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A Systematic Literature Review: How Mastery of Whole Number Concepts Develops Students' Problem-Solving Skills

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Abstract

Conceptual difficulties and visual representation barriers are often major challenges in learning integers, especially related to understanding negative numbers and mathematical operations such as addition and subtraction. This study aims to identify the problems faced by students in learning integers, evaluate the effectiveness of various teaching methods, and propose innovative approaches to improve students' understanding. The methodology used is a systematic review based on Systematic Literature Review (SLR), by analyzing relevant research articles using PRISMA guidelines. This study examines various learning strategies, such as the use of realistic contexts, innovative visual models, manipulatives, and interactive technology. The results showed that a real-world context- based approach and the use of visual models can significantly improve students' understanding compared to conventional methods. Students who engaged in manipulative-based learning and class discussions also showed better mathematical thinking flexibility. These findings highlight the need for further exploration of the use of real contexts, more innovative visual models, and the application of gamification technology in integer learning. In conclusion, integer learning requires a more innovative approach by integrating realistic contexts, new visual models, and interactive technology. This not only increases student engagement but also supports the development of conceptual and procedural abilities more effectively.

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INTRODUCTION

Mathematics is a science that acts as a link for various other fields of knowledge. The integrity of the concept and the importance of the discipline of mathematics have contributed greatly to the development of science and technology in the current era. (Arwanto et al., 2019) . Various scientific papers have examined the nature and importance of mathematics (*Courant, Robbins, Herbert 1996)* ,) ; (Putwain et al., 2021) , (Gravemeijer et al., 2017) (Laurens et al., 2018) . Several of these articles have discussed the importance of mathematics in various fields of science as well as in everyday life. NCTM has set 5 material standards in mathematics, namely numbers and operations, algebra, geometry, measurement, data analysis and probability (Joung & Byun, 2021) . Mastery of numbers or figures plays a very important role in decision making and solving everyday problems .

(Mitchell, 2001) (Keeley, 2015)

Curriculum Focal Points (2006) recommends that preschoolers begin building an understanding of whole numbers. (Walle et al., 2020) Integers are important to teach to students because understanding them can help them solve various problems they face in everyday life. (Musser, 2007) . Historically, integers were indicated by numbers using a positive sign (+), zero (0) and numbers using a negative sign (-). (Merdekawati, 2022) , (Kilpatrick, Swafford, Findell, 2017) (Muliyah, Aminatun, Nasution, Hastomo, Sitepu, 2020) The integer meaning framework can help teachers build specific content knowledge (SCK) to teach integers, moving from state meaning to change meaning and formal models to context (S. Kumar et al., 2017) . One of the concepts of numbers is integer arithmetic operations (Fouryza et al., 2019). Integer operations are essential in computer arithmetic, with multiplication as a crucial operation. (Dwivedi, 2013) (S. Kumar et al., 2017) . Integer operations refer to the ability to perform single-digit or multidigit addition, subtraction, multiplication, and division (Peng et al., 2016)

In elementary school, students work a lot with counting. Booker also stated that children generally tend to make mistakes when faced with problems in learning mathematics, including in solving integer problems (Sovia & Herman, 2019) (Fouryza et al., 2019) (Musser, 2007) . Students' difficulties in learning integer arithmetic operations often arise because of their lack of understanding of the abstract concepts of negative and positive numbers and the change from whole numbers to negative integers (Bofferding & Wessman-Enzinger, 2017) . Students often experience confusion when they have to connect concrete experiences with the concept of negative numbers, which cannot be seen or felt in everyday life (Bofferding, 2014) . The *Conceptual Change* theory explains that students have prejudices or wrong initial concepts about integers, especially regarding the subtraction and addition operations of negative numbers. (Vlassis, 2008) (Vosniadou, S. 2013). (Lewis et al., 2020) This concept must be reconstructed through meaningful learning so that they can understand the role of negative numbers in arithmetic operations. (Skemp , 1976) distinguishes between "instrumental understanding" (procedural understanding) and "relational understanding" (conceptual understanding). Conceptual understanding of integers allows students to not only follow the rules of operations, but also understand the reasons behind the operations. This relational understanding is important in the curriculum because it supports meaningful and ongoing learning.

Learning barriers can also occur due to a lack of balanced conceptual and procedural understanding. Students may be able to follow rules or procedures for integer operations, but fail to understand the meaning behind those procedures, resulting in difficulties when they are confronted with more complex problems (Rittle-Johnson & Schneider, 2014) . Factors such as the use of visual strategies such as number lines or real-world contexts have been shown to help reduce these difficulties, as noted by Thompson and Dreyfus (2016), who found that visual approaches can strengthen students' understanding of integer operations.

Integer operations play an important role in developing students' problem-solving abilities. (Rittle-Johnson & Schneider, 2014) conceptual understanding of integer operations helps students identify patterns and relationships between numbers in the context of real-world problems. The use of visual models such as number lines and real-world contexts,

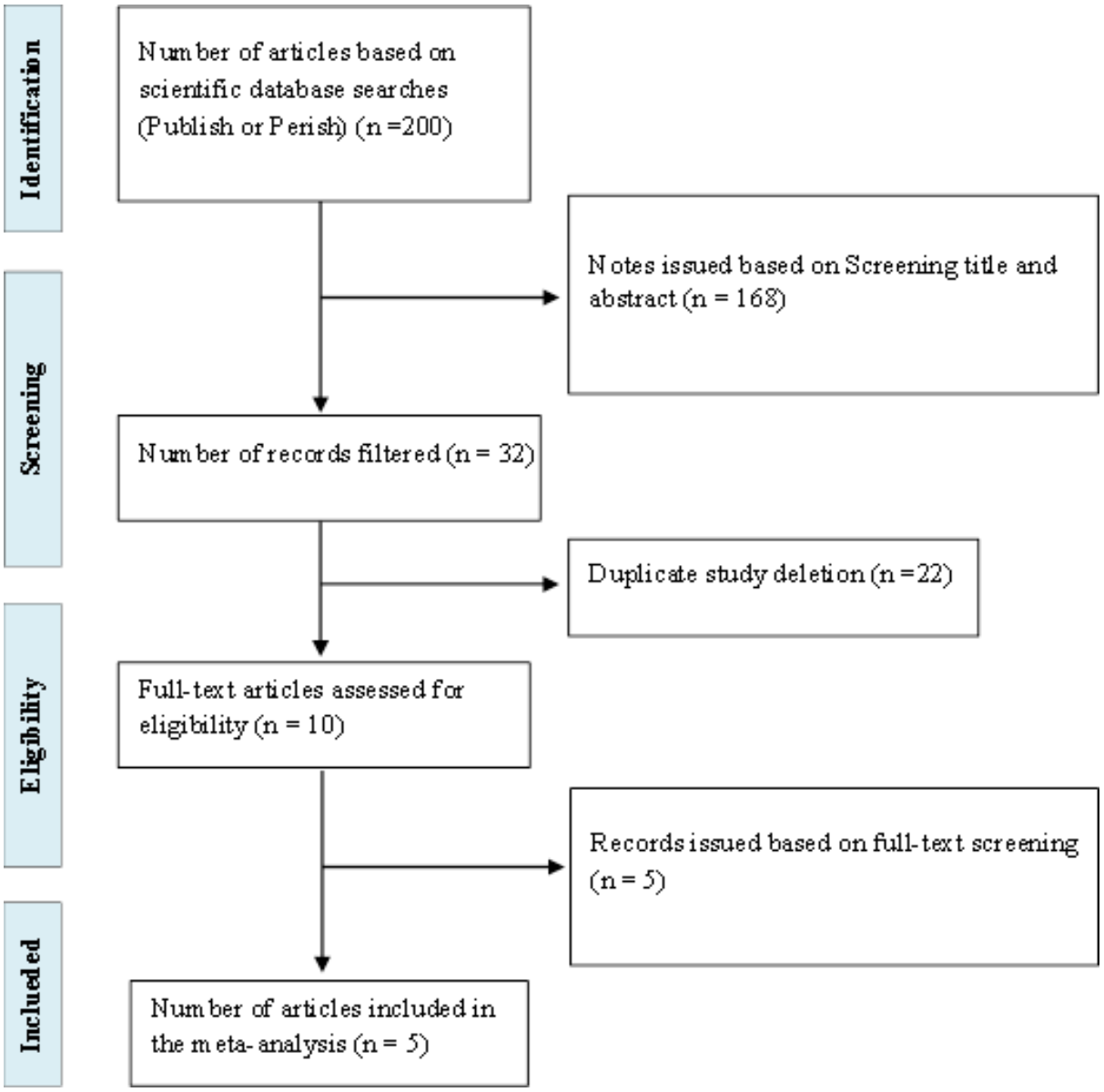
strengthens students' ability to solve problems through negative and positive number representations, so that they are able to apply these concepts in complex situations (Vlassis, 2004) . Problem-solving skills are very important in everyday life because they help individuals deal with complex situations and make the right decisions. Problem solving involves stages such as understanding the problem, designing strategies, and evaluating solutions (Polya, 1957) . This ability allows a person to face a variety of challenges, from managing finances to resolving interpersonal conflicts. in the context of education also emphasizes that problem solving encourages critical and adaptive thinking which is needed in a dynamic environment (Jonassen. 2011).

Formulation of the problem

What strategies are effective in improving students' mastery of integer concepts so that students' problem-solving abilities develop?

METHODS

This study focuses on peer-reviewed English-language empirical research articles, particularly those discussing writing guidelines or frameworks in mathematics education. To compile this review, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009)



FINDINGS

The first step taken is to analyze the abstract to see the research problem and the strategies used to solve the problem and the results of implementing the solution strategy. The results of the analysis are as follows.

The first article (Fuadiah et al., 2019) is part of a series of Didactical Design Research at the prospective analysis stage to comprehensively identify barriers to learning negative integers. The and arithmetic to students, as well as their contribution in causing misunderstandings. Within the framework of epistemological barriers, the results of this study are used as a basis for designing a learning program that can address problems related to teaching and learning negative integers.

The second article (Yilmaz et al., 2019) discusses the use of number line models as visual aids for students to understand the relationships between integers and facilitate learning of integers and their operations. This study uses a qualitative case study approach

to analyze in depth how junior high school students use number line models and which models they instinctively choose in various real-life contexts. Data were collected through questionnaires containing real-life context problems related to integers and interviews to understand students' thinking in more depth. The results showed that students had three conceptual images of number line models, namely horizontal, vertical, and Cartesian plane models that combine the two. The horizontal number line model was more dominantly used, even in contexts that are usually associated with the vertical model. However, more than half of the participating students were unable to use the number line model correctly. In addition, this study found a symbiotic relationship between arithmetic calculations and the use of number lines, where errors in one method can often be corrected through the other.

The third article (Bofferding, 2012) presents the results of a seventh-grade teaching experiment aimed at supporting students' understanding of integer addition and subtraction. The experiment was conducted to test and revise a hypothetical learning trajectory to propose a potential teaching theory for integer addition and subtraction. The learning sequence was designed using Realistic Mathematics Education (RME) theory with a financial context as a basis, and the empty vertical number line (VNL) model was used to help students organize their addition and subtraction strategies. The study highlights the mathematical practices that developed during the learning, showing that students were able to successfully leverage their experiences with assets, liabilities, and net worth to build an understanding of integer addition and subtraction.

The fourth article (Bofferding, 2014) presents the results of a study with a pretest, learning, and posttest design that aims to identify students' mental models of integers and explore how these models change after learning about the unary and/or binary meaning of the minus sign. The study involved 61 first-grade students whose responses to interview questions about the value of negative integers, order, and directed magnitude were analyzed to characterize their mental models. The findings indicate that initially, students tend to rely too much on various combinations of positive integer principles in understanding negative numbers. However, a significant number of students successfully developed formal mental models after participating in the study.

The fifth article (Kwakye & Aggrey, 2022) examines the use of Number Rule to improve junior high school (SMP) students' abilities in learning addition and subtraction of integers. A mixed approach was used in this study, involving quasi-experiments and interviews. Two schools were selected, with one class as a control group (34 students) taught using the conventional method, and an experimental group (37 students) taught using Number Rule. Both groups were tested with a pre-test and post-test using an essay test consisting of 15 questions. The results showed that students taught using the Number Rule method had better post-test results compared to students taught using the conventional method. In addition, the Number Rule method makes learning more efficient, easy to understand, interesting, and practical. Therefore, it is recommended that teachers use the Number Rule method to teach mathematical concepts, especially addition and subtraction of integers. This study is important for teachers and prospective teachers because it shows the effectiveness of using manipulatives in teaching mathematics.

The next step is Analysis is done by reading and grouping findings based on problems, problem-solving strategies, and main results or findings in the article. Here is the

analysis of the article in terms of Research Problems:

The first article The problems raised in the article are related to the difficulties faced by students in understanding the concept of negative numbers. Some of the main points that are the focus of the problems in this study are:

1. **Student Misconceptions** : This study identified various misconceptions experienced by students when learning about negative numbers, which may be caused by ineffective teaching methods or a lack of understanding of basic concepts.
2. **Epistemological Obstacles** : This article discusses the epistemological obstacles faced by students, namely difficulties in understanding and constructing knowledge about negative numbers, which can hinder their learning process.
3. **Influence of Teaching Methods** : This study also explores how the teaching methods used by teachers affect students' understanding of negative numbers. This includes how teachers explain concepts and how students respond to these explanations.
4. **Learning Program Design** : The findings of this study are used as a basis for designing a learning program that can address problems related to teaching and learning negative numbers, with the aim of improving students' understanding.

The second article, in the article, several problems were identified related to the use of the number line model by middle-class students in solving contextual problems involving integers, including:

1. **Difficulty Using Models** : Many students had difficulty using number line models correctly. More than half of the students who participated in the study were unable to use number line models correctly, indicating a gap in their understanding of this visual representation.
2. **Variation in Conceptual Drawings** : Students have three different conceptual drawings related to the number line model, namely the horizontal line model, the vertical line model, and a combination of the two. However, the horizontal line model dominates, even in contexts that are usually more suited to the vertical model. This suggests that students may not fully understand when and how to use the different models.
3. **Relationship between Calculation and Representation** : There is a symbiotic relationship between arithmetic calculation and the use of the number line, where errors made in one aspect are often corrected by the other. However, students often use inappropriate or illogical movements on the number line, which can interfere with their calculation process.
4. **Difficulty in Interpreting Representations** : Students also have difficulty in expressing the same information using multiple representations, as well as in transferring mathematical statements into representations appropriate for solution. This indicates challenges in their conceptual understanding and ability to adapt to different contexts.

In the third article the problems identified relate to students' understanding of integers, particularly in the context of addition and subtraction. Here are some of the main problems faced:

1. **Conceptual Difficulties** : Students often have difficulty understanding the concept of negative numbers and how they operate in addition and subtraction. This includes difficulty visualizing numbers less than zero and understanding the rules of arithmetic for whole numbers, such as why the negation of a negative number results in a positive number.
2. **Inadequate Learning Models** : Before this study, many models used to teach integers were not effective enough in helping students organize their addition and subtraction strategies.

   This study attempts to introduce the vertical number line (VNL) model as a better tool for understanding integer operations.
3. **Limitations in Using Context** : This study also shows that the contexts used in teaching, such as assets, liabilities, and net worth, can help students make meaning of integer operations. However, there are still challenges in extending these contexts to include other operations such as multiplication and division of integers.
4. **Complex Classroom Argumentation** : Analyzing arguments in classroom discussions involving multiple speakers is challenging. This study notes the difficulty in documenting mathematical practices in the classroom and how students interact with each other in constructing their understanding.

In the analysis results in the fourth article, several problems were identified, including:

1. **Instructional Time Constraints** : Research shows that students require more time to understand negative number concepts than is currently provided in the curriculum. This suggests that the time allocated to teaching negative numbers may not be adequate to support the development of student understanding.
2. **Variability in Understanding** : There was significant variation in students' understanding of negative numbers, indicating that learning experiences play a larger role than age or developmental level. Some students even had difficulty accepting that values below zero exist, indicating that their understanding of negative numbers is still very limited.
3. **Reliance on Prior Knowledge** : Students often rely on prior knowledge when faced with new problems, which can hinder their understanding of negative numbers. For example, they may be more likely to interpret word problems involving negative numbers from a positive perspective.
4. **Lack of Understanding of Notation** : The study also noted that there was a lack of understanding in students about the notation and various meanings of the minus sign. This suggests that students may not fully understand the difference between the subtraction sign and the negative sign, which can lead to confusion in integer operations.

5. **Limitations of Teaching Methods** : This study focused on one instructional model, namely the number line model, and did not explore other models such as the cancellation model. This suggests that there is the possibility of gaining additional insights into student understanding if a variety of teaching methods are explored.

The fifth article identifies several problems, including:

1. **Differences in Student Performance** : Although students taught with the Number Rule method performed better than those taught with the conventional method, there are challenges in understanding why the conventional method does not produce the same results. Students who use the conventional method often use incorrect calculation procedures, which can affect their learning outcomes 11, 10.
2. **Test Difficulty Level** : The post-test results indicate that some students may have difficulty due to the more challenging test items compared to the pre-test. This may lead to differences in understanding and application of the concepts taught. 10.
3. **Limited Conceptual Understanding** : Students taught using conventional methods may not have the depth of understanding needed to apply their mathematical knowledge in new contexts and solve problems. This suggests that the teaching methods used may affect the depth of students' understanding 10.

4. **Use of Manipulatives** : Although the use of manipulatives (such as Number Rules) has been shown to be effective, there are challenges in the implementation and acceptance of this method by all teachers and students. This suggests the need for better training and support for teachers in using this method effectively. 2

The next analysis is an analysis in terms of Teaching Strategies used to solve the problems found in the previous analysis. The first article in the study on negative numbers, some of the specific teaching methods analyzed include:

1. **Use of Didactic Situations** : This study emphasizes the importance of didactic situations designed by teachers during the teaching process. These situations include real contexts that are relevant to students' daily lives, which can help them understand the concept of negative numbers better.
2. **Classroom Interaction** : Teaching methods that encourage interaction between teachers and students, as well as between students themselves, are analyzed. Small group discussions and collaborations allow students to share their thoughts and strategies, which can deepen their understanding of negative numbers.
3. **Contextual Approach** : This study also explores the use of contextual approach in teaching negative numbers, where teachers relate mathematical concepts to real situations that students can understand. This helps students to see the relevance of negative numbers in everyday life.
4. **Active Learning Models** : Methods that encourage students to be actively involved in the learning process, such as through experiments, games, or practical activities, are also analyzed. This approach aims to increase student engagement and help them

build a stronger understanding of negative numbers.

5. **Providing Feedback** : This study highlights the importance of constructive feedback from teachers during the learning process. Appropriate feedback can help students identify errors and improve their understanding of negative numbers.

Second article: In the article, some teaching strategies are proposed to help students overcome problems in using number line models and understanding integer operations including:

1. **Using Real-Life Contexts** : Integrating real-life contexts into math teaching is essential. By using everyday life situations, such as temperature, profit and loss, or movement, students can more easily understand the concept of whole numbers and how the number line model can be applied in those contexts.
2. **Connections between Representations** : Activities that support students in connecting different representations (such as arithmetic sentences, number lines, and word problems) are essential for meaningful mathematics learning. Situations that allow for transitions between these representations should be designed to encourage students to make connections between these concepts.
3. **Providing Explanation and Discussion** : Through interviews and discussions, teachers can help students explain their choices in using the number line model. This provides an opportunity for students to reflect on their thinking and correct errors in their understanding of the model used. them understand when

   and how to use the appropriate model. It can also help students develop flexibility in mathematical thinking.
4. **Practice and Feedback** : Providing a variety of practice and constructive feedback on the use of number line models can help students correct their errors. Timely and specific feedback can help students understand their errors and improve their strategies for solving problems.
5. **Discovery-Based Approach** : Encouraging students to discover for themselves how to use the number line model through exploration and experimentation can enhance their understanding. By providing opportunities to experiment with the model, students can develop a deeper understanding of the concepts being taught.

Third Article In this study, several teaching strategies were used to address students' understanding of addition and subtraction of integers. Here are some of the main strategies applied:

1. **Using Realistic Contexts** : This study uses financial contexts, such as assets, liabilities, and net worth, to help students understand the concept of whole numbers. By relating mathematical operations to real-world situations, students can more easily relate abstract concepts to their everyday experiences.
2. **Vertical Number Line (VNL) Model** : This study introduces the vertical number line model as a visual aid to help students organize their addition and subtraction

strategies. This model allows students to see the relationship between positive and negative numbers more clearly, and helps them understand arithmetic operations.

3. **Classroom Discussions and Mathematical Practices** : This study emphasizes the importance of classroom discussions as a means of building collective understanding. Through discussions, students can share their thoughts and strategies, and learn from each other. The mathematical practices that emerge during these discussions are important indicators of learning that occurs in the classroom.
4. **Constructivist Approach** : The teaching strategy used is based on constructivist theory, where students are considered as active participants in the learning process. They are expected to organize and reorganize their understanding through social interaction and relevant mathematical contexts.
5. **Feedback and Adjustment** : This study also emphasizes the importance of feedback from the analysis of mathematical practices in the classroom to improve and adjust the teaching theory being developed. By documenting and analyzing how students participate in discussions, teachers can make necessary changes to improve the effectiveness of teaching.

The fourth article some learning strategies are used to help students understand the concept of negative numbers and overcome the problems identified. Here are some of these strategies:

1. **Using the Number Line Model** : The number line model is used as a visual tool to help students understand the order of whole numbers, including negative numbers. By seeing numbers on a number line, students can more easily understand the concept that negative numbers are to the left of zero and are smaller than positive numbers.
2. **Practical Activities and Games** : The study involved practical activities, such as a numerical board game, where students could move along a number line and interact with negative numbers. These activities were designed to promote early mathematics learning and increase student engagement.

3. **Class Discussion and Explanation** : During class sessions, the teacher asks questions related to the main activity and asks students to provide explanations. This helps students to reflect on their understanding and reinforce the concepts that have been taught.
4. **Providing Opportunities for Exploration** : Students are given opportunities to explore problems involving minus and negative signs. For example, they can compare and contrast problems involving both signs, and discuss the results. This helps students understand the differences between operations involving positive and negative numbers.
5. **Use of Contextual Representation** : Students are encouraged to understand negative numbers through relevant contexts, such as negative temperatures or debt. By linking mathematical concepts to real-world situations, students can more easily understand the meaning of negative numbers.

6. **Problem-Based Education** : Students are presented with problems involving negative numbers and encouraged to find solutions. This helps them to develop problem-solving skills and apply their understanding of negative numbers in a broader context.

The fifth article in the context of using the Number Rule method, includes:

1. **Use of Manipulatives** : This strategy involves the use of visual aids and manipulatives to help students understand mathematical concepts. By using manipulatives, students can be actively engaged in learning and develop a better understanding of adding and subtracting whole numbers.
2. **Question-Based Approach** : In teaching, teachers use question and answer methods to relate prior knowledge to new concepts. This helps students to build a stronger understanding and relate the concepts taught to their own experiences.
3. **Application of Concepts Through Examples** : Students are given various examples and relevant situations to apply the concepts they have learned. In this way, students can see how mathematical concepts are applied in real contexts, which can improve their understanding.
4. **Collaboration and Discussion** : Students are encouraged to collaborate and discuss with peers. This not only increases student engagement but also allows them to learn from each other and develop a deeper understanding of the material being taught.
5. **Diverse Assignments** : The assignments and exercises given to students are designed to cover a range of difficulty levels and learning styles. This helps ensure that all students, regardless of their ability, can engage and learn in a way that works for them.
6. **Reflection and Feedback** : After each lesson, students are given the opportunity to reflect on what they have learned and receive feedback from the teacher. This helps students understand their mistakes and improve their understanding of the concepts taught.

Next is the analysis in terms of research results or research findings that have been conducted in the article. The first article, the main findings related to students' misconceptions about negative numbers in this study include several important points:

1. **Conceptual Misperception** : Students often misunderstand the concept of negative numbers, especially in the context of mathematical operations such as subtraction. They tend not to understand the role of the minus sign as a marker for negative numbers and often associate it only with rules of thumb or formulas without a deeper understanding..

   Reliance on a single context makes it difficult for students to relate the concept of negative numbers to a wider range of situations.
2. **Dominance of Lecture Method** : The learning process dominated by the lecture method from the teacher reduces the opportunity for students to interact and discuss.

This results in a lack of deep understanding, because students do not have the opportunity to express their thoughts or discuss their mistakes with peers.

3. **Lack of Class Discussion** : Less than optimal discussion between teachers and students contributes to misunderstandings. When interaction is limited, students are unable to share and modify their thinking, which is essential to building a better understanding of negative numbers.
4. **Limitations in Mental Representation** : Students often do not have an appropriate mental representation of negative numbers, which results in difficulty in understanding the concept. Inadequate mental activity in developing an appropriate concept can hinder their understanding.
5. **The Importance of Feedback and Reflection** : Research shows that constructive feedback and opportunities for reflection are essential in helping students overcome their misconceptions. Without appropriate feedback, students may not recognize their mistakes and continue to hold onto their misconceptions.

In the second article, the main results or findings in this study include several important points related to the use of the number line model by students in the context of real problems involving integers. Here is a summary of the main findings:

1. **Use of Number Line Models** : Students showed variation in their use of number line models, both horizontal and vertical, when solving problems. The study identified that students tended to select the model they found most intuitive for a given context, although they did not always use the most appropriate model.
2. **Calculation Strategy** : Two main calculation strategies are identified:
    - **Equal Division and Jump Method** : Where students divide the number line into equal parts and make jumps to reach the result.
    - **Necessary and Jump Division Method** : Where students divide the number line into unequal parts according to their calculation needs. This finding shows that students use units on the number line as calculation steps.
3. **Strategy Appropriateness** : The study found that not all of the moves students made on the number line could be considered appropriate. Some moves were categorized as “questionable” or “illogical,” indicating that students may not fully understand the role of numbers in the context of the given problem.
4. **Student Perceptions** : Through interviews, students provided insight into the reasons behind their choice of using the number line model. Some students felt more comfortable with certain models, while others acknowledged difficulties in understanding how to apply the model in different contexts.
5. **Connections between Representations** : Findings show the importance of connecting different mathematical representations. Students who can connect between arithmetic sentences, number lines, and word problems tend to have a better understanding of the concepts being taught.
6. **Research Limitations** : the given problem and the characteristics of students in one

classroom in Turkey. Different results may be obtained if conducted in a different context or population.

Article Three The main results or findings of this study cover several important aspects related to students' understanding of addition and subtraction of integers. Here is a summary of the main findings:

1. **Improved Student Understanding** : Research shows that students who engage in instruction that uses a financial context and the vertical number line (VNL) model experience significant improvements in their understanding of adding and subtracting whole numbers. They are better able to relate the concept of negative numbers to real- world situations, such as assets and liabilities.
2. **Emergent Mathematical Practices** : During the instruction period, five different mathematical practices emerged in class discussions. These practices reflect how students interact with integer concepts and how they use context to construct their understanding. This suggests that students can use their experiences with assets and liabilities to create meaning for integer operations.
3. **Effectiveness of the VNL Model** : The vertical number line model has been shown to be an effective tool in helping students organize their addition and subtraction strategies. The model provides a clear visual representation of the relationship between positive and negative numbers, which helps students understand arithmetic operations.
4. **Context as a Learning Tool** : This research supports the idea that learning in real-world contexts provides students with greater opportunities to abstract mathematical structures and meanings. The financial context used in instruction helps students understand more complex concepts, such as negative numbers, in a more accessible way.
5. **Teaching Theory Revision** : The results of this experiment contribute to the development of a more stable teaching theory for integer addition and subtraction. This study demonstrates the importance of combining realistic contexts with mathematical models to enhance students' understanding.

The fourth article some of the main results or findings identified are as follows:

1. **Students' Initial Abilities** : Research shows that first graders have the ability to understand the concept of negative numbers, although they initially rely on the whole number principles they already know. Many students showed limited understanding of the order and value of negative numbers at the beginning of the study.
2. **Mental Model Development** : After instruction, a significant number of students successfully developed more formal mental models of negative numbers. This suggests that with appropriate instruction, students can transition from a more intuitive understanding to a more formal, structured understanding of negative numbers.
3. **Effect of Instruction on Comprehension** : The results of the study indicate that well- designed instruction can significantly improve students' understanding of negative numbers. Students who received instruction on the unary and binary

meanings of the minus sign showed greater improvements in their understanding than students who did not receive such instruction.

4. **Variability in Understanding** : Although many students showed progress, there was also significant variation in their understanding of negative numbers. Some students still struggled with the concept of values below zero, suggesting that learning experiences and context strongly influence their understanding.

5. **Connections to Other Concepts** : Research has found that understanding negative numbers can deepen students' understanding of other math concepts, such as the role of zero and the meaning of addition. By introducing negative numbers early, students can develop a more coherent understanding of math as a whole.
6. **Need for Curriculum Change** : These findings suggest that curriculum developers and policymakers need to reconsider the sequencing and relevance of number topics in the elementary mathematics curriculum. Research suggests that students are capable of learning about negative numbers earlier than is typically taught in fifth grade.

The fifth article includes:

1. **Effectiveness of Number Rule Method** : Students taught using the Number Rule method showed better understanding and higher performance in addition and subtraction of integers compared to students taught using the conventional method. The use of manipulatives helps students to understand concepts more deeply and apply them in real situations.
2. **Increased Student Engagement** : Students showed high enthusiasm when using manipulatives and engaging in group discussions. They were more active in solving problems and sharing ideas, which contributed to more effective learning.
3. **Better Application of Concepts** : Students who used the Number Rules method were able to apply the concepts they had learned in a broader context, such as understanding that the sum of two negative integers is always negative. This shows that they are not just memorizing procedures, but also understanding the concepts behind mathematical operations.
4. **Increased Positive Perceptions of Mathematics Learning** : The majority of students had positive views of the use of Number Rules, which they felt improved their understanding and performance. Students felt that manipulatives made mathematics learning more realistic and enjoyable.
5. **Recommendations for Teaching** : This study recommends that teachers be trained in the use of manipulatives and the Number Rule method to enhance mathematics instruction. In addition, it is recommended that further research be conducted to explore the use of manipulatives in other mathematics topics, such as addition and subtraction of fractions.

DISCUSSION

Based on The results of the analysis of the previous article study can be synthesized that One of the main problems in learning integers is the conceptual difficulties experienced by students. They often face misunderstandings in understanding the concept of negative numbers, especially in their use in mathematical operations such as addition and subtraction. These errors are often caused by a lack of appropriate mental representation and reliance on irrelevant prior understanding. In addition, the limitations of teaching methods are a factor that worsens the situation. Many teaching approaches are not yet effective in helping students understand the abstract concept of negative numbers or linking the concept to real situations. Another obstacle arises in the use of visual representations, such as number line models, which often confuse students, especially when they have to choose the right model according to the context of the problem. The combination of these various obstacles indicates the need for innovation in methods and tools for learning integers.

Various teaching methods have been proposed to help students understand integer operations more effectively. One recommended approach is the use of realistic contexts, such as financial situations involving assets and liabilities, to bridge abstract concepts with students' real- world experiences. In addition, visual models, such as vertical and horizontal number lines (VNLs), are used to help students visualize the relationship between positive and negative numbers. Learning strategies based on interaction and class discussion are also considered effective, where collaboration between students and reflection on their understanding are key elements in overcoming conceptual misunderstandings. The use of manipulatives, such as the Number Rule method or other visual aids, has been shown to increase student engagement while strengthening their conceptual understanding. By integrating these various methods, the learning process is expected to be more meaningful and provide optimal results.

The results showed that the contextual and visual approaches significantly improved students' understanding compared to the conventional method. The use of visual models, especially the vertical number line, proved effective in helping students organize their strategies for solving integer operations. In addition, students who engaged in manipulative-based learning and classroom discussions showed greater flexibility in mathematical thinking, allowing them to connect different representations of concepts more easily. The real-world context also had a positive impact, making learning more relevant and meaningful, allowing students to better understand abstract concepts such as negative numbers. These findings underscore the importance of diverse and contextual approaches to improving the quality of integer learning.

The results of the study on integer learning provide significant opportunities for innovation in several aspects. One of them is the development of more diverse learning contexts, where existing approaches, such as financial contexts, can be extended to other situations such as Games. This aims to broaden the appeal of learning and help students relate integer concepts to broader real-world experiences.

In addition, the development of new visual models is also a promising potential. The combination of visual models, such as comics or interactive animations, offers a more intuitive and interesting representation for students. This model can not only help students visualize the relationship between positive and negative numbers in more depth but also

make it easier for them to understand more complex integer operations, such as multiplication and division.

Another novelty lies in the exploration of technology to support integer learning. The use of interactive applications, simulations, and gamification has not been fully researched, although these technologies have great potential to increase student engagement and understanding. Gamification- based learning, for example, can present integer operational challenges in a fun and competitive format, while interactive simulations can provide a more immersive and meaningful learning experience.

CONCLUSIONS

This study successfully achieved its objectives with the following findings:

Conclusion

The conclusion that can be drawn from the results of the synthesis and the innovations offered is that learning integers requires a more innovative approach to overcome the various obstacles faced by students. Conceptual difficulties, limitations of teaching methods, and obstacles in visual representation indicate that conventional teaching strategies are not yet fully effective. The innovations offered include the development of more diverse learning contexts, such as games, to make learning more relevant to students' lives. In addition, the development of new visual models, such as comics or interactive animations, provides opportunities to improve the visualization of more complex integer concepts. Interactive technologies, such as simulation and gamification applications, also offer great potential to increase student engagement in understanding integer operations through more enjoyable learning experiences. By integrating contextual approaches, innovative visual models, and interactive technologies, integer learning can be designed to more effectively support the development of students' conceptual and procedural abilities.

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