ijolii

Indonesian Journal Of Learning and instructional Innovation
Volume 3, Issue 2 (2025), pp. 73-81 |, e-ISSN: 3025-8316
https://journal.uns.ac.id/ijolii | https://doi.org/10.20961/ijolii.v3i2.2375

Theoretical Analysis of the Use of Manipulative Media in Improving Mathematical Concepts Understanding in Elementary Schools

Intan Nur Aini[1], Hanif Amrulloh[2]
[1,2]Institut Agama Islam Ma'arif NU (IAIMNU) Metro Lampung
E-mail: [1]intannraini240@gmail.com*, [2]hanifamza17@gmail.com
*Corresponding Author

Article History: Received: May 30, 2025; Accepted: December 28, 2025; Published: December 31, 2025

ABSTRACT

Mathematical concepts understanding at the elementary school level is often hampered by the abstract and lack of contextual nature of the material. This study aims to theoretically analyze the role of manipulative media in improving mathematical concept understanding and active student engagement. The method used is a literature study with a descriptive analysis approach to various academic sources from the last ten years (2015-2025). The findings indicate that manipulative media functions as a cognitive bridge that transforms abstract concepts into concrete experiences through tactile and motor interactions. The integration of manipulative media with the Problem-Based Learning (PBL) model has been shown to improve memory retention, reduce mathematical anxiety, and strengthen students' problem-solving skills. This study also highlights the transformation of manipulative media from physical to digital forms, such as GeoGebra and AI-based simulations, which offer greater flexibility in modern learning. The novelty of this article lies in the complementary synthesis of physical and digital media within the framework of Piaget's and Vygotsky's constructivist theories. The conclusion of this study emphasizes that the use of adaptive and innovative manipulative media is a primary prerequisite for creating meaningful mathematics learning at the elementary school level.

Keywords: concepts understanding**,** elementary schools**,** manipulative media, mathematics learning, Problem-Based Learning

INTRODUCTION

From a theoretical perspective, the use of manipulative media in learning aligns closely with constructivist theories, as proposed by Piaget and Vygotsky, which emphasize the importance of direct experience and social interaction in children's learning. Practically, the application of manipulative media, especially when combined with learning models such as Problem-Based Learning (PBL), can create a more active and collaborative classroom atmosphere (Dewanti et al., 2025; Muhamad et al., 2021; Setyawati et al., 2023). This is crucial considering that mathematics is a core subject taught in elementary school (SD) and Islamic elementary school (MI). The goal is to equip students with the ability to think logically, critically, analytically, and systematically in dealing with various problems (Raziana & Wibawanto, 2025; Siyamsih, 2024). However, many students still experience difficulties in understanding

mathematics due to its abstract nature. This is a big challenge for teachers in delivering material so that it is easier to understand and interesting for students (Ayyubi et al., 2025; Siregar, 2025).

One of the main factors that causes students to struggle to understand mathematical concepts is a learning approach that is too teacher-centered and lacks active student involvement (Muhamad et al., 2021; Siyamsih, 2024). Generally, learning is still conducted through theoretical or symbolic explanations without providing meaningful, hands-on experiences for students. As a result, students tend to simply memorize problem-solving steps without understanding the underlying concepts (Ayyubi et al., 2025; Nugroho et al., 2022). This clearly contradicts the goal of mathematics learning, which should be to develop thinking and reasoning skills. The weakness of this conventional method is often caused by the use of media that is not yet integrated with an appropriate learning model. However, the use of manipulative media and interactive multimedia has been proven to significantly improve students' conceptual mastery and cognitive learning outcomes (Efendi et al., 2020; Nugroho et al., 2022).

To address the challenges of thinking and reasoning skills, more interactive and concrete learning methods are needed. One approach is to utilize manipulative media. Manipulative media are learning aids that students can touch, move, and manipulate to help them understand abstract concepts more concretely (Ayyubi et al., 2025; Nugroho et al., 2022). Examples include aids such as number blocks, geometric objects, beads, and various other props relevant to the material being taught.

Keberadaan media manipulatif dalam pembelajaran matematika terbukti memberikan banyak manfaat. Selain menjadikan materi lebih mudah dipahami, media ini juga meningkatkan keterlibatan dan motivasi belajar siswa (Dewanti et al., 2025; Raziana & Wibawanto, 2025). Dengan berinteraksi langsung dengan objek konkret, siswa lebih terdorong untuk berpikir aktif, mencoba berbagai pendekatan pemecahan masalah, dan terlibat dalam diskusi kelompok. Hal ini menjadikan proses pembelajaran lebih bermakna dan menyenangkan bagi mereka.

The use of manipulative media in mathematics learning has been proven to provide numerous benefits. In addition to making the material easier to understand, this media also increases student engagement and motivation (Dewanti et al., 2025; Raziana & Wibawanto, 2025). By interacting directly with concrete objects, students are more encouraged to think actively, try various problem-solving approaches, and engage in group discussions. This makes the learning process more meaningful and enjoyable for them.

The integration of the Problem-Based Learning (PBL) model with the aid of manipulative media has proven effective in increasing active student engagement, with both independent and group participation rates reaching above 91% (Dewanti et al., 2025; Muhamad et al., 2021; Setyawati et al., 2023). Furthermore, the use of this media also plays a significant role in improving students' arithmetic operations and concrete visual understanding (Ayyubi et al., 2025; Listrianti et al., 2021; Siregar, 2025).

However, the use of manipulative media must be carried out with careful planning. Teachers need to adapt the type of media to the material being presented, pay attention to the students' developmental levels, and design activities that allow students to explore and discover concepts independently. Inappropriate or excessive use of media can actually disrupt student focus and hinder student understanding. Therefore, it is crucial for teachers to understand strategies for using media effectively (Tjandra, 2023; Siregar, 2025).

Through this study, the author aims to provide a theoretical and practical review of the use of manipulative media in mathematics learning in elementary schools. The study will cover the theoretical basis underlying the use of this media, the types of media that can be used, and effective implementation strategies in the classroom. It is hoped that this paper can serve as a reference and guide for teachers, prospective educators, and educational researchers in improving the quality of mathematics learning in elementary schools.

METHODS

This study uses a Narrative Literature Review approach to synthesize theory and empirical findings regarding the use of manipulative media in mathematics learning in elementary schools. Unlike a traditional literature review, this approach involves a critical analysis of selected literature to develop a new framework or strengthen existing theory (Siregar, 2025; Raziana & Wibawanto, 2025).

The data analyzed is secondary data collected through a systematic search of digital academic databases. The literature search strategy focused on journal articles published within the last five years (2020–2025) to ensure the relevance of the data reviewed. Articles were selected based on their direct relevance to the understanding of mathematical concepts, the Problem-Based Learning (PBL) model, and the effectiveness of manipulative media in elementary schools.

The data analysis process was conducted qualitatively using Content Analysis techniques. The analysis stages included: (1) thematic mapping based on the study focus; (2) critical comparison between empirical study results; and (3) synthesis of the results to formulate a strategy for implementing effective manipulative media in darjah rooms. The validity of the analysis is guaranteed through consistent comparisons between various literary sources that have varying contexts but have the same substantive focus.

RESULTS AND DISCUSSION

The results of a descriptive analysis of the collected literature indicate that the integration of media and learning models is key to transforming mathematics education at the elementary level. The following discussion outlines a synthesis of findings from various empirical studies to provide a comprehensive overview of the effectiveness of manipulative media.

Theory and Basic Concepts of Manipulative Media

Manipulative media are learning tools that can be directly experienced through touch, sight, and hearing, and can be utilized in the learning process. These media can be derived from simple tools or recycled materials. The use of these media allows students to construct understanding through direct sensory-motor experiences, thus facilitating the transition from abstract thinking to clear visual representations (Ayyubi et al., 2025; Nugroho et al., 2022). These media are not limited to manufactured tools but also include various objects in the surrounding environment that can be modified to suit the instructional needs of the class.

The use of manipulative media requires an appropriate approach and in-depth understanding from the teacher. The teacher's role is not only to explain but also to be able to demonstrate the use of these media effectively. Furthermore, it is important to consider the students' developmental level to ensure that the media used is truly appropriate for their thinking stage (Sucahyo et al., 2024).

These concrete media can stimulate students' thinking processes according to their ability level, thereby increasing the effectiveness of mathematics learning. The use of manipulatives also helps students build understanding through direct experience, rather than simply memorizing or abstract theories. Thus, manipulative media can bridge the gap in overcoming mathematics learning difficulties and support gradual and meaningful concept formation.

Similarly, Santrock (2022) emphasized that manipulative media must be tailored to students' knowledge levels and delivered through a concrete approach, particularly in elementary school, to facilitate student comprehension. Implementing these media has also proven effective in improving students' gross and fine motor skills through structured manipulative play activities (Dewi & Verawati, 2021).

The Influence of Manipulative Media on Mathematical Concept Understanding

Conceptual understanding is a fundamental aspect of quality mathematics learning. A student is said to have understood a concept if they can explain, apply, and illustrate the concept in various situations (Kirana & Nur, 2022). However, many elementary school students experience difficulty understanding mathematics because their understanding is too abstract and lacks context. In this case, the use of manipulative media can be an effective approach to address these difficulties and improve students' understanding of mathematical concepts through concrete, active, and enjoyable learning experiences (Akmalia et al., 2021; Ayyubi et al., 2025).

Manipulative media refers to concrete learning aids that can be used directly by students to explore mathematical concepts. By directly touching, moving, and manipulating objects, students can build understanding through real-world experiences. This approach aligns with the constructivist view, which states that students construct knowledge through active interaction with their surroundings. Manipulative media bridges the gap between abstract concepts and concrete learning experiences, making learning easier to understand, more meaningful, and more relevant to the real world students experience in their daily lives (Cahyono et al., 2024).

Various studies have shown that mathematics learning supported by manipulative media significantly improves conceptual understanding. Students who learn using concrete tools tend to more easily understand the relationships between concepts and are able to relate the material to everyday life (Sundari, 2016). Furthermore, student retention or memory of the material also improves, as concepts are acquired through a process involving the senses and motor skills. The use of interactive animation media such as Powtoon can also be combined to strengthen the visualization of concepts learned through physical media (Akmalia et al., 2021). The use of this media can also reduce anxiety in math lessons, as students feel more confident exploring concepts through hands-on activities involving the senses and movement. This allows them to focus more on the process of understanding rather than fearing mistakes. Ultimately, they are able to gradually build conceptual mastery and increase their motivation to learn in a more enjoyable and less boring environment.

The use of manipulative media has also been shown to increase students' active participation in the learning process. By engaging directly, students are encouraged to ask questions, discuss, and solve problems with their peers. In this process, the teacher acts as a facilitator, guiding and guiding students so that the concrete experiences they gain can be processed into a comprehensive understanding. Therefore, teachers need to be skilled in selecting appropriate media and adapting them to the students' cognitive developmental stage (Rahmawati et al., 2023).

Overall, manipulative media plays a significant role in helping students understand mathematics more deeply. These media not only present material in a concrete form but also foster logistical and analytical thinking skills, which are crucial in mathematics learning (Bangkirai, 2016). Therefore, the use of manipulative media should be an integral part of innovative, enjoyable, and student-centered learning strategies, particularly at the elementary/Islamic elementary school level. At this stage, students are in the concrete operational cognitive development phase, according to Piaget's theory, which requires extensive direct experience in understanding abstract concepts such as those in mathematics lessons (Noverita, 2019).

Student Engagement and Problem-Solving Skills Development

Student engagement plays a crucial role in developing critical thinking, the ability to evaluate information, and problem-solving skills. When students are actively involved in the learning process, they tend to demonstrate greater responsibility for their learning, are better able to understand context and formulate problems, and can effectively apply various problem-solving strategies. According to Fredricks, Blumenfeld, and Paris (2024), student engagement can be viewed across three main dimensions: behavioral, emotional, and cognitive engagement. Behavioral engagement is characterized by students' active participation in learning activities (Musa'ad et al., 2024). Meanwhile, emotional engagement refers to students' affective responses to teachers, classmates, and learning materials. Cognitive engagement describes students' intellectual efforts in deep thinking and the use of higher-order learning strategies. These three dimensions synergistically support the development of higher-order thinking skills, including problem-solving.

To increase student engagement while developing their problem-solving abilities, a number of learning approaches can be implemented. One approach is Problem-Based Learning (PBL), which involves students working in groups to analyze and solve real-life problems relevant to their lives (Adolph, 2016). Furthermore, the Active Learning approach is also effective because it encourages students to engage in interactive activities such as discussions, experiments, simulations, and case studies that stimulate critical thinking and problem-solving skills (Putri et al., 2024). Another approach is Project-Based Learning, which challenges students to complete real-life projects collaboratively, creatively, and innovatively, while simultaneously seeking solutions to complex problems. Cooperative learning models such as mind mapping can also be integrated with manipulative media to help students organize their conceptual understanding systematically (Rahmawati et al., 2023). Overall, these approaches not only increase student engagement in the learning process but also strengthen problem-solving skills, which are crucial for facing real-world challenges.

Analysis of Problem-Based Learning with Manipulative Media

Problem-Based Learning (PBL) is an instructional approach that emphasizes student active participation in solving real-life problems. In this model, students act as the primary subjects of learning, exploring, investigating, and discussing to find solutions. PBL encourages collaboration among students and fosters critical and analytical thinking skills, as students not only receive material but also construct their knowledge through the problem-solving process (Hidayat, 2022).

Meanwhile, Manipulative media refers to learning aids that students can touch and operate directly, such as blocks, concrete objects, or three-dimensional visual models. These media serve to facilitate the understanding of abstract concepts in a more tangible way, especially for elementary to secondary students.

When the PBL approach is implemented with manipulative media, the learning process becomes more lively and effective. Through physical and visual activities with aids, students not only utilize cognitive abilities to solve problems but also develop their motor and sensory aspects. The use of this media also increases student engagement from an emotional, behavioral, and mental perspective, as they actively interact, experiment, and evaluate various alternative problem-solving approaches. Collaboration and reflection are also important parts of their learning experience.

Addressing the need for practical guidance, the following is a concrete example of teaching the concept of "Fractions" using PBL and Manipulative Media (Dewanti et al., 2025; Nugroho et al., 2022): (1) Problem Orientation: The teacher presents a problem involving dividing martabak (a type of pancake) into four equal parts; (2) Learning Organization: Students are given a

manipulative media, a "fraction plate" or circular origami paper; (3) Investigation: Students physically cut the media into four equal parts to find the value of ¼; (4) Result Development: Students attach the pieces to the board and explain their relationship to the numerator and denominator; and (5) Evaluation: The teacher reinforces the concept that fractions are part of a whole, based on the students' physical experiences.

However, implementing PBL with manipulative media presents several challenges. Structured planning, adequate tools, and teacher competence in managing open and flexible learning are required. Furthermore, because these activities often require more time, efficient time management is crucial. Nevertheless, numerous studies have shown that the combination of PBL and manipulative media has a positive impact on students' conceptual understanding, critical thinking skills, and learning motivation (Adar Bakhsh Baloch, 2017).

The Role of Technology in the Use of Manipulative Media

Technology plays a significant role in developing and enhancing the use of manipulative media in learning activities. With the advancement of the digital world, manipulative media now takes the form of not only physical tools such as blocks or real objects, but has also evolved into virtual manipulative media that can be operated through digital devices such as computers, tablets, and smartphones (Utami, 2022).

Technological advancements have transformed manipulative media from physical to digital, enabling students to learn abstract concepts in a more interactive and flexible way (Aboraya, 2021). In mathematics learning, for example, students can utilize platforms like GeoGebra or the Math Learning Center to dynamically explore topics such as geometry, algebra, and statistics (Widianita, 2023). These digital manipulative media not only mimic the experience of using physical tools but also include additional features such as animation, visual changes, and simulations, making learning more engaging. The use of software like GeoGebra has proven effective in transforming abstract objects into interactive visual representations (Siregar, 2025). Students can freely set parameters, observe results directly, and explore various solutions, thus increasing their engagement and motivation to learn.

On the other hand, digital manipulative media excels in accessibility and flexibility. Students can access them anytime and anywhere, supporting both online and blended learning. Features such as screen readers, display magnification, and touch controls also help students with special needs learn more inclusively (Tjandra, 2023). This technology also supports collaborative learning; students can collaborate online on problem-based tasks using digital manipulatives, even from different locations.

It is important to note that physical and digital manipulative media are complementary in the context of PBL. Physical media build students' early sensory intuition through tactile manipulation, while digital media expands these physical boundaries through dynamic simulations that enable limitless exploration (Siregar, 2025). However, in rural elementary schools in Indonesia, infrastructure challenges such as weak internet signals and limited device availability remain major barriers to the implementation of digital media (Tjandra, 2023). Therefore, teachers in rural areas are encouraged to be more creative in developing manipulative media from natural or recycled materials as a practical solution.

For educators, the use of digital manipulative media is very helpful in the learning planning and evaluation process. Many applications already provide automatic data on student activity, such as recordings of interactions, levels of difficulty encountered, and student-chosen problem-solving strategies (Hutauruk et al., 2022). Furthermore, the development of artificial intelligence (AI)-based manipulative tools in the future (2024-2025) is predicted to provide more personalized, adaptive feedback tailored to each student's learning patterns (Raziana & Wibawanto, 2025; Siregar, 2025).

The novelty of this study lies in the integrative synthesis of the PBL model, the use of physical manipulative media, and the transformation to AI-based digital media within a unified theoretical framework. Unlike previous studies that focused solely on one aspect, this article emphasizes the complementary relationship between physical tactile experiences and digital exploration to address the cognitive challenges of elementary school students. Furthermore, this study provides specific solutions to educational challenges in rural areas by emphasizing the adaptation of local media, supported by robust theoretical analysis (Levitskaya & Fedorov, 2021).

Future research should further explore the effectiveness of using Augmented Reality (AR) as a bridge between physical and digital manipulative media in real-time in the classroom. Furthermore, broader field experiments are needed to test the adaptation model of manipulative media in areas with technological limitations to ensure equitable distribution of the quality of mathematics learning across Indonesia. Evaluating teachers' digital competence in operating AI-based manipulative media is also a crucial area that requires further in-depth study.

CONCLUSION

The use of manipulative media in mathematics learning at the elementary school level has been proven to significantly improve student conceptual understanding, engagement, and critical thinking and problem-solving skills. The abstract nature of mathematics often presents a barrier for students, especially when conventional learning methods are used with minimal interaction. Manipulative media, both physical and digital, bridge this gap by providing concrete, contextual, and enjoyable learning experiences. The use of technology also expands access and effectiveness of manipulative media, particularly in the context of digital and inclusive learning.

However, the effectiveness of manipulative media utilization depends heavily on careful planning, appropriate media selection, and the teacher's ability to facilitate the learning process. Therefore, teachers need to have a good understanding of student characteristics, learning materials, and innovative learning strategies. With the support of the right approach and optimal use of technology, manipulative media can be a strategic solution to improve the quality of mathematics learning in elementary schools in a holistic and sustainable manner.

CONFLICT OF INTEREST

No conflict of interest for this study.

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