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ANALYSING INTEGER DIVISION KNOWLEDGE AND SKILLS IN PROSPECTIVE PRIMARY TEACHERS

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ABSTRACT

This study aims to investigate prospective primary (MI) teachers' knowledge of the sign of the division result of integers, their skills in illustrating the division model of integers, and their ability to perform integer division operations. This study comprehensively describes prospective MI teachers' work on integer division problems through a descriptive qualitative research approach. Data were collected using a test. The participants were considered to have received instruction on integer division material, thus preparing them to become teachers who understand the concept of integer division. They demonstrated the correct knowledge regarding the sign of the division result of integers. They illustrated the division models of integers in four categories: (1) unable to illustrate the division models of integers, (2) illustrating integer division models incorrectly, (3) illustrating integer division models correctly but without demonstrating their understanding, and (4) illustrating integer division models correctly and understandably. The skills of the MI teachers in performing integer division included using downward division by separating integer signs correctly, using downward division by attaching integer signs correctly, using downward division by attaching integer signs incorrectly, and not explaining any methods for operating with integers. This study's results can serve as a basis for improving the learning process, curriculum, and training programs for prospective MI teachers.

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INTRODUCTION

Concepts can be likened to stones in thinking. A concept is one of the objects in mathematics learning materials (Soemoenar & Noornia, 2014). Understanding mathematical concepts within mathematics learning principles is stated in the (NCTM, 2000) which asserts that students learn mathematics by actively constructing understanding to build new learning experiences from prior knowledge. The understanding of mathematical concepts is a fundamental principle for achieving meaningful mathematics learning (Yulianty, 2019). Concepts in mathematics do not stand alone; rather, they are interconnected with other concepts (Purwandari & Wahyuningtyas, 2017).

Students' understanding and learning outcomes related to integer division and multiplication material are still low (Indah et al., 2020; Prasetyo, 2022; Sihombing et al., 2023). Mathematics learning faced by students often focuses solely on memorizing visible facts, making it difficult for elementary school students (SD/MI) to grasp division and multiplication material because the learning objectives are not concrete. A study found that students are required to master the division and multiplication of integers primarily by instilling the concept that numbers with the same sign, when multiplied or divided, yield a positive result, while two numbers with opposite signs yield a negative result (Sukenti, 2014). Students frequently score below the minimum standard score, known as KKM, because they lack an understanding of arithmetic operations for the division and multiplication of whole numbers in concrete form (Kusumadewi et al., 2019; Purwandari & Wahyuningtyas, 2017; Rohmah, 2015).

Teachers remain one of the main sources in the classroom learning process for students. Consequently, what students should do largely depends on the teacher's instructions. Teachers play a significant role in students' success, from problem-solving to curriculum reform in mathematics, which ultimately hinges on the teacher (Abu-Elwan, 2014; Ertmer & Simons, 2005; Sundari, 2017). Understanding the whole number division material among *Madrasah Ibtidaiyah* (MI) teachers is crucial, as it provides important information for identifying prospective teachers' abilities to understand the material.

Studies of prospective teachers have shown weaknesses in understanding the basic concepts of integer division (Ball, 1990; Bofferding & Wessman-Enzinger, 2018). Thus, teacher education and training programs need to strengthen the understanding of basic concepts or algebra prerequisites to ensure that prospective teachers have a correct and in-depth

understanding (Nurlita et al., 2016). Interviews conducted with prospective mathematics teachers revealed five difficulties they experience: solving integer division problems; performing algebraic manipulation and recognizing structures in algebraic expressions that correspond with the division algorithm or definition of divisibility; distinguishing between variables and parameters in division problems presented in algebraic expressions; linking division algorithms with definitions; and applying properties and theorems of divisibility (Fitrianti et al., 2020). The main cause of errors and misconceptions is superficial understanding, likely stemming from teachers rushing to complete a broad syllabus, which forces students to memorize rules without a deep comprehension (Khalid & Embong, 2019). More specifically, one of the factors influencing the difficulty of understanding division calculation operations is the teacher's role (Unaenah et al., 2022). Based on these research findings, no comprehensive descriptions of the understanding of integer division among prospective MI teachers have been provided. Most studies only offer an overview of the misconceptions or errors of prospective teachers or students regarding specific concepts in the field of mathematics.

Teacher mastery of teaching materials is a key professional competence that must be developed before starting classroom instruction. The scope of MI/SD mathematics material covers four main areas: (1) numbers, including integers, whole numbers, primes, fractions, multiples and factors, simple powers and roots, along with their operations—addition, subtraction, multiplication, and division; (2) geometry and measurement, which involves flat and spatial shapes, relationships between lines, weight, length, area, volume, angles, time, speed, and discharge, as well as the location and coordinates of an object; (3) statistics, including the presentation and interpretation of single data sets; and (4) algebra, all of which are applied to solve real-life problems. Based on this scope, teachers need to master integer operations, including division. It is crucial that teachers have a solid understanding and ability to perform integer division before implementing instruction. If teachers do not grasp the concept of integer division properly, they risk providing incorrect explanations to students. This can result in students misunderstanding the concept or failing to understand it entirely (Rohmah, 2015). Additionally, if teachers are unaware of students' common misconceptions about integer division, they may struggle to identify and correct these errors effectively.

The *Pendidikan Guru Madrasah Ibtidaiyah* or Madrasah Ibtidaiyah Teacher Education (PGMI) program is designed to prepare future MI/SD teachers to be ready for the teaching

profession. To prevent students from developing misconceptions about integers, the program must ensure that prospective teachers have a strong grasp of essential concepts, one of which is the division of integers. In this study, the prospective MI teachers are students enrolled in the PGMI program. As future MI teachers, PGMI students who will soon enter the teaching field must master the content of Numbers and Counting Operations in the Mathematics 1 (Numbers and Data Processing) course. Ensuring that students have a solid understanding of integer division is essential.

This study examines the understanding of integer division, focusing on three aspects: knowledge of the sign of the result of integer division; ability to illustrate the model of integer division; and proficiency in performing integer division operations. The aim of this study is to describe prospective MI teachers' knowledge of the sign of the result of integer division, their ability to illustrate a model for integer division, and their skills in performing integer division.

This context motivates researchers to explore the extent of prospective MI teachers' understanding of the concept of integer division, as they are individuals who will eventually plan and manage learning in the classroom. The researcher considers it important to analyze the prospective MI teachers' comprehension of integer division. Specifically, this study aims to investigate their knowledge of the sign of the result of integer division, their skill in illustrating models of integer division, and their proficiency in performing integer division. This analysis serves as the basis for researchers to reflect on and improve the emphasis in the Mathematics 1 course within the PGMI Study Program.

METHOD

This research generates descriptive data in the form of written or spoken responses from prospective teachers, indicating that the study follows a descriptive-qualitative approach. The subjects were 16 students (14 female and 2 male) from the *Madrasah Ibtidaiyah* Teacher Education (PGMI) study program in their second semester. These students had attended lectures on integer division in the Mathematics 1 (Numbers and Data Processing) course. The subjects were selected using purposive sampling, as they had already received instruction on integer division, preparing them to become teachers with a solid understanding of the concept.

The Integer Division Understanding Test was designed to assess and reveal prospective MI teachers' comprehension of integer division. Since this qualitative research was not intended to generalize results or produce data that could be measured quantitatively, the instrument used

did not require formal content validation. The goal was to gain deeper insights rather than quantitatively measure understanding. The test was developed based on three key indicators of understanding whole numbers: (1) knowledge of the sign of integer division, (2) the ability to illustrate models of integer division, and (3) proficiency in performing integer division operations. The test was conducted in June 2023.

Data validity was ensured through triangulation, specifically source triangulation. Source triangulation involves comparing the results of one subject's Integer Division Comprehension Test with those of another subject. The researcher analyzed the patterns and diversity in the subjects' responses to each test item.

Qualitative data analysis in this study was conducted continuously, starting from the data collection phase and concluding with the writing of the research report (Moleong, 2018). According to Miles and Huberman (1992), qualitative data analysis consists of three simultaneous activities: data reduction, data presentation, and conclusion drawing. Data reduction involved simplifying and organizing the raw data to focus on the most relevant information regarding the conceptual understanding of integer division among prospective MI teachers. The reduced and organized data was then presented in charts and tables to identify patterns or relationships. In the presentation phase, the researcher highlighted key findings. Conclusion drawing involved identifying patterns, verifying conclusions through triangulation, and refining them as necessary.

RESULT AND DISCUSSION

This section discusses findings of the study following the three key indicators of understanding whole numbers.

Knowledge of the Sign in Integer Division

Four short fill-in questions were used to assess the subjects' knowledge of the sign in the division of whole numbers. Figure 1 presents bar charts illustrating the research subjects' responses to these four items.

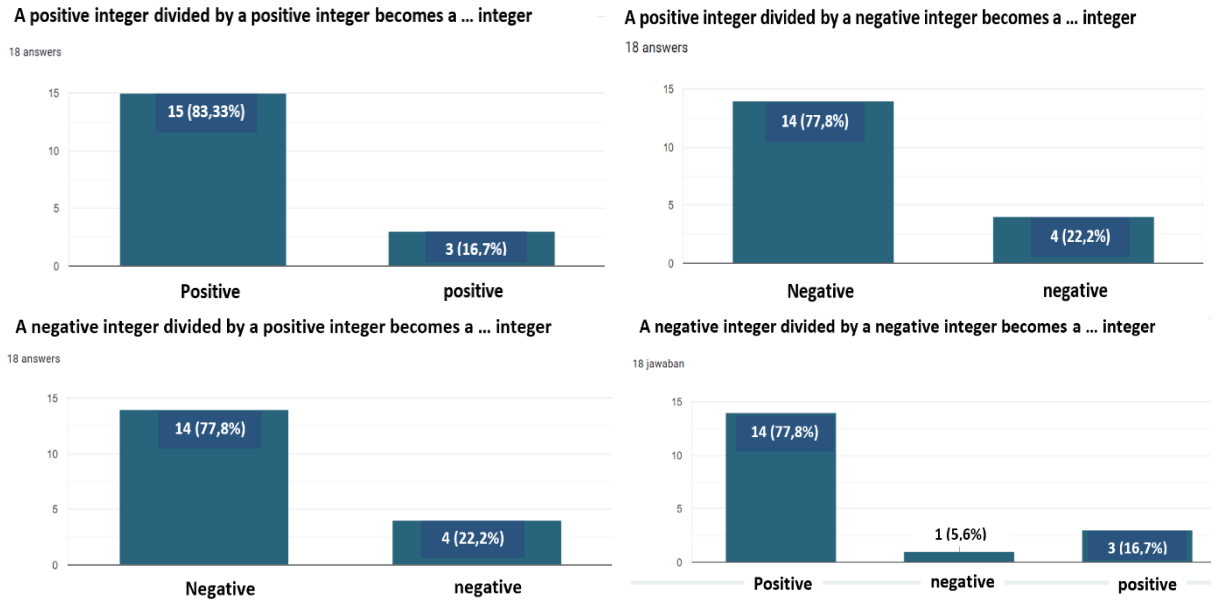


Figure 1. Responses to Knowledge Items on the Sign in Integer Division

Almost all of the 16 research subjects answered correctly that: (1) dividing two positive integers results in a positive integer; (2) dividing a positive integer by a negative integer result in a negative integer; (3) dividing a negative integer by a positive integer results in a negative integer; and (4) dividing two negative integers results in a positive integer.

However, one subject incorrectly answered that dividing two negative integers results in a negative integer. This misconception aligns with findings from other studies, where students commonly make errors in performing operations with negative integers. These errors often occur because students struggle to distinguish whether the "-" or "+" symbol represents an operation or the sign of a number (Nurlita et al., 2016).

Illustrating the Integer Division Model

The results of the integer division comprehension test, which assessed the subjects' ability to illustrate the integer division model, revealed four categories: (1) subjects did not illustrate the integer division model; (2) subjects illustrated the integer division model incorrectly; (3) subjects illustrated the model correctly but without demonstrating an understanding of it; and (4) subjects illustrated the integer division model correctly while demonstrating an understanding of the concept.

Subjects Who Did Not Illustrate the Integer Division Model

Subjects in this first category did not illustrate the integer division model. While all subjects in this category were able to correctly describe the model representing an integer, their illustrations of the integer division operation merely involved changing the mathematical symbol of the integer to a representation using integer chips. The division operation symbol, ÷, was still included in their illustrations (see Figure 2).

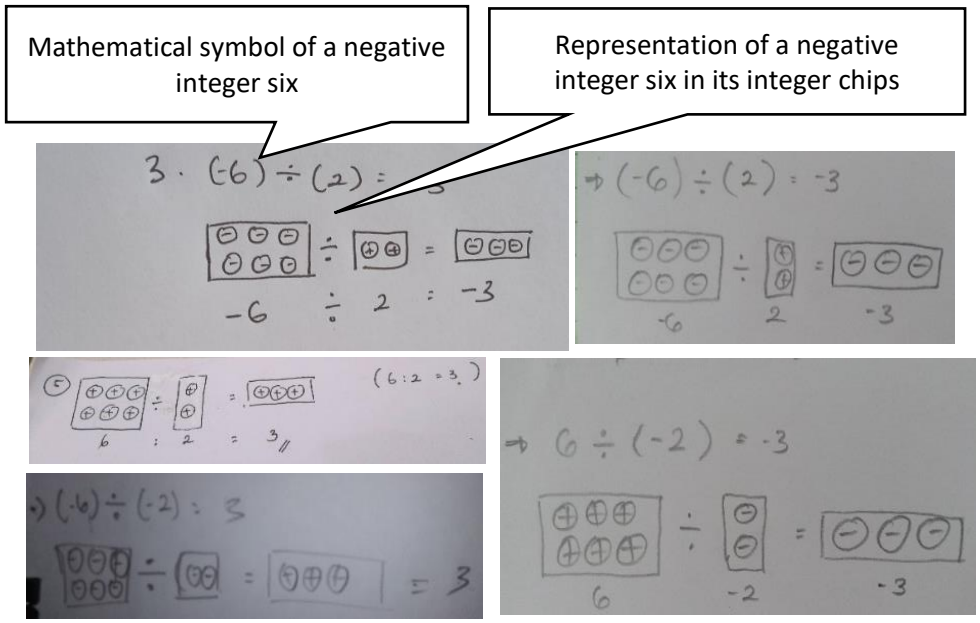
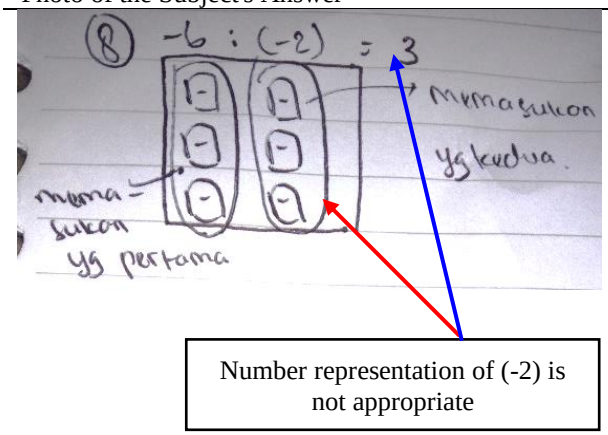
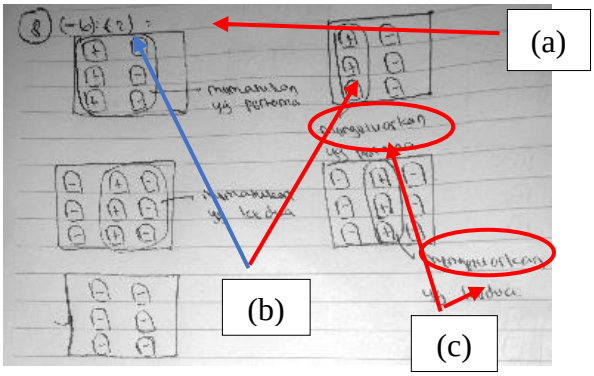


Figure 2. Subjects Who Did Not Illustrate the Integer Division Model

The Subjects Illustrated the Integer Division Model Incorrectly

The subjects in this second category understood the illustration of the whole number division model. However, they did not fully grasp the illustration of the integer division model when asked to illustrate the division of an integer by another number. The subjects correctly understood the principle that 'What is divided (±a) is the desired final piece.' However, they made errors in applying this principle: (1) The divisor (±b) is the piece that is moved (inserted or removed); and (2) The quotient (±c) indicates the number of activities involved in moving (inserting or removing) the piece to or from the square, ensuring that the square contains the desired piece. A positive quotient indicates that pieces are inserted into the square, while a negative quotient indicates that pieces are removed from the square. Table 1 shows the mistakes made by the subjects in the test results.

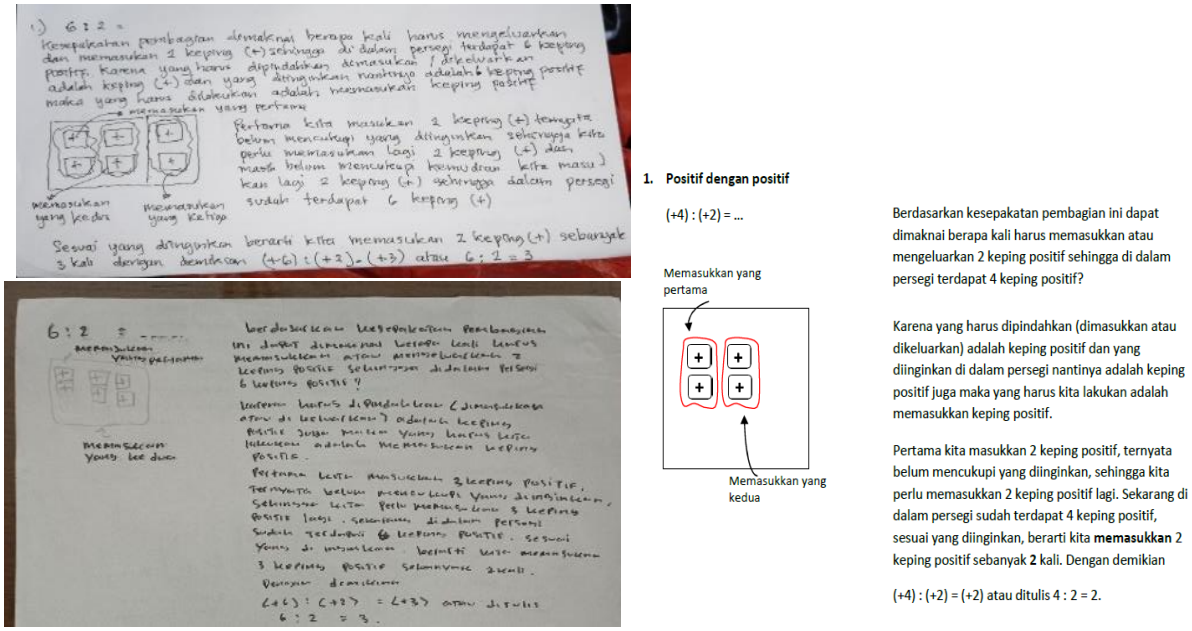
Table 1. Subjects Who Illustrated the Integer Division Model Incorrectly

Photo of the Subject's Answer	Description
	The subject understood that they needed to place six pieces of negative charge into the square. However, the representation of the second number (-2) in the model illustration was incorrect. The number of pieces inserted each time was wrong; it should have been two pieces of negative charge, but they instead inserted three pieces of negative charge each time.
	(a) The subjects did not conclude the result of (-6) ÷ (-2) = ⋯. (b) They removed the incorrect number of pieces of charge, specifically removing 3 pieces when they should have inserted (-2). The subjects illustrated the removal twice to conclude the quotient as (-2). (c) However, the correct illustration should involve inserting three pieces to yield a quotient of 3

Based on the errors presented in Table 1, there is a need for improved instruction in teaching whole number division. It is essential for PGMI programs to help prospective teachers address these misconceptions or, at the very least, monitor their impact (Arnett, 1989; Makaraka et al., 2021; Tirosh & Graeber, 1989).

Subjects Who Illustrated the Integer Division Model Correctly Without Demonstrating Understanding

Subjects in this third category appeared to imitate the text and illustrations in their responses. This is evident from the subjects using a series of words that are almost identical, and in some cases, exactly the same as the teaching materials (Figure 3b) provided in the Mathematics 1 (Numbers and Data Processing) course for PGMI students in semester II. The only adjustments made were to the numbers, which aligned with the items on the research instrument. The subjects did not use their own words to describe the illustration of the integer division model (Figure 3a).



(a) (b)

Figure 3. Comparing Correct Illustrations of the Integer Division Model Without Demonstrating Understanding to the Teaching Materials

Subjects Who Illustrated the Integer Division Model Correctly by Demonstrating Understanding

In fourth criterion, the subjects illustrated the division of integers correctly by demonstrating their understanding. This is evident in their work, as shown in Figure 4. The subjects skillfully illustrated the model of integer division and were able to explain each step of inserting or removing pieces correctly, ultimately determining the quotient that corresponds to the process. For instance, in the division of (-6) ÷ 2, the subjects accurately explained that this division operation can be interpreted as the number of times to insert or remove 2 positive pieces in order to have 6 negative pieces in the square. The subjects further elaborated:

"*The desired chips in the box will be the negative chips, while the ones to be moved, inserted, or removed are the positive chips. I first fill the square with zeros, using 2 pairs of positive and negative pieces. The 2 pairs are used because the number of pairs of zeros is adjusted to the number of chips that need to be moved. Then, I remove the 2 positive chips from the box. I repeat this process until there are 6 negative chips in the box*"

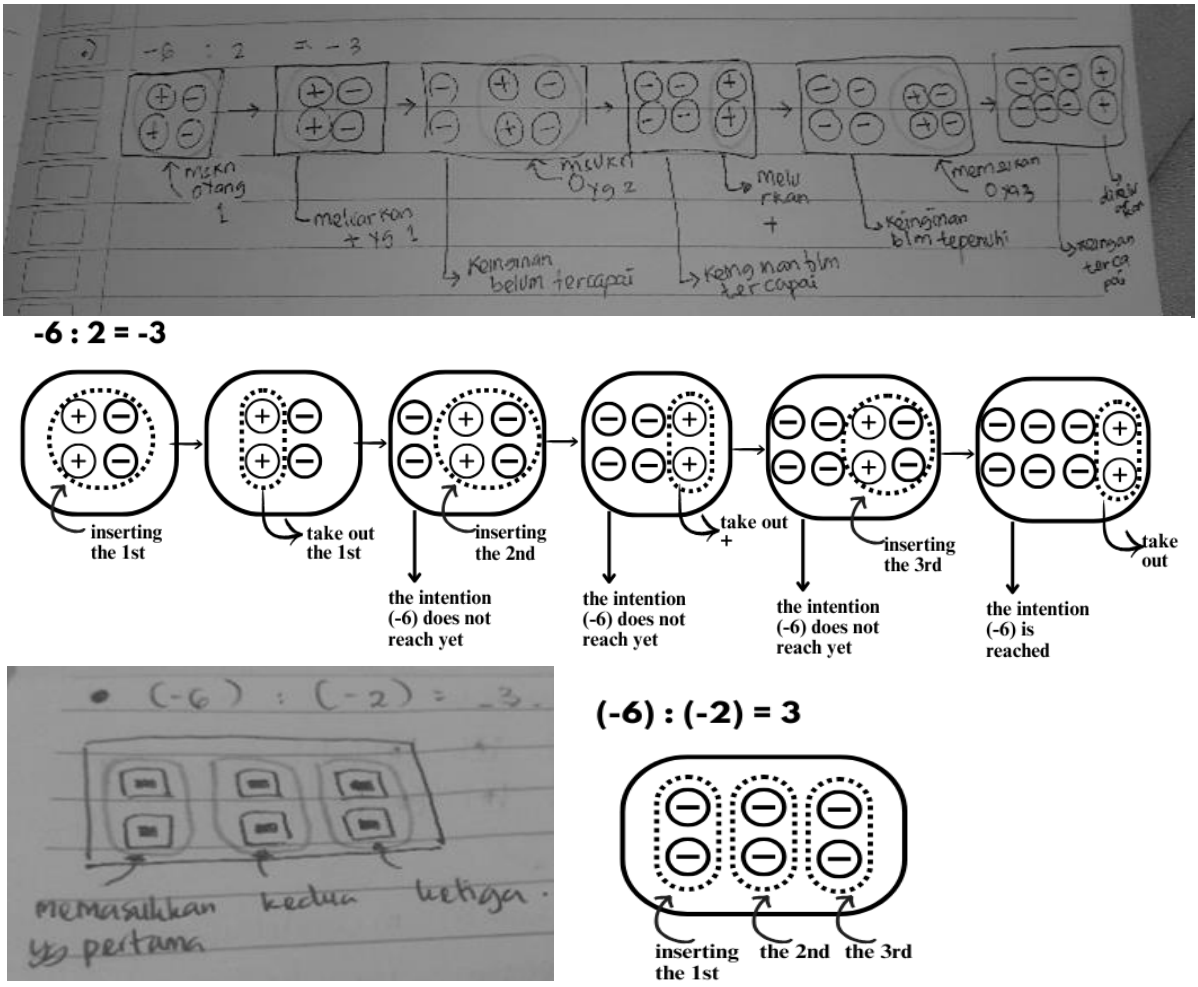


Figure 4. Correctly Illustrating the Integer Division Model While Demonstrating Understanding

Skill in Performing Integer Division

The results of the integer division comprehension test, which assessed the skill of performing integer division, indicate that there are four categories: 1) using downward division with proper separation of integer signs; 2) using downward division with appropriate attachment of integer signs; 3) incorrectly attaching integer signs; 4) without explaining any methods for performing integer operations.

Using Downward Division with Proper Separation of Integer Signs

In the first criterion, the subjects skillfully performed whole number division. They used the downward division method, accurately separating the integer signs without any errors. This is illustrated in Figure 5.

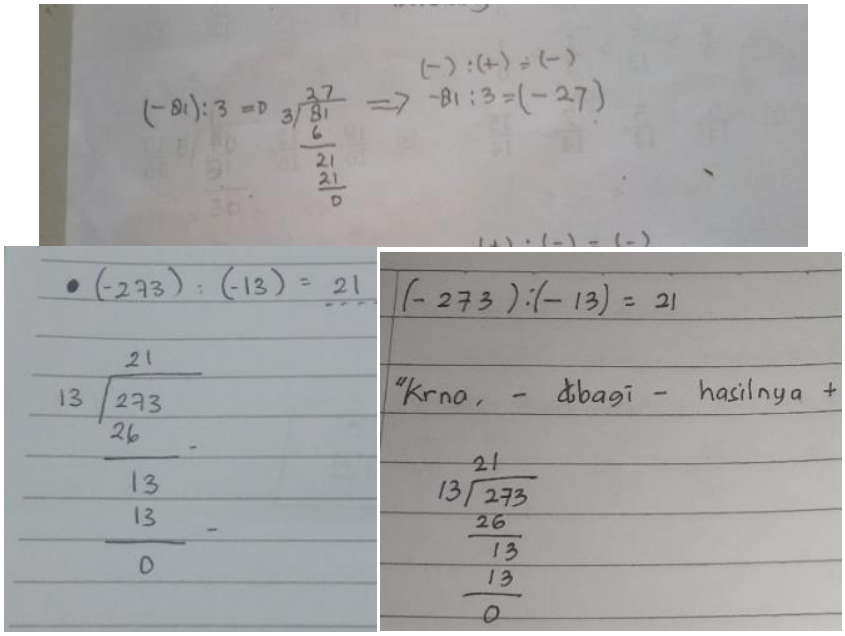


Figure 5. Downward Division with Proper Separation of Integer Signs

Using Downward Division with Appropriate Attachment of Integer Signs

In the second criterion, the subjects also skillfully performed integer division, but they did so differently than in the previous criterion, which involved using downward division by separating the integer signs. Instead, the subjects used the downward division method by attaching integer signs without any errors. This approach was effective only for division operations where one of the numbers was a negative integer; however, none of the subjects skillfully applied this method for division operations involving two negative integers. This is illustrated in Figure 6.

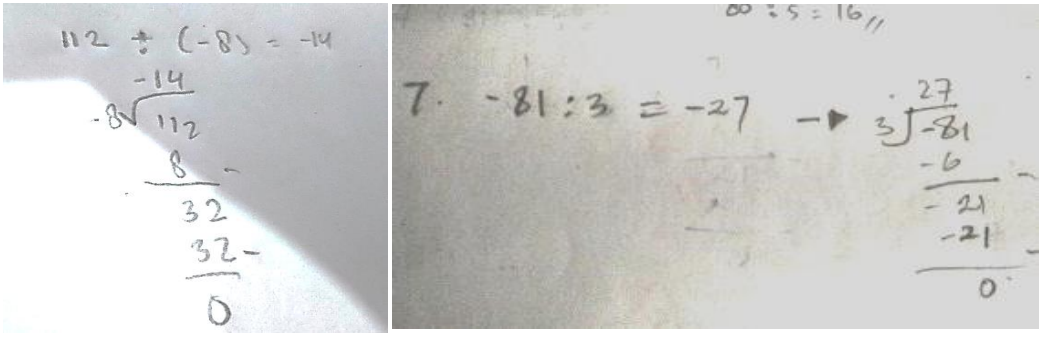


Figure 6. Downward Division with Appropriate Attachment of Integer Signs

Using Downward Division by Incorrectly Attaching Integer Signs

In the third criterion, the subjects divided integers with less skill. They used the downward division method by attaching integer signs but applied the method incorrectly. There were two types of mistakes made by the subjects:

a) The subjects divided the tens (-80) but wrote that what can be divided by 3 is 60 instead of (-60), which affected the division involving the units (-21); they should have used 21.
b) The subjects divided the tens (-80) and incorrectly wrote that what can be divided by 3 is (-80) instead of (-60). When subtracting (-81) from (-60), the subjects incorrectly stated that the result is 21 when it should have been (-21). Figure 7 illustrates these errors.

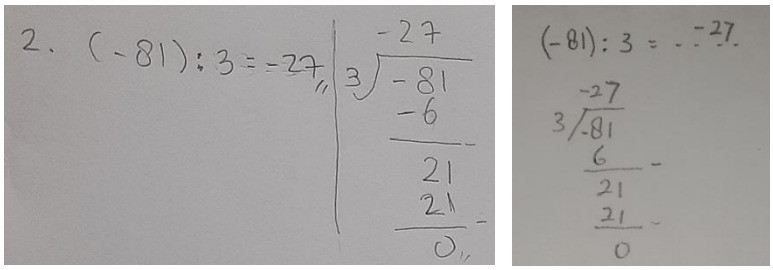


Figure 7. Attaching Integer Signs

Without Explaining Any Methods for Performing Integer Operations

In this fourth criterion, the subjects performed integer division without using any specific method. They simply wrote the division operation as presented in the question, adding the result of the operation. This is illustrated in Figure 8.

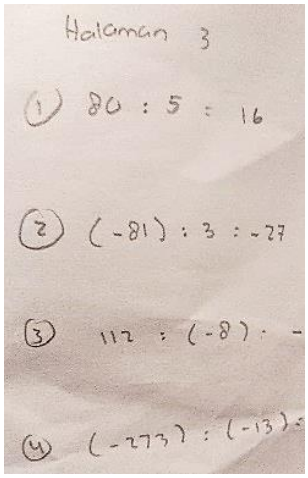


Figure 8. Without Explaining Any Method for Performing Integer Operations

According to Hawkins (Ma'rufi & Ilyas, 2017) there are three essential knowledge components for teachers in teaching mathematics: knowledge of mathematics, knowledge of teaching, and knowledge of students. Therefore, prospective teachers' understanding of mathematical concepts, including the division of integers, is a critical consideration when developing a *Madrasah Ibtidaiyah* or elementary school teacher education program. Without adequate understanding, prospective teachers may encounter difficulties in fulfilling their

responsibilities (Makaraka et al., 2021).

CONCLUSION

Prospective MI teachers should have a solid understanding of the signs of division results for whole numbers. Their ability to illustrate whole number division models falls into four categories, namely, unable to illustrate whole number division models, illustrating whole number division models incorrectly, illustrating whole number division models correctly but not using their own understanding, and illustrating whole number division models correctly with comprehension.

Additionally, the skills of prospective MI teachers in performing whole number division can be categorized as follows: correctly using downward division by separating whole number signs; correctly using downward division by attaching whole number signs; incorrectly using downward division by attaching whole number signs; and failing to explain any method for performing whole number operations.

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