

Experimental Test of the Use of Montessori-Based Positive-Negative Educational Games on the Mathematical Connection Skills of Students with ADHD

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Abstract. The purpose of this study was to determine the mathematical connection ability of ADHD students after using the positive negative game application based on the Montessori method that has been developed. This research method is pre-experimental using the One-Shot Case Study Design research design. Based on calculations related to classical completeness, 6 students completed and 1 student did not complete the KKM for mathematics subjects set for Phase D level (equivalent to junior high school) in SLB C for students with special needs, namely a score of 65. Based on the data obtained 85.71% of students completed classically. This means that the learning media of the Positive Negative Educational Game Application Based on the Montessori Method is effective in the learning process. So, it can be concluded that the mathematical connection ability of ADHD students is completed classically after participating in learning with the Positive Negative Educational Game Application Based on the Montessori Method which is in accordance with the objectives of this study.

Keywords: educational games, positive-negative, Montessori, mathematical connection skills, ADHD.

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1. Introduction

Education is an important process in developing the potential of students, including students with special needs such as Attention Deficit Hyperactivity Disorder (ADHD). ADHD is a neurodevelopmental disorder characterized by difficulty maintaining attention, impulsivity, and hyperactivity, which can impact students' learning in the classroom, particularly in mathematics, which requires high levels of concentration and understanding of abstract concepts.

In the context of mathematics learning, students with ADHD often experience difficulty understanding concepts, connecting concepts (mathematical connections), and maintaining focus when solving problems. This is in line with research showing that students with ADHD have difficulty maintaining attention and processing learning information sustainably, resulting in poor mathematics learning outcomes (Kusmawati et al, 2024).

Mathematical connection skills are an important competency students must possess. This ability encompasses the ability to connect mathematical concepts with other concepts, both within mathematics itself and in everyday life. However, in reality, this ability remains low, especially among students with special needs, due to conventional learning methods that lack meaningful learning experiences.

Along with technological advancements, innovations in learning continue to develop, one of which is through the gamification approach. Gamification in mathematics learning has been shown to increase student motivation, attention, and engagement, particularly in students with ADHD. Recent research shows that the use of educational game-based applications can significantly improve the attention and academic performance of students with ADHD compared to conventional learning methods (Dai et al, 2025). In addition, other studies also confirm that gamification has a positive impact on increasing the concentration and learning outcomes of students with special needs in inclusive schools (Kusmawati et al, 2023).

Furthermore, the use of gamification in mathematics learning has also proven effective in improving the mathematical competence of students with ADHD, including thinking skills and conceptual understanding. This approach can create a fun and interactive learning environment, making it easier for students to understand the material (Espinoza, 2024).

On the other hand, the Montessori Method approach is also a relevant alternative in learning for students with ADHD. The Montessori Method emphasizes concrete activities, independent learning, and the use of manipulative media appropriate to student characteristics. Recent research shows that the Montessori approach can improve academic performance, learning behavior, and self-regulation in students with ADHD compared to traditional learning methods (Marius-Costel & EŞI, 2024).

The integration of gamification and the Montessori method is a potential innovation in mathematics learning. This combination not only provides a fun learning experience, but also helps students build understanding of concepts through structured and meaningful activities. Thus, the use of Montessori-based positive and negative game applications is expected to be able to optimally improve the mathematical connection abilities of students with ADHD.

Based on this description, research is needed to examine the effectiveness of using Montessori-based positive-negative game applications in improving the mathematical connection skills of students with ADHD. This research is crucial in efforts to provide adaptive, interactive learning innovations that are appropriate to the characteristics of students with special needs, particularly in mathematics learning.

2. Method

This research method is pre-experimental using the One-Shot Case Study Design. This method was used because there were no control variables and the sample was not selected randomly (Sugiyono, 2016). The sample for this study was determined using a purposive sampling technique. The variable in this study was the mathematical connection skills of students with ADHD. The following is the research design: The One-Shot Case Study Design, presented in Figure 1.

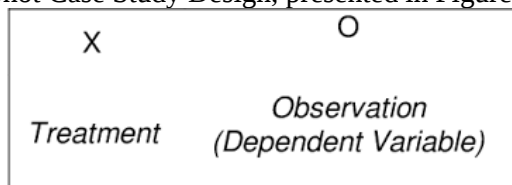


Figure 1. Research design The One-Shot Case Study Design

Based on Figure 1, students with ADHD are given learning using a positive-negative game application based on the Montessori method. Then, observations or assessments of mathematical connection skills are carried out using a mathematical connection ability test instrument. The results of the mathematical connection ability assessment are analyzed using classical completeness through

the school's KKM score, in this case SLB Dharma Asih Pontianak, which is a score of 65 for mathematics.

3. Results and Discussion

The results of the tests conducted by researchers on students with ADHD in the form of mathematical connection ability test questions for 7 students with ADHD from SLB Dharma Asih Pontianak, West Kalimantan. Based on calculations related to classical completeness, 6 students completed and 1 student did not complete the KKM for mathematics subjects set for Phase D level (equivalent to junior high school) at SLB C Tunagrahita, which is 65. Based on classical completeness data, 85.71% was obtained, indicating an effectiveness result of 85.71% with a very effective category. This means that the positive-negative game application learning media based on the Montessori method is effective for use in the classroom learning process for students with ADHD. So it can be concluded that the mathematical connection ability of students with ADHD is classically complete after being given mathematics learning with the positive-negative game application based on the Montessori method in accordance with the initial expectations in this study. The following is a display of the positive-negative game application based on the Montessori method presented in Figure 2.



Figure 2. Display of the Positive Negative Game Application Based on the Montessori Method

Mathematics learning on integer operations for eighth-grade junior high school students with ADHD was implemented using a Montessori-based positive-negative game application. Students were facilitated with gadgets as a means of the game application. The class teacher conveyed the learning objectives and then facilitated students in using the game application in the mathematics learning process in class. The implementation of mathematics learning with the Montessori-based positive-negative game application is presented in Figure 3.



Figure 3. Implementation of the Positive Negative Game Application Based on the Montessori Method at SLB C Dharma Asih Pontianak

Furthermore, in this study, the characteristics of the mathematical connection abilities of students with ADHD were analyzed and obtained, which were already in the category of 85.71% of students completing the mathematical connection ability posttest classically out of a total of 7 students who worked on the mathematical connection ability posttest questions. The process of working on the mathematical connection ability posttest questions by students with ADHD is presented in Figure 4.

Based on the results of research conducted on 7 students with ADHD at Dharma Asih Special Needs School in Pontianak, data showed that 6 students achieved mastery and 1 student did not, with a Minimum Mastery Criteria (KKM) of 65 in Phase D (equivalent to junior high school). As a class, the mastery level reached 85.71%, which is in the very effective category.

These results indicate that the use of Montessori Method-based positive-negative game applications as learning media significantly improves the mathematical connection skills of students with ADHD. This success is due to the characteristics of the Montessori approach, which emphasizes concrete activities, independent exploration, and the use of engaging and interactive media (Lillard, 2017), so that it suits the learning needs of ADHD students who tend to have a short attention span and require visual and kinesthetic stimulation.

Furthermore, integrating games into mathematics learning also has a positive impact on student motivation and engagement. Positive-negative game applications enable students to understand the concept of integer operations in a more contextual and enjoyable way. This aligns with the opinion of Piaget (1970) which states that learning will be more meaningful if students are directly involved in the process of constructing knowledge through concrete experiences.



Figure 4. Students with ADHD Completing Posttest Questions

Specifically, students' mathematical connection skills improved because they not only understood the procedures for integer operations but were also able to relate these concepts to visual representations in the game. This supports the mathematical connection theory of NCTM (2000) which emphasizes the importance of the ability to connect various mathematical concepts, as well as linking mathematics to real situations.

The learning implementation shows that teachers act as facilitators, guiding the use of the application, while students actively interact with the learning media through gadgets. This creates student-centered learning, which has been proven effective in improving learning outcomes, particularly for students with special needs.

However, there was still one student who did not achieve completion. This could be due to individual factors such as ADHD severity, differences in cognitive abilities, or lack of focus during learning. According to Barkley (2015), Students with ADHD have variations in attention and self-control abilities, thus requiring a more individualized and sustainable learning approach.

Overall, the results of this study indicate that a Montessori-based positive-negative game application is effective in improving the mathematical connection skills of students with ADHD. This finding supports previous research that suggests that the use of game-based interactive media can improve students' understanding of mathematical concepts and their engagement in learning (Mayer, 2009; Prensky, 2001). Study Susiaty et al (2026) also showed consistent results, namely that interactive media and gamification effectively increase the focus, motivation, and engagement of students with ADHD because they provide visual stimuli, short activities, and quick feedback that are appropriate

to their characteristics. Furthermore, the results of the study also showed that the implementation of HOTS-based Android gamification significantly improves higher-order thinking skills in students with ADHD (Susiatty & Lesmana, 2026).

4. Conclusion

Based on the results of research conducted on students with ADHD at SLB Dharma Asih Pontianak, it can be concluded that the use of positive negative game applications based on the Montessori Method has proven effective in improving students' mathematical connection skills. This is indicated by the classical completion rate of 85.71%, where 6 out of 7 students achieved a score above the established KKM, which is 65. This percentage is in the very effective category, so it can be stated that the learning media used is able to help students understand and connect mathematical concepts, especially in the material on integer operations.

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