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Application of Positive and Negative Board Based on Montessori Method on Junior High School Students' Mathematical Connection Abilities

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Abstrak

Tujuan dari penelitian ini adalah untuk mengetahui seberapa baik aplikasi papan positif negatif berbasis metode Montessori terhadap kemampuan koneksi matematis siswa SMP. Subjek penelitian adalah siswa di kelas VII SMP. Data dikumpulkan menggunakan teknik pengukuran dan teknik komunikasi tidak langsung. Soal tes kemampuan adalah alat pengumpul data. Berdasarkan hasil pengembangan, penelitian, dan diskusi tentang penggunaan papan positif negatif berbasis metode Montessori terhadap kemampuan koneksi matematis siswa SMP, dapat disimpulkan bahwa pengembangannya mencapai tingkat kelayakan yang sesuai dengan kriteria validitas, praktisitas, dan efektifitas.
Kata Kunci: aplikasi; koneksi matematis; metode Montessori; positif negatif.

Abstract

The aim of this research is to find out how well the positive and negative board application based on the Montessori method affects junior high school students' mathematical connection abilities. The research subjects were students in class VII of junior high school. Data was collected using measurement techniques and indirect communication techniques. Ability test questions are a data collection tool. Based on the results of development, research and discussions regarding the use of positive and negative boards based on the Montessori method on junior high school students' mathematical connection abilities, it can be concluded that the development has reached a level of feasibility that is in accordance with the criteria of validity, practicality and effectiveness.
Keywords: application; mathematical connections; Montessori method; positive negative.

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I. INTRODUCTION

Learning about integers may seem simple in elementary school, which often leads students to underestimate the importance of this material when they reach junior high school (SMP) (Tristanti, Ernawati, & Hidayati, 2021). The basic concepts of integers become a source of confusion when they encounter more complex problems at higher levels (Setiawan, Muhammad, & Soeleman, 2021). These mistakes make it difficult for junior high school students to connect and relate the material or concepts they have previously learned. The ability to make mathematical connections is crucial for linking or associating mathematical concepts (Soleha & Wulantina, 2023). Students typically can make these connections independently (Lubis, Harahap, & Nasution, 2019). Those who possess the ability to make mathematical connections can gain a broad understanding of the material that is long-lasting (Ikhsan & Afriansyah, 2023). Students who excel in this area are able to link or associate topics related to the mathematics content itself and its connections to everyday life (Puteri & Riwayati, 2017; Linda & Afriansyah, 2022).

It is essential for students to have the ability to connect mathematical concepts to one another, as this helps them solve problems and understand the importance of learning mathematics (Indriani & Noordyana, 2021; Indriani & Sritresna, 2022). Mathematical connection skills need to be well-developed to help students understand how various mathematical concepts relate to each other and how mathematics can be applied in daily life (Nuryatin & Zanthy, 2019; Mutiarani & Sofyan, 2022; Robiah & Nuraeni, 2023; Sulastri, 2023; Kosasih, Saputra, & Mutmainnah, 2023). According to Nurudini et al. (2019), mathematical connections are those that have relevance both within the context of mathematics itself and in the teaching material. The NCTM (2000) identifies three types of mathematical connections: (a) relationships between mathematical topics, (b) relationships with other disciplines, and (c) relationships with daily life.

The application of the Positive and Negative Board, based on the Montessori method, can help address students' connection problems in mathematics learning, especially in integer concepts. Gunawan (2019) mentions that Android, the newly released operating system by Google, is used in smartphones and tablets. Android applications are created using the Java programming language and the Android Software Development Kit (SDK). The SDK includes development tools such as software libraries, a debugger, a QEMU-based handset emulator, documentation, sample code, and tutorials. The Eclipse IDE officially supports the use of the Android Development Tools plugin (Adrianto & Pribadi, 2017).

Additionally, the "Positive and Negative Board" is an Android-based application that features a magnetic whiteboard as a manipulative tool, with round magnetic pieces of different colors (Ratnasari, Firdaus, & Susiaty, 2019). This manipulative tool was developed by the researchers themselves. Furthermore, an application designed based on the Montessori method, with a board containing both positive and

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negative charges, was created based on research by Susiaty et al. (2021), who developed a Montessori manipulative tool to help students with ADHD.

Mariyah et al. (2017) state that Montessori manipulatives have been used by many countries worldwide. These tools are tailored to children's developmental stages, which is a hallmark of Montessori development. The characteristics of Montessori materials include: (1) engaging, (2) graded, (3) self-correcting, (4) self-teaching, and (5) contextual (Montessori, 2002). The researcher developed an application for a positive and negative charge board based on the Montessori method to enhance the mathematical abilities of junior high school students. This application is designed for digital use as a manipulative tool with a positive and negative charge board, following the Montessori method.

This study refers to a research strategy focused on the development of innovative learning materials. One example is the Positive and Negative Board application developed based on the Montessori method, which focuses on the mathematical connection abilities of current junior high school students. Thus, the researcher aims to develop a positive and negative charge board application based on the Montessori method, focusing on enhancing the mathematical connection skills of junior high school students.

II. METHOD

This research and development (R&D) are a type of research. The application of positive-negative boards based on the Montessori method to improve middle school students' mathematical connection abilities was conducted using Thiagarajan's 4-D development model, which includes the stages of Define, Design, Develop, and Disseminate. However, this study does not include product development.

In this study, the product trial subjects were 7th-grade students selected based on their teachers' decisions. The research was conducted at SMP Koperasi Pontianak because it was the school where the researcher had previously conducted research.

Several data collection methods, including measurements and indirect communication, were used. Expert validation sheets, tests, and questionnaires were the tools used to collect data. The study examined the feasibility of the application (validity, practicality, and effectiveness) through data analysis techniques, as shown in Tables 1, 2, and 3.

Table 1.
Validation Assessment Criteria

Interval	Criteria	Description
0,81 – 0,100	Very Valid	The application is deemed worthy of use
0,61 – 0,80	Valid	The application is deemed worthy of use
0,41 – 0,60	Moderately Valid	The application is deemed worthy of use
0,21 – 0,40	Less Valid	The application is not deemed worthy of use
0 – 0,20	Very Invalid	The application is not deemed worthy of use

Modification from (Ridwan, 2012)

The positive-negative board application based on the Montessori method for

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improving students' mathematical connection abilities can be used as a teaching tool if the developed product meets the valid criteria.

Practicality data was collected from questionnaires filled out by students and teachers. The following is the analysis of practicality data:

Table 2.
Practicality Assessment Criteria

Interval	Criteria	Description
0,81 – 0,100	Very Practical	The application is deemed worthy of use
0,61 – 0,80	Practical	The application is deemed worthy of use
0,41 – 0,60	Moderately Practical	The application is deemed worthy of use
0,21 – 0,40	Less Practical	The application is not deemed worthy of use
0 – 0,20	Very Impractical	The application is not deemed worthy of use

Modification from (Ridwan, 2012)

Test results were used to determine how effectively students could connect their mathematical abilities through pre-test and post-test assessments.

Table 3.
Product Effectiveness Percentage

Interval	Effectiveness Criteria	Description
0,81 – 0,100	Very Effective	The application is deemed worthy of use
0,61 – 0,80	Effective	The application is deemed worthy of use
0,41 – 0,60	Moderately Effective	The application is deemed worthy of use
0,21 – 0,40	Less Effective	The application is not deemed worthy of use
0 – 0,20	Very Ineffective	The application is not deemed worthy of use

(Source: Riduwan, 2015)

The positive-negative board application based on the Montessori method is considered effective and can be used as a learning media in school activities if its minimum score is deemed effective. The test results showed an improvement in students' mathematical connection abilities from pre-test to post-test.

III. RESULT AND DISCUSSION

A. Result

The positive-negative board application based on the Montessori method is designed to enhance the mathematical connection skills of middle school students in this study. The Definition stage is carried out to identify the needs based on a problem analysis.

In the design stage, the product is created and adjusted to address the issues identified in the Definition stage. In the development stage, the positive-negative board application is refined through evaluation and revisions before it becomes a valid, practical, and effective product.

The positive-negative board application is validated by three experts from the mathematics education study program. Each expert serves as a content expert, media expert, and trial validator. In other words, each of the three experts and validators assess and provide recommendations on what should be improved regarding the use of the negative results board, as well as determining the construct validity of the trial. The results of

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the evaluation of the positive-negative board application are as follows:

Table 4.
Expert Evaluation Results

Expert Number	Expertise Fields	Total Score	Criteria
Expert 1	Materials and Media	0,76	Valid
Expert 2	Materials and Media	0,89	Valid
Expert 3	Materials and Media	0,76	Valid

Therefore, the validity results received an average score of 0.80 for all valid criteria. Additionally, tests validated by all experts were also considered valid for all and could only be tested in limited quantities. The researcher also created a new positive-negative board application after improving it.

SMP Bina Utama is the only school that has the same accreditation and student characteristics, which conducted a limited trial. This trial tested the positive-negative board application that had been validated. The goal was to determine the effectiveness of using this application with seventh-grade students. The sample tested consisted of six students selected by the teacher.

On the first day of the study, the researcher taught the seventh-grade students using the positive-negative board based on the Montessori approach. On the second day, the researcher and students revisited the material covered in the previous session using the positive-negative board, also based on the Montessori method. The students appeared very enthusiastic during the lesson, both in terms of receiving the material, generating ideas about the material, completing exercises as shown in the application guidebook, and working on practice problems.

On the third day, the researcher administered a response questionnaire to the teacher and all the students to assess the use of the positive-negative board. The practicality of using the positive-negative board was evaluated through this questionnaire. One class hour was given by the teacher. The questionnaires were returned after the teacher and all the students completed them. Afterward, students were given a task to complete a post-test using the previously trialed questions. This post-test was conducted to assess how effective the use of the positive-negative board was. The questions were distributed, and the students had two sessions of 40 minutes each to complete them.

The questionnaire was then calculated to determine the practicality percentage. A formula was used to calculate and compile the teacher's and students' scores. The result was 0.82, which was considered very practical. This means that the positive-negative board based on the Montessori approach is suitable for seventh-grade students.

For the post-test results, students first received their scores. These scores were then used to calculate the percentage of effectiveness of the positive-negative board. The result was 0.84, indicating that the use of the board was very effective.

The improved positive-negative board application includes (See Figure 1-8).

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Figure 1. Main Page of the Positive-Negative Board Application.

Figure 2. Menu Selection Page of the Positive-Negative Board Application.

Figure 3. Experiment 1-6 Selection Page of the Positive-Negative Board Application.

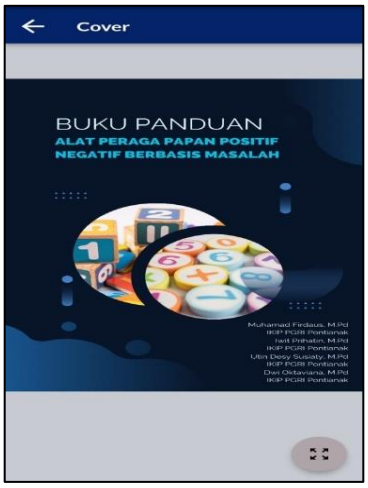

Figure 4. Guidebook Cover Page in the Positive-Negative Board Application.

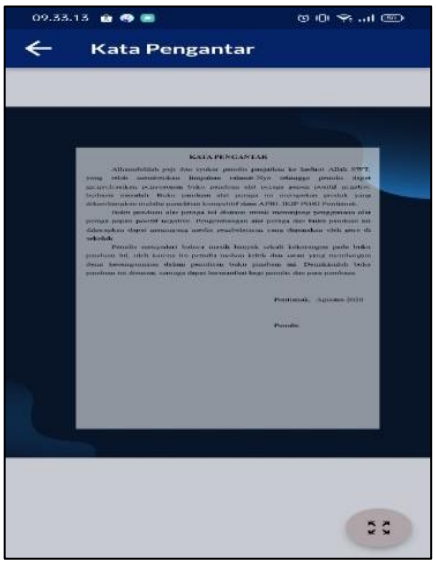

Figure 5. Guidebook Introduction Page in the Positive-Negative Board Application.

Figure 6. Table of Contents Page of the Guidebook in the Positive-Negative Board Application.

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Figure 7. Content Page of the Guidebook in the Positive-Negative Board Application.

Figure 8. Experiment Section Page in the Positive-Negative Board Application.

Due to limitations, this study did not proceed to the dissemination phase because there was insufficient time and funding. Additionally, since the researcher did not understand the Mathapp application design, they created the positive-negative board application using Microsoft Word for both the title and content, then converted it into a PDF file. Furthermore, the researcher only observed one school in this study, not an entire district or region.

B. Discussion

The positive-negative board application based on the Montessori method is designed to enhance the mathematical connection skills of these junior high school students. The 4-D Thiagarajan development model involves R&D steps such as Definition, Design, Development, and Dissemination. Based on the researcher's analysis of the students' needs and characteristics, a learning medium was created that can be used independently, can be repeated at home if there is not enough time at school, attracts students' attention, and fosters students' interest in learning. The goal of creating this medium is to improve students' mathematical connection skills, which are crucial skills to develop in school (Widiyawati, Septian, & Inayah, 2020).

The learning media created is the result of careful planning by the researcher. Moreover, this media is very feasible because it has been revised by several experts. Thus, the positive-negative board based on the Montessori method to improve junior high school students' mathematical connection skills, developed by the researcher, can be considered appropriate for use. The criteria of validity, practicality, and effectiveness were met. This indicates that the learning media created, based on valid, practical, and highly effective standards, is very reliable for producing learning media that is feasible and practical (Ayuningtyas & Sukriyah, 2020; Lamote, 2023; Masykur, Nofrizal, & Syazali, 2017; Mulyani & Anugrahana, 2023; Nasrulloh, Ibrahim, & Solihatin, 2024; Pratiwi & Silalahi, 2021; Rahman & Indrawati, 2023; Shela Jazilatul Izah & Nanang Nabhar Fakhri Auliya, 2023; Sunaryo & Bernard, 2022; Syarwa Sangila, Asran, & Ardianto, 2021; Ulfah, Tri Azizah., Wahyuni, Eva Ari., Nurtamam, 2021; Widayati & Hendroanto, 2022). Therefore,

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this media can now be used by mathematics teachers when teaching relevant topics in the future. This will increase student motivation and improve their ability to make mathematical connections, a skill that students must master (Bakhril et al., 2019; Naziah & Setyaningsih, 2024; Siagian, 2016; Widiyawati et al., 2020; Istiqomah & Nurulhaq, 2021).

IV. CONCLUSION

There are three stages in the development of the positive-negative board application based on the Montessori method for improving junior high school students' mathematical connection skills, according to the development results, discussions, and findings. The first stage is the needs and student analysis. This is conducted to identify problems and find solutions. The second stage is the design phase, which includes creating questionnaires or assessment instruments and developing the positive-negative board application. These questionnaires were created based on the elements of the 2007 BSNP. The third stage, involving validation and repeated revisions, includes testing and calculations until the final product is perfected.

The positive-negative board application based on the Montessori method for improving junior high school students' mathematical connection skills has reached a level of feasibility that includes practicality, effectiveness, and validity. The application meets the validity criteria with a valid status.

The choice of learning media aligns with the mathematics learning process, especially in achieving learning objectives related to mathematical skills, particularly mathematical connection skills. One part of the ongoing effort to support changes in digital education is the integration of digital technology with digital applications to enhance mathematical connection skills.

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