

## EFFECTIVENESS OF USING MANIPULATIVES IN MATHEMATICS TEACHING IN INCLUSIVE EDUCATION PROGRAMS IN AN ELEMENTARY SCHOOL

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### Abtrak

Penggunaan manipulatif dalam pendidikan matematika terbukti efektif dalam meningkatkan pemahaman konsep matematika siswa dan keterlibatan dalam proses pembelajaran. Pendidikan inklusif bertujuan untuk menciptakan ruang kelas yang dapat diakses oleh semua siswa, tanpa memandang kemampuan atau kecacatan mereka. Dalam konteks ini, manipulatif dapat memainkan peran penting dalam membantu siswa dengan kebutuhan khusus, seperti mereka yang memiliki ketidakmampuan belajar atau ketidakmampuan fisik, untuk memahami konsep matematika dan terlibat dengan mata pelajaran tersebut. Namun, penggunaan manipulatif dalam pengajaran matematika juga dapat menimbulkan tantangan, seperti biaya, penyimpanan, pemeliharaan, dan pelatihan yang tidak memadai. Abstrak ini merangkum manfaat dan tantangan penggunaan manipulatif dalam pengajaran matematika untuk program inklusif, menyoroti pentingnya mempertimbangkan penggunaan manipulatif dalam pendidikan matematika inklusif dan kebutuhan akan sumber daya dan pelatihan yang memadai untuk mendukung penerapannya yang efektif.

**Kata Kunci:** Manipulatif, Matematika, Inklusif

### Abstract

The use of manipulatives in mathematics education has proven effective in increasing students' understanding of mathematical concepts and involvement in the learning process. Inclusive education aims to create classrooms that are accessible to all students, regardless of their abilities or disabilities. In this context, manipulatives can play an important role in helping students with special needs, such as those with learning disabilities or physical disabilities, to understand mathematical concepts and engage with the subject. However, the use of manipulatives in mathematics teaching can also pose challenges, such as inadequate cost, storage, maintenance, and training. This abstract summarizes the benefits and challenges of using manipulatives in mathematics teaching for inclusive programs, highlighting the importance of considering the use of manipulatives in inclusive mathematics education and the need for adequate resources and training to support their effective application.

**Keywords :** *Manipulative, Mathematics, Inclusive*

## Introduction

Mathematics is a very important subject in everyday life and helps lay the foundation for higher thinking skills. In recent years, the concept of inclusive education has become a popular topic in the field of education, focusing on creating classrooms that are welcoming and accessible to all learners, regardless of ability or deficiency (Yang et al., 2017 ). In integrated classrooms, students with special needs can learn with their peers who are physically healthy and they can use educational programs that have been adapted to the needs of all students (Zabir, 2018). This particular approach requires educators to have a deep understanding of their students and use different teaching strategies to help them learn. One such strategy is to use manipulatives which involve physical objects that can be manipulated by each learner to help them visualize and understand mathematical concepts. This paper discusses the effectiveness of using manipulative tools in mathematics education in inclusion programs, with a special focus on benefits for students with special needs (Watt-Douglas & George, 2021).

Manipulatives are a widely used tool in math classes and support students' conceptual understanding of math content (Karten & Murawski, 2020). The use of manipulative tools helps students provide real visual representations of mathematical concepts that can increase their understanding and absorption of abstract ideas. Many educational experts and researchers agree that the use of manipulatives in mathematics class can have a positive impact on student learning, especially for students with special needs and joining inclusive programs. Manipulation also encourages active learning and problem-solving, which can improve students' critical thinking skills and independent learning (Muammar & Suhartina, 2018).

In addition, manipulatives can support the learning of students with different learning styles, for example how to learn from a visual learner or kinesthetic learner. The use of manipulatives has been shown to increase students' understanding of math concepts, increase their engagement, and strengthen their problem-solving skills. Inclusive programs are designed to provide a safe and supportive learning environment for students with diverse abilities and learning styles, and the use of manipulative tools can play an important role in supporting these learners.

Different teaching methods in teaching mathematical concepts according to the level of success. These methods are "transmitting" and "interactive" approaches, and studies have shown that "interactive" approaches are more effective than "transmitting" approaches. Research has shown that the use of manipulative tools can have a positive impact on students' math performance, especially among students in inclusion programs. For example, one study found that students who used manipulatives in math class performed better than their peers who did not use manipulatives (Bouck et al., 2020) .

According to UNESCO, "Inclusive education is the process of strengthening the capacity of the education system to reach all students and provide them with quality education without discrimination. Inclusive education means that all students attend neighborhood schools and are accepted into neighborhood schools, receive regular, age-appropriate classes, and are supported to learn, participate and participate in all areas of school life (Osana & Duponsel, 2016) . Inclusive education is an educational approach that aims to ensure that all students, regardless of background, abilities, or deficiencies, have equal opportunities to learn and excel in the same class. Inclusive education is more than inclusion, but the integration of students with disabilities into existing classrooms without changing the curriculum, teaching methods, or support structures.

Inclusive education values diversity and promotes respect for all students, regardless of background or ability. The aim is to provide the necessary facilities, resources, and support for students with disabilities to learn alongside their able-bodied peers. Inclusive education is not only beneficial for persons with disabilities themselves, but also for students with disabilities who are seeking to develop valuable skills and attitudes such as empathy, teamwork and problem-solving. These things are very necessary when interacting with peers who have special needs.

Manipulatives are a widely used tool in mathematics education to support students' conceptual understanding of the content (Ikawati & Kowiyah, 2021) . Manipulatives are objects that assist students in understanding mathematical concepts by providing concrete representations of abstract ideas. These objects can be concrete or abstract in nature, ranging from simple objects such as blocks, patterns, and rows of numbers to more complex objects such as geometric shapes, diagrams, and graphs. Manipulatives allow students to further explore and experiment with mathematical concepts, thereby making learning more interactive and interesting.

For students with special needs, manipulatives can provide additional uses. Manipulatives are common tools for students with special needs, and evidence shows that manipulatives can increase students' attention and involvement in mathematical activities (Sezuni, 2022). Researchers have found that the manipulatives presented in a step-by-step framework are evidence-based practices for learners with specific learning disabilities and are effective in common use across disability groups and are presented in accordance with the recommendations of the Individuals with Disabilities Education Act (Lehr et al. , 2009). Peltier et al. (2018) suggest, based on the results from the literature regarding the influence of existing manipulative research, that educators should use manipulative methods on students with special needs both in terms of the type or format of the manipulative (for example, concrete or virtual) failing to be a problem in terms of the benefits received learners. By providing concrete representations of abstract ideas in mathematics, it is hoped that manipulatives can support the learning process of students, especially those with special needs.

Based on several definitions of manipulative from the experts above, the researcher concludes that manipulative is a physical or digital tool used in education, especially in mathematics lessons to help students understand mathematical concepts by enabling them to manipulate and explore mathematical objects in a concrete and real way. These tools can be blocks, patterns, and number lines or more complex geometric shapes, graphs, charts, and interactive software. The use of manipulatives has shown an increase in students' conceptual understanding, encourages active learning, supports different learning styles, improves problem-solving skills, and supports inclusive education (Rosita et al., 2018). Therefore, it can be concluded that manipulatives provide opportunities for students to explore and experiment with mathematical concepts and make the learning process more interactive and interesting.

**Increase Conceptual Understanding:** Manipulatives help learners to better understand mathematical concepts and processes by providing visual and concrete representations of mathematical ideas. For example, students can use blocks to understand multiplication and division, number lines to understand addition and subtraction, and patterns to understand fractions. By providing real representations of abstract ideas, students can better understand the underlying concepts and make learning more meaningful and effective (Bela et al., 2018).

**Encourage Active Learning:** Manipulatives provide learners with the opportunity to be actively engaged in learning at their own pace. As a substitute for a learning method that passively listens to the teacher, students can use manipulatives to explore, experiment, and understand mathematical concepts. This hands-on learning approach can help students internalize mathematical ideas and increase their motivation to learn (Alisa et al., 2022) .

**Supporting Different Learning Styles:** Each student has a different learning style, and manipulatives can help meet the needs of diverse groups of students (Asnawati et al., 2019) . For example, students who are visual learners can benefit from manipulatives that provide visual representations of mathematical concepts. Meanwhile, students who are kinesthetic learners can benefit from manipulatives that allow them to physically manipulate mathematical objects (Ardina et al., 2019) .

**Improve Problem-Solving Skills:** Manipulatives can help learners to develop their problem-solving skills by providing opportunities for exploration and experimentation. For example, students

can use blocks to model real-world problems and find solutions. By being actively involved in problem-solving activities, students can improve their ability to think critically and independently (Anawati, 2020) .

**Supporting Inclusive Education:** Manipulatives are especially beneficial for students in inclusive programs, where students with diverse abilities and learning styles are taught in the same class. By providing concrete representations of mathematical concepts, manipulatives can help support the learning of students who may struggle with abstract ideas (Syamsuddin, 2018) .

Based on the opinions of the experts above, the authors conclude that there are many advantages, especially for inclusive education programs. Manipulatives provide concrete representations of abstract mathematical concepts, promote active engagement, support different learning styles, and can lead to an increased understanding of the mathematics (Latifah et al., 2021) . By using manipulatives, educators can provide equal educational opportunities for all students and support the development of their love for mathematics. Despite the many advantages of using manipulatives in teaching mathematics, there are also some challenges that need to be considered (Amelia et al., 2022) .

1. **Cost:** One of the biggest challenges of using manipulatives is cost. Manipulatives can be expensive, especially for schools with limited budgets. Manipulative purchasing costs can be prohibitive, especially for schools in low-income areas.
2. **Storage:** Another challenge is storage. Manipulatives come in all sizes and shapes and are difficult to store when not in use. This can be especially challenging for schools with limited space.
3. **Limited Availability:** Manipulative availability can also be a challenge. Schools may have difficulty finding the right manipulatives for their teaching concepts. In some cases, manipulatives may not be available for purchase or must be ordered in advance.
4. **Teacher Training:** Another challenge is teacher training. Teachers need to be trained on how to effectively use manipulatives in the classroom. This takes time, effort, and resources. Teachers also need to understand how to use manipulatives in ways that support inclusive education.
5. **Resistance from Students:** Some students may resist using manipulatives in class. For example, students may find manipulatives too childish or may feel that manipulatives are not necessary for their learning. Teachers must be able to deal with this problem effectively and involve students in using manipulatives.
6. **Cultural Differences:** Manipulatives may also have cultural differences. For example, some manipulatives may not be culturally appropriate for certain groups of students. Teachers need to be aware of these cultural differences and ensure that manipulatives are used in a culturally sensitive way.
7. **Inadequate Implementation:** Finally, manipulatives may not be used effectively in the classroom. Teachers may not use manipulatives in ways that encourage active and engaged learning, nor may they use them in ways that support inclusive education.

There are several indicators that can be used to assess the effectiveness of using manipulatives in learning mathematics for inclusion programs. These indicators can help educators understand how well students engage with manipulatives and whether they effectively support students in developing their math skills and understanding (Wondo & Meke, 2021). Some of the main indicators include:

1. **Student Engagement:** Observing the level of student involvement and interest in the use of manipulatives can be a key indicator of the effectiveness of the use of manipulatives. High levels of involvement and enthusiasm indicate that students are actively involved in the learning process and find manipulatives helpful in their understanding of mathematical concepts.
2. **Mathematical Understanding:** Assessing students' understanding of math concepts before and after using manipulatives can be a useful way of determining the impact of

manipulatives on individual students' learning. For example, pre and post-tests can be used to determine changes in students' mathematical abilities from time to time.

3. **Problem-Solving Skills:** Observing students' ability to use manipulatives to solve mathematical problems and work on complex concepts can be an indicator of the effectiveness of using manipulatives. Students who are able to use manipulatives to solve problems and understand mathematical concepts tend to be more confident and capable in their mathematical abilities.
4. **Inclusiveness:** Measuring the level of inclusivity in the classroom and ensuring that manipulatives are accessible and used for all learners, regardless of ability or disability, can be an important indicator of the effectiveness of using manipulatives in inclusive programs.
5. **Student Feedback:** Gathering student feedback on their experiences with manipulatives can provide valuable insight into their perceptions of the usefulness of manipulatives in their mathematics learning.

## **Method**

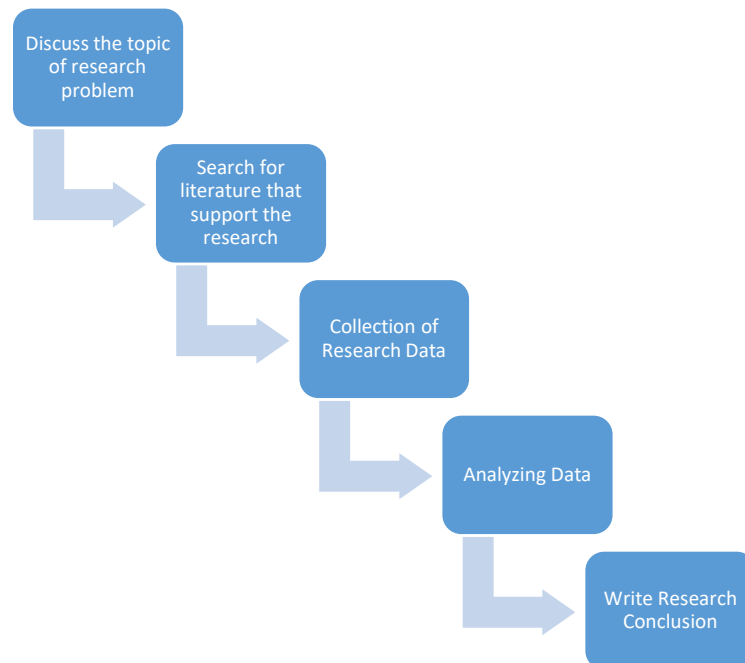
This study used a survey and interview research design to explore the effectiveness of using manipulatives in learning mathematics in inclusive education programs in elementary schools. This research was conducted at an international school in Jakarta. The researcher is one of the homeroom teachers and started implementing inclusion as a teaching and learning strategy in classroom practice. Data was collected through interviews with educators and observations of math classes using manipulatives (Marsinah et al., 2019).

Researchers designed a self-prepared questionnaire. The questions are designed in a Likert scale format. Self-written questionnaires and interviews were conducted with other homeroom teachers in the schools where the researcher taught with the aim of obtaining more data about implementation and strategies and how inclusion is implemented in classroom practice. The total number of homeroom teachers interviewed at this international school was 10 (6 girls, 4 boys) in the Basic Education Program (PYP) at an international school in Jakarta.

The guiding questions in the survey focused on the status of inclusion programs, the importance of implementing inclusion programs, school support, and explanations for their application in mathematics. In addition, educators were also given questions about the inclusion program implemented in the school. This study focuses on three research questions:

1. What inclusion activities are used in class?
2. How ready are the homeroom teachers to teach in an inclusive learner environment?
3. How do educators deal with the class if there are students with special learning needs?
4. How do educators use manipulatives in teaching mathematics?
5. What are the benefits of using manipulatives in learning mathematics for inclusive education programs?
6. What are the challenges of using manipulatives in learning mathematics for inclusive education programs?

There are several limitations in this research. First, the population is limited to homeroom teachers only. Second, the questions that are targeted only focus on Mathematics, so modifications are needed for other subjects if you want to replicate this research. The research method will be explained in the flowchart below:



**Figure 1. Research method**

## Results and Discussion

This study found that teachers use manipulatives in a variety of ways, including introducing new concepts, reinforcing learning, and providing hands-on activities (Aryanti et al., 2022) . The use of manipulatives turns out to have several benefits, including increasing students' understanding of mathematical concepts, increasing student involvement in the learning process, and supporting the inclusion of students with diverse learning needs (Apriana et al., 2020) . However, teachers also face several challenges in using manipulatives, including limited resources and training, difficulty adapting manipulatives for different learning needs, and time constraints (Murni et al., 2022) .

**Table 1. Results of Research Analysis**

No.	Statement	Percentages			
		0-25%	25-50%	50-75%	75-100%
1	How engaged do you feel when using manipulatives in your math class?			2	8
2	Have you noticed any differences when teaching mathematical concepts using manipulatives versus other learning methods?			3	7
3	Has/have the student(s) ever received any special support? Explain shortly, please.			3	7
4	Are there any written reports done on the child's special education needs? Write a short explanation, please.			2	8
5	Do you think that the use of manipulatives impacts your students' ability to retain and recall mathematical concepts?			2	8
6	Do you feel that the use of manipulatives in math class has helped to make mathematical concepts more accessible for students with disabilities or disabilities?			3	7

7	Have you noticed any differences in your students' ability to solve math problems before and after using manipulatives in class?	1	1	8
8	Do you think that the use of manipulatives impacts your students' problem-solving skills in math?		4	6
9	How inclusive do you feel your math classroom is for students of disabilities or disabilities?	1	3	6
10	Do you think that the use of manipulatives can benefit students from diverse backgrounds in math class?		2	8
11	Do you think that manipulatives can be improved or modified to better aid your students' understanding of mathematical concepts?		2	8
12	Have you noticed any differences in your ability to explain mathematical concepts to your students since the introduction of manipulatives in class?		3	7

The data above reflects responses to various questions related to the use of manipulatives in math classes and their impact on students' learning and inclusivity.

1. Engagement with Manipulatives: A majority of respondents (75-100%) reported feeling engaged when using manipulatives in their math class.
2. Differences in Teaching Mathematical Concepts: Most respondents (50-75% and 75-100%) noticed differences when teaching mathematical concepts using manipulatives compared to other learning methods.
3. Special Support for Students: The majority of respondents (50-75% and 75-100%) indicated that students have received special support in their classrooms.
4. Written Reports on Special Education Needs: A large portion of respondents (75-100%) reported having written reports on the special education needs of students.
5. Impact on Retaining and Recalling Mathematical Concepts: The majority of respondents (75-100%) believed that the use of manipulatives impacted students' ability to retain and recall mathematical concepts.
6. Accessibility for Students with Disabilities: Most respondents (50-75% and 75-100%) felt that the use of manipulatives made mathematical concepts more accessible for students with disabilities or disabilities.
7. Differences in Problem-Solving Skills: There were mixed responses regarding the impact of manipulatives on students' ability to solve math problems, with a few respondents reporting noticeable differences (25-50% and 75-100%).
8. Impact on Problem-Solving Skills: A majority of respondents (50-75% and 75-100%) believed that manipulatives positively impacted their students' problem-solving skills in math.
9. Inclusivity in Math Classroom: Respondents had varying perceptions of inclusivity in their math classrooms for students of different abilities or disabilities, with a mix of responses across the percentage range.
10. Benefit for Students from Diverse Backgrounds: Most respondents (75-100%) believed that manipulatives could benefit students from diverse backgrounds in math class.
11. Improvements to Manipulatives: The majority of respondents (75-100%) agreed that manipulatives could be improved or modified to better aid in students' understanding of mathematical concepts.

12. Differences in Explaining Mathematical Concepts: Most respondents (50-75% and 75-100%) noticed differences in their ability to explain mathematical concepts to students since the introduction of manipulatives in class.

From the results of the questionnaire, we can conclude that the use of manipulatives was seen as engaging, effective in teaching mathematical concepts, and beneficial for students with disabilities. However, opinions on their impact on problem-solving skills and varied inclusivity. There was a consensus on the potential for improvements to manipulatives to enhance students' understanding, and overall, respondents reported positive changes in their teaching since incorporating manipulatives.

## Discussion

For this article, the researcher also conducted interviews with class teachers about inclusive education in schools. Based on the responses, some signs of learning difficulties were observed in the students. Some students need frequent guidance when completing assignments on their own. There are also examples of learning disabilities associated with low self-esteem. Difficulty staying focused is also a common problem for students. In particular, some students find it difficult to understand and solve word problems that require both math and reading skills. Limited attention span during the study, poor reading comprehension, and difficulty deciphering words are also evident. In addition, some students lack fluent reading and writing, and concentration. In addition, some students face the challenge of mental processing math problems and multi-step operations.

When asked about their specific educational needs, the researcher received a wide variety of responses. The student is currently unable to read due to special needs. Some students are struggling to work independently and need support. One of her respondents mentioned the need for face-to-face contact and suggested the possibility of an Individualized Education Program (IEP) to support students. Language issues were identified as particularly necessary as students who are not fluent in the language of instruction have difficulty understanding mathematical vocabulary and concepts. Another respondent highlighted the importance of social cues, emotional management, attention span, and related questions as specific educational needs. In some cases, the educational needs of students were uncertain or unrecognized due to parents' refusal to seek professional evaluation and lack of formal professional diagnosis. Finally, students receive additional support from teachers during math time and are grouped with lower ability students during math rotations.

Regarding the special support received by the students, several forms of assistance were mentioned. One student receives one-on-one pull-out sessions with an LST (Learning Support Teacher). Another student benefits from guidance and counseling services, which provide advice and temporary remedies. Some students participate in special sessions or therapy to address their specific needs. Teachers offer modifications, specialized instructions, and differentiated activities to support students in overcoming obstacles. In one case, a co-teacher provides one-on-one teaching. Buddy support, where a student is paired with an advanced student, is also utilized. Teachers provide different tasks and additional materials to assist specific students. Additionally, some students receive help from the SST (Student Support Team) during math lessons, with the SST teacher offering scaffolding support. However, it should be noted that not all students have received special support according to the responses received.

Based on your responses, various written reports will be produced regarding your child's special educational needs. Some students write reports showing progress but still fall short of class-level expectations. One interviewee said he received a written report from a psychologist who was part of the guidance counselor's support team. Another report refers to the assessment of language impairment. In some cases, the written report includes anecdotes, counselor observations, and school-provided report card comments. Therapists provided detailed reports highlighting student improvement and increased independence. However, in some cases no written report was mentioned or presented. Written reports often contain the student's learning goals and are usually prepared by counselors to provide parents for further action and discussion. In one case, there was no discussion or reporting specifically focused on mathematics, but the student's need for additional support, slow pace of learning, and difficulties with



quick thinking and memory were noted.

Responses varied when it came to independent assessments and reports conducted by educational psychologists and other professionals for physical, emotional and academic reasons. Some students undergo surveys and assessments that reveal conditions such as dyslexia or other specific needs. These students often receive one-on-one instructions to address their individual needs. In some cases, parents actively support their child's needs and seek professional evaluation. Suggestions are made to support students in the classroom environment. Independent assessment is usually recommended for young children who are struggling in various areas such as listening, speaking, reading, writing and dealing with emotions. However, in some cases, no independent assessments or reports were included. Some respondents were aware of the possibility of receiving such evaluations but had never met a student who received such evaluations. The presence or absence of independent assessment varied, with some students benefiting from it and others with no additional learning disabilities beyond their known range.

Responses varied when it came to independent assessments and reports conducted by educational psychologists and other professionals for physical, emotional and academic reasons. Surveys and assessments have revealed that some students have conditions like dyslexia or other specific needs. These students often receive one-on-one instructions to address their individual needs. In some cases, parents actively support their child's needs and seek professional evaluation. Suggestions are made to support students in the classroom environment. Independent assessment is usually recommended for young children who are struggling in various areas such as listening, speaking, reading, writing and dealing with emotions. However, in some cases, no independent assessments or reports were included. Some respondents were aware of the possibility of receiving such evaluations but had never met a student who received such evaluations. Overall, the presence or absence of independent assessment is varied, with some students benefiting from it and others with no additional learning disabilities beyond what is known.

## **Conclusion**

The findings of this study indicate that the use of manipulatives in mathematics learning can be effective in supporting the learning and inclusion of students with diverse needs. However, teachers need to be provided with sufficient resources and training to use manipulatives effectively, and they need to be able to adapt manipulatives to meet the needs of different learners. Further research is needed to explore the long-term impact of manipulatives on student learning and engagement in mathematics classrooms. The use of manipulative tools in mathematics lessons has several advantages for students with special needs, especially students with learning difficulties or physical disabilities.

Here are some of the main benefits of using manipulatives:

- **Improved Comprehension:** Manipulations provide concrete representations of abstract mathematical concepts that can help students with special needs better understand mathematical concepts and deepen their understanding of the subject. This can be especially helpful for students with learning disabilities who struggle with abstract concepts.
- **Increased engagement:** The use of manipulation can be an interesting and interactive way of learning mathematics for students with special needs. By physically manipulating objects, students actively participate in the learning process, which can increase their motivation and engagement.
- **Improved problem-solving skills:** Manipulation can also be used to help students with special needs develop their problem-solving skills. By experimenting with different solutions, students can improve their critical thinking and problem-solving skills, which are important for success in math and other subjects.
- **Accessibility:** For students with physical disabilities, manipulation can provide opportunities to participate in math classes that may not be possible with traditional methods. The course allows students to approach mathematical concepts in a way that suits them, thereby increasing their ability to approach the subject.

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