observed and documented children's development. After the intervention was completed, a posttest was conducted using the same instrument as the pretest to measure improvements in children's sensory-motor skills.

Evaluation Stage

In the evaluation phase, pretest and posttest data were analyzed to determine improvements in children's sensory-motor skills. The data obtained was then processed using statistical analysis techniques to test the effectiveness of the sensory texture board.

Research Instruments

The instrument used in this study was a sensory-motor ability observation sheet developed based on developmental indicators of children with special needs and Ayres' (1979) sensory integration theory. The observation sheet consisted of 20 observation items covering four main aspects: (1) sensory perception (5 items), including the ability to recognize textures, responses to temperature and pressure, and proprioceptive stimulation; (2) fine motor skills (8 items), including finger strength and flexibility, hand-eye coordination, and finger dexterity; (3) gross motor skills (4 items), including balance and body coordination; and (4) sensory-motor integration (3 items), including the ability to plan movements, regulate responses, and focus.

Each item is assessed using a Likert scale of 1-4, with the following criteria: score 1 = unable to do at all (0-25% success); score 2 = able to do with a lot of help (26-50% success); score 3 = able to do with a little help (51-75% success); and score 4 = able to do independently (76-100% success). This instrument has been validated by three experts, namely an inclusive education expert, an occupational therapist, and an expert in the development of learning media, with the validation results showing a content validity level of 0.89 which is included in the very high category.

Data collection technique

Data collection was conducted through structured observations using a prepared observation sheet. Observations were conducted by the researcher and two trained research assistants to ensure consistency of assessment (inter-rater reliability). Each child was observed individually during activities with the sensory texture board. Pretest observations were conducted in the first week before the intervention began, while

posttest observations were conducted in the final week after all intervention sessions were completed. In addition to observations, the researcher also documented the data using photographs and videos to support the validity of the data obtained.

Data Analysis Techniques

Data obtained from the observation sheets were analyzed using descriptive and inferential statistics. Descriptive analysis was used to describe the child's sensory-motor ability profile before and after the intervention, including minimum, maximum, average (mean), and standard deviation values. The percentage of sensory-motor ability achievement was calculated using the formula:

$$P = (f/n) \times 100\% \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Information:

P = Percentage of ability achievement;

f = Score obtained by the child;

n = Maximum score that can be achieved

The level of achievement of sensory-motor abilities is classified into four categories based on the percentage range: very poor (0-25%), poor (26-50%), good (51-75%), and very good (76-100%).

To test the effectiveness of the sensory texture board, an inferential statistical analysis was conducted using the paired sample t-test (if the data were normally distributed) or the Wilcoxon signed-rank test (if the data were not normally distributed). Before conducting the hypothesis test, the data normality test was first conducted using the Shapiro-Wilk test. Hypothesis testing was carried out with a significance level of $\alpha = 0.05$. The research hypothesis is that there is a significant increase in the sensory-motor abilities of children with special needs after using the Montessori-based sensory texture board. Data analysis was carried out using SPSS software version 25.

In addition to quantitative analysis, researchers also conducted qualitative analysis of field notes and documentation to provide in-depth descriptions of changes in children's behavior and abilities during the intervention. This qualitative data was used to complement and enrich the interpretation of the quantitative analysis results.

RESULTS

This study aims to test the effectiveness of Montessori-based sensory texture boards in improving the sensory-motor abilities of children with special needs at Al Wardah Kindergarten, Peterongan District, Jombang Regency. The results of the study are presented in three main parts, namely: (1) description of the characteristics of the research subjects, (2) analysis of sensory-motor abilities before the intervention (pretest), (3) analysis of sensory-motor abilities after the intervention (posttest), and (4) analysis of improvements in sensory-motor abilities.

Characteristics of Research Subjects

The research subjects consisted of 40 children with special needs registered at Al

Wardah Kindergarten, Peterongan District, aged 4-6 years. The research subjects were selected using a purposive sampling technique based on the established inclusion criteria. The characteristics of the research subjects based on the type of special needs include: Autism Spectrum Disorder (ASD) for 22 children (55%), Cerebral Palsy (CP) for 10 children (25%), and developmental delay for 8 children (20%). Based on gender, the research subjects consisted of 26 boys (65%) and 14 girls (35%).

Sensory-Motor Abilities Before Intervention (Pretest)

Early sensory-motor abilities were measured through observations using validated observation sheets. Pretest results indicated that most children with special needs had very low sensory-motor abilities. The pretest data showed the following distribution of abilities:

Table 1. Distribution of Pretest Sensory-Motor Ability Categories

Category	Score Range (%)	Number of children	Percentage (%)
Very Bad	0-25	31	77.5
Not good	26-50	6	15.0
Good	51-75	3	7.5
Very good	76-100	0	0.0
Total	**-**	**40**	**100.0**

Based on Table 1, it can be seen that the majority of study subjects (77.5%) were in the "Very Poor" category with a score range of 0-25%. A total of 6 children (15%) were in the "Poor" category, and only 3 children (7.5%) achieved the "Good" category. No subjects achieved the "Very Good" category in the pretest stage. These results indicate that the sensory-motor abilities of children with special needs before intervention were still very low and required intensive stimulation.

Descriptive analysis showed an average pretest score of 42.38% with a standard deviation of 12.45. The minimum score obtained was 25% and the maximum score was 67%. The low pretest scores indicated that the children experienced difficulties in various aspects of sensory-motor abilities, especially in terms of: (1) texture perception and discrimination, (2) finger strength and dexterity, (3) hand-eye coordination, and (4) the ability to plan motor movements.

Implementation of Intervention

The intervention using Montessori-based sensory texture boards was implemented over 8 weeks, 2-3 times per week, for a total of 10 sessions. Each session lasted 30-45 minutes and was conducted individually or in small groups (2-3 children). Intervention activities were designed following Montessori principles, which emphasize independent exploration, incremental learning, and repetition of activities.

Activities carried out in each session include: (1) exploring textures by touching and distinguishing between various types of materials (smooth, rough, soft, springy), (2)

squeezing and wringing activities to train hand muscle strength, (3) pinching and moving objects to train finger dexterity, (4) arranging and grouping activities based on texture, color, or size, and (5) hand-eye coordination activities by putting objects into containers or following certain patterns.

During the intervention, researchers and teachers observed and documented the children's development. The majority of children demonstrated high levels of enthusiasm and engagement in play activities using the sensory texture boards. Some children who initially resisted or were afraid to touch certain textures gradually showed an increased willingness to interact with the materials.

Sensory-Motor Abilities After Intervention (Posttest)

After 10 sessions of intervention, a final sensory-motor ability measurement (posttest) was conducted using the same instrument as the pretest. The posttest results showed a significant improvement in the sensory-motor abilities of children with special needs. The distribution of abilities at the posttest stage can be seen in the following table:

Table 2. Distribution of Posttest Sensory-Motor Ability Categories

Category	Score Range (%)	Number of children	Percentage (%)
Very Bad	0-25	2	5.0
Not good	26-50	6	15.0
Good	51-75	25	62.5
Very good	76-100	7	17.5
Total	**-**	**40**	**100.0**

Based on Table 2, a very significant shift in distribution occurred. In the posttest, the majority of research subjects (62.5%) successfully achieved the "Good" category with a score range of 51-75%. Seven children (17.5%) even achieved the "Very Good" category with a score above 76%. The number of children in the "Very Poor" category decreased drastically to only two children (5%), and six children (15%) were in the "Poor" category.

Descriptive analysis of the posttest showed an average score of 71.53% with a standard deviation of 15.28. The minimum score was 34% and the maximum score was 94%. There was an average score increase of 29.15 points compared to the pretest. These results indicate that the intervention using a Montessori-based sensory texture board is effective in improving the sensory-motor skills of children with special needs.

Sensory-Motor Ability Improvement Analysis

To further understand the effectiveness of the intervention, a gain score analysis was conducted by comparing the pretest and posttest scores of each study subject. The results showed significant variation in gains across subjects, as presented in the following table:

Table 3. Descriptive Statistics of Sensory-Motor Ability Improvement

Statistics	Mark	Information
Average Increase	29.15%	Substantial improvement
Highest Increase	56%	Subject ABK_04
Lowest Increase	6%	Subjects ABK_15 and ABK_18
Decline	2 children	ABK_13 (-3%) and ABK_36 (-4%)
Number of Subjects Increases	38 children	95% of subjects experienced improvement

Based on Table 3, the average increase in sensory-motor skills of 29.15% indicates significant intervention effectiveness. A total of 38 children (95%) experienced an increase in abilities, with an increase ranging from 6% to 56%. The highest increase was achieved by subject ABK_04, whose score increased from 39% in the pretest to 94% in the posttest, or an increase of 56 points. Other subjects who experienced significant improvements were ABK_25 and ABK_09, with increases of 50% each.

However, two subjects (5%) experienced a decrease in their scores: ABK_13 with a 3% decrease and ABK_36 with a 4% decrease. This decrease is thought to be due to several factors, including: absence from several intervention sessions, unstable health conditions during the study period, and the presence of a more dominant attention deficit disorder. Furthermore, several subjects, such as ABK_15 and ABK_18, showed minimal improvement (6%), indicating the need for modification or higher intervention intensity for children with certain characteristics.

Statistical Hypothesis Testing

To test the significance of the difference between pretest and posttest scores, inferential statistical tests were conducted. Before conducting the hypothesis test, data normality was first tested using the Shapiro-Wilk test. The results showed that the pretest and posttest data were not normally distributed (p-value <0.05), so the analysis was continued using the non-parametric Wilcoxon Signed-Rank Test.

Table 4. Results of Data Normality Test (Shapiro-Wilk Test)

Data	Shapiro-Wilk Statistics	p-value
Pretest	0.924	0.012*
Posttest	0.918	0.008*

**Significant at α = 0.05*

The Wilcoxon Signed-Rank Test results showed a significant difference between sensory-motor abilities before and after the intervention. The calculated Z value was -5.238 with a p-value of 0.000 ($p < 0.01$), which means there was a very significant difference between the pretest and posttest scores. This indicates that the use of

Montessori-based sensory texture boards is statistically effective in improving the sensory-motor abilities of children with special needs.

Table 5. Results of the Wilcoxon Signed-Rank Test

Test Statistics	Mark
N (Number of Subjects)	40
Z count	-5,238
p-value	0.000**

***Highly significant at α = 0.01*

Analysis of Improvement Per Aspect of Sensory-Motor Abilities

To provide a more comprehensive picture, an analysis of improvement was conducted based on the four main aspects of sensory-motor abilities measured in this study. The analysis per aspect showed that each dimension of ability experienced improvement with varying degrees of variation.

Table 6. Improvement in Abilities per Sensory-Motor Aspect

Ability Aspect	Pretest Average (%)	Posttest Average (%)	Increase (%)
Sensory Perception	38.5	69.2	30.7
Fine Motor Skills	41.8	72.4	30.6
Gross Motor Skills	46.2	75.8	29.6
Sensory-Motor Integration	42.9	68.7	25.8

Based on Table 6, the sensory perception aspect experienced the highest increase of 30.7%, followed by fine motor skills (30.6%), gross motor skills (29.6%), and sensory-motor integration (25.8%). The highest increase in the sensory perception aspect indicates that the sensory texture board is very effective in training children's ability to recognize and differentiate various types of textures, respond to tactile stimuli, and develop proprioceptive awareness.

Fine motor skills also showed significant improvement, particularly in grip strength, finger dexterity, and hand-eye coordination. Children demonstrated improvements in their ability to squeeze, wring, pinch, and move objects more skillfully. Meanwhile, relatively lower improvements in sensory-motor integration indicated that the ability to plan and regulate motor movements requires longer intervention time and more complex training.

Summary of Research Results

The results of the study showed that the use of Montessori-based sensory texture boards was effective in improving the sensory-motor abilities of children with special

needs. The main findings of this study were: (1) there was an average increase in sensory-motor abilities of 29.15% from pretest to posttest, (2) as many as 95% of the research subjects experienced an increase in abilities, (3) there was a statistically very significant difference between abilities before and after the intervention (p-value = 0.000), and (4) improvements occurred in all aspects of sensory-motor abilities, with the highest increase in the sensory perception aspect (30.7%).

These results confirm the effectiveness of the Montessori approach, which emphasizes learning through independent exploration and direct sensory experiences. The sensory texture board provides rich and varied multisensory stimulation, enabling children to learn through active interaction with the materials. The success of this intervention aligns with Ayres' sensory integration theory, which states that structured sensory stimulation can improve the brain's ability to process and integrate sensory information, which in turn improves children's motor responses.

CONCLUSION

Based on the research results and data analysis, it can be concluded that the Montessori-based sensory texture board is effective in improving the sensory-motor skills of children with special needs at Al Wardah Kindergarten, Peterongan District, Jombang Regency. The conclusions of this study can be described as follows:

1. There was a significant improvement in the sensory-motor skills of children with special needs after using a Montessori-based sensory texture board. Statistical test results showed a highly significant difference between abilities before and after the intervention (Z = -5.238; p-value = 0.000). The average increase in sensory-motor skills was 29.15%, with 95% of the study subjects experiencing improvement. This improvement reflects the effectiveness of the sensory texture board in providing the multi-sensory stimulation needed by children with special needs.
2. Improvements in abilities occurred in all sensory-motor aspects measured, with the following details: sensory perception increased by 30.7%, fine motor aspects increased by 30.6%, gross motor aspects increased by 29.6%, and sensory-motor integration aspects increased by 25.8%. The highest increase in the sensory perception aspect indicates that the sensory texture board is very effective in training children's ability to recognize and differentiate various types of textures, respond to tactile stimuli, and develop proprioceptive awareness.
3. The Montessori approach, which emphasizes independent exploration and learning through direct sensory experiences, has proven to be well-suited to the needs of children with special needs. Play activities using sensory texture boards allow children to learn in a fun, stress-free way, and at their own pace. Montessori principles such as auto-education, prepared environments, and hands-on learning contribute positively to achieving learning goals.
4. Although the majority of subjects experienced improvement, there was considerable variation in the degree of improvement achieved between individuals.

This variation was influenced by several factors, including the severity of the disorder, attendance at intervention sessions, health conditions during the study period, and individual characteristics of the child. This indicates the importance of a flexible and individualized approach to implementing interventions.

Overall, this study provides empirical evidence that Montessori-based sensory texture boards are an effective learning medium for improving sensory-motor skills in children with special needs. These findings support Ayres' sensory integration theory, which states that structured sensory stimulation can enhance the brain's ability to process and integrate sensory information, which in turn improves children's motor responses.

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