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Preservice Mathematics Teachers' Self-Efficacy and Competence in using Visual Representations for Teaching Fractions

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ABSTRACT

Visual representation is crucial for enhancing students' conceptual understanding of fractions and correcting misconceptions. This explanatory-sequential mixed study assessed Indonesian preservice mathematics teachers' perceptions, self-efficacy, and implementation competencies using visual representations in fraction learning and identified gaps among these three aspects. A total of 251 students from three study programs participated in a validated online survey ($\alpha = 0.89$). Quantitative data were analyzed using descriptive statistics. Seven participants were then purposefully selected for semi-structured interviews; transcripts were analyzed using Braun & Clarke's six-stage thematic analysis with researcher triangulation. The results showed that although prospective teachers had a very high perception of the pedagogical value of visual representations ($M = 4.41$; $SD = 0.153$; 78.9% agreed/strongly agreed), their self-efficacy level was only in the moderate category ($M = 3.21$; $SD = 0.617$), with only 28.3% showing high efficacy, and 61.3% were in the medium category. Implementation competence was even lower, with only 17% of participants being able to select and explain visual models pedagogically and 27.8% meeting the sufficient criteria in the teaching reasoning test. The combined analysis of quantitative and qualitative data confirmed the existence of a systemic gap between strong conceptual understanding and limited practical skills, which was mainly caused by uncertainty in model selection, minimal misconception-oriented practical experience, and weak pedagogical reflection. Integrating high-fidelity micro-teaching, representational scenario-based simulations, and video reflections is recommended to enhance self-efficacy and implementation competency.

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A. INTRODUCTION

Visual representation is one of the key approaches in teaching fractions that aims to help students build deeper conceptual understanding. Through the use of models such as area, number lines, and other visual contexts, students can not only understand the meaning of fractions more concretely but also overcome common misconceptions that often arise in learning this topic (Patahuddin et al., 2018; Riccomini, 2020; Lee & Lee, 2023). The National Council of Teachers of Mathematics (NCTM) also emphasizes the importance of using various forms of mathematical representations in a meaningful and contextual way Joyner & Reys (2000) as part of effective mathematics learning, especially in fractions.

However, the effectiveness of visual representation in learning is highly dependent on teachers' pedagogical ability and self-confidence in implementing it systematically in the classroom. In the context of teacher education, several studies have shown that prospective mathematics teachers generally have a positive perception of the importance of visual representation. However, there is a significant gap between this conceptual understanding and their practical ability and self-efficacy in applying it in real life in the learning process (Lewis & Perry, 2017; Johnson & Siegler, 2022). This gap becomes even more striking in conceptually more complex fraction materials, such as multiplication and division of fractions, which require a more profound mastery of Pedagogical Content Knowledge (PCK) (Getenet & Callingham, 2021; Shih et al., 2023). Consequently, the affective dimension of self-efficacy becomes a key determinant: teachers who are confident in their abilities are more consistent and creative in using representations (Rittle-Johnson & Siegler, 2022).

In addition to beliefs, implementation competencies the skills to select, adapt, and explain visual models pedagogically often lag. Many teacher education programs in Indonesia still emphasize symbolic procedural mastery over misconception-based practice exercises (Fraser, 2019). The lack of high-fidelity micro-teaching and video reflections means that prospective teachers are less exposed to real-world scenarios, widening the theory-practice gap. The disconnect between conceptual perception, self-efficacy, and implementation competencies indicates a gap in the literature. Previous studies have generally focused on only one dimension for example, perception (Patahuddin et al., 2018) or PCK (Getenet & Callingham, 2021), without examining how the three relate to each other and influence readiness to teach fractions visually in the context of Indonesian mathematics study programs.

Furthermore, being an important part of studying in this study is The Role of Visual Representations in Teaching Fractures; Self-Efficacy and Its Influence on Teaching Practices; and Preservice Teachers' Competence and the Theory–Practice Gap. Visual representation has long been recognized as a very effective tool in mathematics education, especially in teaching the abstract concept of fractions that are often difficult for students to understand (Rau, 2017; Morano & Riccomini, 2020). Various forms of representation, such as area models, number lines, and set models, serve as cognitive bridges that connect students' concrete experiences with an abstract understanding of fractions (Morano & Riccomini, 2020; Lee & Lee, 2023). Through these representations, students can visualize fractional quantities, understand basic fraction operations, and develop a more flexible understanding of fractional relations and equivalences. These representations facilitate the conceptualization process and help reduce misconceptions and procedural errors common in learning fractions in elementary schools.

The National Council of Teachers of Mathematics (NCTM) explicitly recommends using multiple meaningful representations in mathematics instruction as part of effective teaching practices (Bowman et al., 2019). This is especially important in teaching multiplication and division of fractions, which are conceptually more complex and less intuitive than addition or subtraction. However, the effectiveness of this strategy is primarily determined by the teacher's ability to select and implement representations appropriate to the learning objectives and student characteristics (Rau & Matthews, 2017; Matsumoto-Royo & Montoya, 2021; Barbieri & Rodrigues, 2025). However, limited research examines explicitly how preservice mathematics teachers understand and operationalize visual representations in the context of more complex fraction operations. This indicates an important gap in the literature, namely the lack of understanding of preservice teachers' readiness to use visual representations pedagogically to teach fraction concepts that require high conceptual understanding.

In Addition, the concept of self-efficacy proposed by Bandura (2023) emphasizes that an individual's belief in their ability to complete a particular task greatly influences how they think, act, and respond to challenges. In education, teacher self-efficacy has been shown to impact instructional decision-making significantly, persistence in the face of difficulties, and openness to innovation in teaching practices (Wilcox & Lawson, 2018; Gesel et al., 2021). Mathematics teachers with high levels of self-efficacy tend to be more confident in implementing student-centered learning approaches, including using visual aids and concrete manipulatives in the learning process (Liljedahl & Oesterle, 2020). In other words, self-efficacy is a psychological indicator and an important predictor of a teacher's pedagogical practice quality.

However, several studies have shown that prospective mathematics teachers often experience low to moderate self-efficacy, especially when teaching abstract and complex materials, such as fraction operations through visual representations (Scherer & Bertram, 2024). This condition is a potential barrier to implementing learning strategies they understand conceptually. Although prospective teachers may recognize the importance of visual representations in supporting student understanding, low self-confidence in designing and implementing such strategies can reduce teaching effectiveness (O'Keeffe et al., 2019; Lemon, 2021; Lin et al., 2022). Unfortunately, little research explicitly explores the dynamics between prospective teachers' self-efficacy and their ability to implement visual representations for challenging mathematics topics. This creates an important gap in the teacher education literature, especially regarding how self-efficacy plays a role in bridging theoretical understanding and real teaching abilities in the field.

The persistent disconnect between theoretical knowledge and classroom practice further exacerbates this imbalance in self-efficacy. Although teacher education programs have provided prospective teachers with theoretical knowledge, many still have difficulty translating this understanding into effective teaching practices. This phenomenon is known as the theory-practice gap (Mitchell & Reid, 2017; Jenset et al., 2018; Henriksen et al., 2020). This gap becomes apparent in areas that require integration between conceptual knowledge and practical skills, such as using visual representations in teaching fractions (Rau & Matthews, 2017). Visual representations require mathematical understanding and pedagogical skills to select, modify, and apply appropriately according to the learning context. This shows that simply knowing the theory is not enough without being accompanied by direct experience that allows prospective teachers to develop confidence and implementation skills.

Research by Getenet & Callingham (2021) and Tossavainen (2024) emphasized that teaching fraction operations especially multiplication and division requires a deep mastery of Pedagogical Content Knowledge (PCK), a combination of understanding mathematical content with insight into how students learn. Unfortunately, many teacher education programs do not emphasize strengthening practical skills through microteaching, peer teaching, and teaching simulations (Aras & Güneş, 2024). As a result, prospective teachers often show a striking difference between their beliefs about the importance of representational learning strategies and their ability to apply them in the classroom. This gap is a significant challenge in ensuring the professional readiness of prospective mathematics teachers. While several studies have focused on one aspect such as perception (Patahuddin et al., 2018), self-efficacy (Wilcox & Lawson, 2018), or pedagogical competence (Getenet & Callingham, 2021), few have explored how these three dimensions interact in shaping preservice teachers' readiness to teach fractions using visual representation strategies. Therefore, this study aims to (1) measure prospective teachers' perceptions and their self-efficacy of the urgency of visual representation in teaching fractions, (2) assess the implementation competence of preservice mathematics teachers in using visual representations to teach fractions, and (3) analyze the gap between conceptual perceptions, self-efficacy, and implementation competence of preservice mathematics teachers in using visual representations to teach fractions.

B. METHODS

1. Research Design

This study used quantitative and qualitative approaches with a descriptive-exploratory design. This approach was chosen to understand the relationship between self-efficacy, perceptions of visual representations, and the implementation competence of prospective teachers in teaching fractions. This design allows researchers to describe general tendencies through quantitative data and qualitatively analyze participants' practical abilities through responses in teaching reasoning tasks. This study focuses on the context of teaching fraction operations, especially multiplication and division, which demand high-level pedagogical skills.

2. Participants

Participants in this study consisted of 251 students of the Mathematics Education study program from three state universities in Indonesia. Two institutional criteria are employed to determine the selection of universities: (a) The status of state universities that have implemented an outcome-based education (OBE) curriculum; (b) The Mathematics Education Study Program has been granted "superior" accreditation. They were selected using a purposive sampling technique, with the inclusion criteria that they had: (1) completed courses related to school mathematics, and (2) participated in at least one learning practice activity, such as microteaching or peer teaching. The composition of participants reflects diversity in terms of year of study, gender, and academic achievement (Table 1), which provides a comprehensive representation of the level of readiness of prospective teachers in implementing visual representation-based learning strategies. Furthermore, six students (Table 2) were selected purposively to be interviewed further from the total participants. The selection of interview subjects was based on the initial analysis of the survey results and reasoning tests, considering variations in the level of self-efficacy and quality of responses to the visual representation task. This strategy aims to capture the spectrum of experiences and perspectives of prospective teachers from different levels of confidence and competence to deepen the interpretation of quantitative data and identify practical challenges faced in implementing visual representation, as shown in Table 1.

Table 1. Participant Characteristics

Characteristics		Frequency (n)	Percentage (%)
Gender	Female	178	71%
	Male	73	29%
Year of Study	2nd year	87	35%
	3rd year	102	41%
	4th year	62	24%
Microteaching Experience	Yes	251	100%
	No	0	0%
Experience teaching in schools	Yes	71	28%
	No	180	72%
Experience using visual representation	Yes	197	78%
	No	54	22%

Table 2. Interview participants

Initial name	Gender	Length of study	Teaching experience in schools	Self-efficacy level
LZ	Female	2 years	No	Very good
NW	Male	3 years	Yes	Very good
EM	Female	3 years	Yes	Good
AR	Male	2 years	Yes	Very good
RR	Male	2 years	No	Very good
AN	Female	3 years	Yes	Good
SY	Female	3 years	Yes	Very good

3. Data Collection

Data were collected through two main instruments: (1) an online questionnaire designed to measure perceptions of the importance of visual representations, levels of self-efficacy in their use, and perceptions of implementation competence, (2) a fraction teaching reasoning test designed to evaluate participants' ability to design and explain fraction teaching strategies using visual representations, and (3) semi-structured interviews. Data collection was conducted over two weeks, and all participants were asked to complete both instruments in the same order to maintain data consistency.

4. Instrument

The instrument used in this study consisted of three main components: a questionnaire, a teaching reasoning test, and a semi-structured interview guide. The questionnaire was structured in the form of a 5-point Likert scale. It included three subscales: (1) perception of the importance of visual representation (6 items), (2) self-efficacy in using visual representation (8 items), and (3) perception of implementation competence in teaching fraction operations (6 items). This instrument was developed based on an adaptation of Lamon's (2020) framework and then adjusted to the context of fraction operations learning in elementary schools. Three mathematics education experts reviewed content validity, while the reliability test produced a Cronbach's alpha value of 0.82, indicating good internal consistency.

The teaching reasoning test consists of three authentic scenarios depicting situations in teaching fractions, specifically multiplication and division. Each scenario asks participants to (1) identify potential student misconceptions, (2) design an appropriate visual representation, and (3) explain the pedagogical rationale behind their choice of representation. The test is designed to contextualize participants' depth of understanding and implementation skills. This instrument was validated by three mathematics education experts (two professors and one teacher practitioner) using the Content Validity Index (CVI). Each item is assessed on a scale of 1–4 (irrelevant - very relevant). The I-CVI value of the entire grain is in the range of 0.83-1.00, with S-CVI/Ave = 0.92, exceeding the recommended 0.80 limit (Almanasreh et al., 2019).

In addition, semi-structured interviews were conducted with seven purposively selected participants based on survey scores and test performance variations. The interview guide included questions that explored participants' perceptions of implementation challenges, experiences using visual representations during practice or microteaching, and factors that influenced their confidence in teaching them. Data from the interviews were used to complement and deepen the interpretation of the quantitative results and to identify patterns of experience not revealed in the survey and test data.

5. Data Analysis

The questionnaire data were descriptively analyzed to identify general trends in the self-efficacy levels, implementation competencies, and perceptions of prospective teachers. Additionally, Pearson correlation analysis was implemented to investigate the correlations among the three variables. In the interim, the teaching reasoning test data were qualitatively analyzed using content analysis techniques (Hsieh & Shannon, 2005). The analysis is carried out in four stages. First, open coding is carried out manually independently by two researchers. Each unit of meaning (i.e., sentence or clause that is intact in ideas) is labeled as an initial code that represents aspects such as the type of representation, the suitability of the strategy of the learning objectives, and the quality of pedagogical reasons. Second, the group grouping is done through a thematic categorization process with constant comparison techniques. Codes with similar meanings are combined into the main categories, namely: (1) Surface-Level Representation vs Conceptual Representation, (2) Procedural vs. conceptual strategy, and (3) low, medium, and high-level pedagogical reasons. Third, the validation of the initial findings was carried out through discussions between researchers. Fourth, data triangulation is carried out by quantitatively comparing the results of qualitative analysis with a self-efficacy questionnaire and the reasoning test results. This comparison helps reveal the mismatch between participants' perceptions and actual competencies.

C. RESULT AND DISCUSSION

1. RQ1. What are Prospective Mathematics Teachers' Perceptions and Self-Efficacy Toward Using Visual Representation in Fractions?

The results of data analysis from a questionnaire filled out by 251 students of the mathematics education study program showed that, in general, prospective teachers have a very positive perception of the importance of using visual representations in teaching fractions. The average score on the perception scale was 4.41 (SD = 0.153) on a Likert scale range of 1–5, indicating a high level of recognition of the pedagogical value of visual representations such as area models, number lines, and set models in building students' conceptual understanding. Most respondents (78.9%) chose the category "agree" or "strongly agree" for items such as "visual representations help students understand fraction operations more deeply" and "the use of visuals reduces misconceptions in learning fractions."

However, when viewed from the aspect of self-efficacy, the results showed a tendency towards a lower level of self-confidence, with an average score of 3.21 (SD = 0.617). Only about 28.3% of respondents indicated a high level of self-efficacy (score > 4.00), while the majority (61.3%) were in the medium category, and the rest (10.3%) were in the low category. The items with the lowest scores included statements such as: "I am confident that I can explain fraction division operations using visual representations effectively" and "I feel able to adjust the type of visual representation to the characteristics of students' errors." The following is descriptive statistical, as shown in Table 3.

Table 3. Descriptive Statistics of Prospective Teachers' Perceptions and Self-Efficacy towards Visual Representation

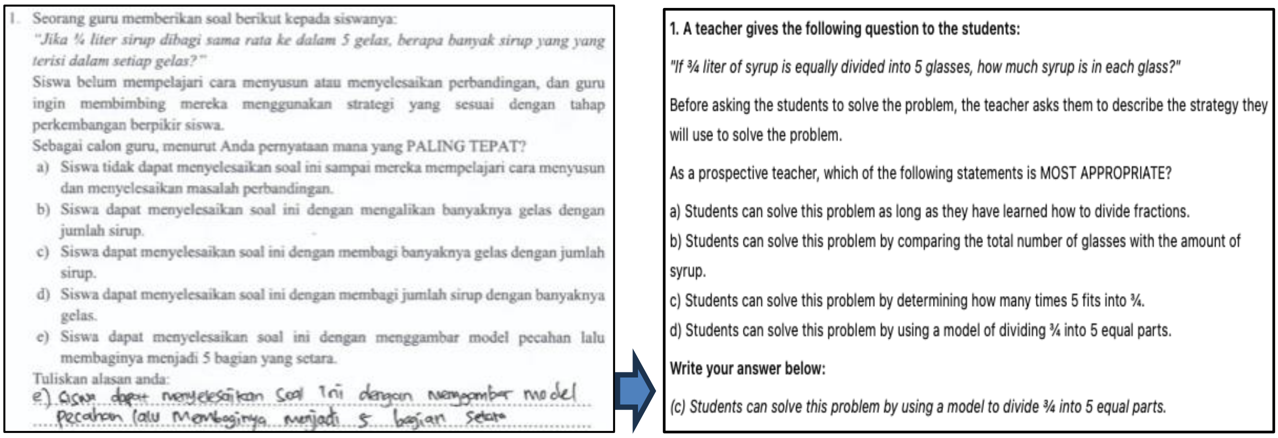
Scale	Number of items	Min score	Max. Score	Mean	SD	Category
Perception of Visual Representation	6	2.83	5.00	4.41	0.153	High (78.9%)
Self-Efficacy of Visual Representation	6	2.00	4.88	3.21	0.617	Medium (61.3%)

The significant difference between positive perceptions and relatively moderate to low self-efficacy indicates an imbalance between conceptual knowledge and implementation self-efficacy, which can hinder the effective classroom implementation of visual learning strategies. This aligns with previous findings Liljedahl & Oesterle (2020), emphasizing that positive perceptions of innovative approaches are not always accompanied by sufficient self-efficacy to implement them in real practice. This gap reflects one of the classic problems in teacher education, namely the disconnect between theory and practice. As Aalto et al. (2019) stated, many teacher education programs overemphasize theoretical aspects without providing enough space for students to internalize and practice pedagogical skills through concrete experiences. In this study, although prospective teachers understand the urgency and benefits of visual representations in fraction learning, they have not fully had sufficient practical experience to grow their confidence in using them flexibly and contextually in the classroom. This is reinforced by the results of interviews, which showed that most respondents felt unsure about being able to choose or adjust the type of visual representation that suits students' errors or needs, especially in teaching multiplication and division of fractions, which are cognitively more complex.

This finding also aligns with Schütze et al. (2017), who found that teacher self-efficacy is closely related to concrete and reflective teaching experiences, not just declarative knowledge. This means that understanding concepts alone is not enough to foster self-efficacy in teaching; direct experience, support in lesson planning, and feedback from real practice are significant. In this study, most participants only had limited experience in the form of short microteaching or observation, which did not provide enough space for them to build a sense of mastery over visual-based learning strategies. On the other hand, this finding contradicts the study by Van Garderen et al. (2018) and Scherer & Bertram (2024), which showed that student teachers who were provided with intensive training based on manipulatives and visual representations in classroom practice showed a high level of efficacy in implementing the strategy. This difference is likely due to the intensity and quality of the practical experience in the teacher education programs being compared. In many education programs in Indonesia, practice-based training is often symbolic or fragmented, without strong integration with Pedagogical Content Knowledge (PCK) development. Overall, these results highlight the need for redesigning teacher education curricula that emphasize the integration of conceptual, affective, and practical aspects. Without support for affective dimensions such as self-efficacy, even strong conceptual knowledge is at risk of not being optimally implemented in real classroom learning. Strengthening implementation competencies through intensive microteaching, representational scenario-based teaching simulations, and video-based pedagogical reflection can be strategic approaches that need to be considered to close this gap.

2. RQ2. How is the Implementation Competence of Prospective Mathematics Teachers in using Visual Representation to Teach Fractions?

The fraction teaching reasoning test results revealed significant variations in prospective mathematics teachers' implementation competencies, especially in using visual representations to help students' understanding. In general, only about 17% of participants showed high abilities in selecting, using, and explaining visual representations appropriately and pedagogically. Most participants were at a moderate level, namely being able to mention visual models but not yet being able to relate them to students' thinking stages or explicitly address misconceptions. One example of an answer that illustrates intermediate implementation competence is: *"If ¾ liter of syrup is divided equally into 5 glasses, how much syrup is filled in each glass?"*, as shown in Figure 1.


1. Seorang guru memberikan soal berikut kepada siswanya:

"Jika ¾ liter sirup dibagi sama rata ke dalam 5 gelas, berapa banyak sirup yang yang terisi dalam setiap gelas?"

Siswa belum mempelajari cara menyusun atau menyelesaikan perbandingan, dan guru ingin membimbing mereka menggunakan strategi yang sesuai dengan tahap perkembangan berpikir siswa.

Sebagai calon guru, menurut Anda pernyataan mana yang PALING TEPAT?

a) Siswa tidak dapat menyelesaikan soal ini sampai mereka mempelajari cara menyusun dan menyelesaikan masalah perbandingan.
b) Siswa dapat menyelesaikan soal ini dengan mengalikan banyaknya gelas dengan jumlah sirup.
c) Siswa dapat menyelesaikan soal ini dengan membagi banyaknya gelas dengan jumlah sirup.
d) Siswa dapat menyelesaikan soal ini dengan membagi jumlah sirup dengan banyaknya gelas.
e) Siswa dapat menyelesaikan soal ini dengan menggambar model pecahan lalu membaginya menjadi 5 bagian yang setara.

Tuliskan alasan anda:

e) siswa dapat menyelesaikan soal ini dengan menggambar model pecahan lalu membaginya menjadi 5 bagian setara

1. A teacher gives the following question to the students:

"If ¾ liter of syrup is equally divided into 5 glasses, how much syrup is in each glass?"

Before asking the students to solve the problem, the teacher asks them to describe the strategy they will use to solve the problem.

As a prospective teacher, which of the following statements is MOST APPROPRIATE?

a) Students can solve this problem as long as they have learned how to divide fractions.
b) Students can solve this problem by comparing the total number of glasses with the amount of syrup.
c) Students can solve this problem by determining how many times 5 fits into ¾.
d) Students can solve this problem by using a model of dividing ¾ into 5 equal parts.

Write your answer below:

(c) Students can solve this problem by using a model to divide ¾ into 5 equal parts.

Figure 1. Student's answers (EM)

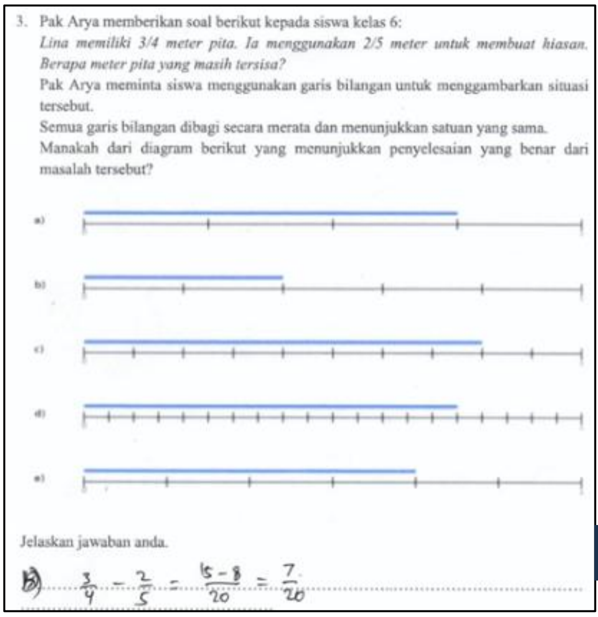
One student chose option (e) as the most appropriate strategy: *"Students can solve this problem by drawing a fraction model and then dividing it into 5 equal parts."* Although this answer shows a correct tendency in directing students to use visual representations (fraction models), the participant's further explanation is limited to mentioning the action of *"drawing a fraction model and then dividing it"* without specifying the type of model in question (e.g., area model, number line, or set), or explaining how the model helps overcome students' conceptual barriers. There is no further exploration of how visualization can facilitate the understanding of dividing fractions by whole numbers in non-routine contexts. This reflects that the level of implementation competence is still limited to reproducing general strategies, not reflective didactic justification.

Findings from interviews with seven selected students reinforce this result. Two informants stated: *"I know pictures can help students, but sometimes I do not know which model to use. I am afraid that it will only confuse me. I do not know which model is most suitable for this problem"* (NW). *"When I tried to use the microteaching time, but I wasn't sure it helped or was even confusing. I don't understand how to adjust the model to the characteristics of students. "*(RR)

This statement shows that although students have conceptual knowledge about various visual representations, they do not yet have the practical skills and confidence to apply them appropriately in meaningful learning contexts. In addition, several participants mentioned that visual representations were discussed more theoretically than practiced in authentic teaching simulations or microteaching during lectures. This limitation is in line with the findings of Norton (2019), which showed that mastery of mathematical content knowledge (MCK) does not guarantee success in pedagogical content knowledge (PCK), especially in the aspects of representation and anticipation of student responses. Likewise, a study conducted by Hill and Chin (2018) emphasizes the importance of the relationship between conceptual understanding, representation selection, and pedagogical decisions in designing learning responsive to student misconceptions.

These findings indicate that many preservice teachers have not fully integrated conceptual understanding with implementation skills. They need learning experiences more oriented towards reflective and contextual practice, for example, through microteaching activities based on misconception cases, lesson studies, or reflections based on video analysis. Such training is important to build professional acumen in selecting and using appropriate visual representations, not only from a mathematical perspective but also from the perspective of students' thinking development.

The third question in the fraction teaching reasoning test challenges participants to use a number line as a visual representation to solve a contextual problem of subtracting two different fractions: *"Lina has ¾ of a meter of ribbon. She used 2/5 of a meter to make a decoration. How many meters of ribbon are left?".* This question tests prospective teachers' ability to select the most accurate visual representation (from five number line diagram options) and include a mathematical explanation to support their choice, as shown in Figure 2.



2. Mr. Arya gives the following problem to 6th grade students:

Lina bought ¾ meter of ribbon. She used ⅖ meter to make a bow.
How many meters of ribbon are left?

Mr. Arya asks students to use number lines to represent the situation.

All number lines are drawn with the same scale and show the same units.

Which number line below correctly shows the solution to the problem?

Explain your answer.

(b) ¾ – ⅖ = 15⁄20 – 8⁄20 = 7⁄20

Figure 2. Student's answers (AR)

One student chose option (b) as the most appropriate answer and included a numerical subtraction process:

$$\frac{3}{4} - \frac{2}{5} = \frac{15}{20} - \frac{8}{20} = \frac{7}{20}$$

Mathematically, the subtraction operation is performed correctly by making the same denominators. However, the discrepancy occurs in the visual representation selection because, in option (b), the number line model does not accurately depict the difference in the length of two fractions based on different units (quarters and fifths). This finding indicates that although students can perform numerical procedures correctly, their ability to connect the operation with an accurate visual representation is still weak. In a follow-up interview, the student who gave this answer explained: *"I chose (b) because the line looks long enough to show the remainder. But I'm not sure if the units are correct."* (LZ)

This statement confirms that students' understanding of the function of visual representation has not fully developed—they tend to choose intuitively based on visual form without verifying the consistency of units or relations between fractions in the context of the number line. This reflects limitations in visual-pedagogical competence, namely the ability to choose and use visual models that are mathematically correct and support students' conceptual understanding.

This finding aligns with the study by Moleko (2021) and Mainali (2021), which showed that prospective mathematics teachers are more fluent in solving mathematical problems symbolically than using visual representations in the teaching context. This can be explained by teacher education curricula' tendency to emphasize procedural and symbolic mastery more than pedagogical-visual aspects. In this context, visual representations are often positioned as a complement, not as the primary tool for building students' conceptual understanding, so they receive less explicit attention in prospective teacher training. Research by Van Garderen et al.

(2018) also underlines a similar problem, namely low representational fluency among novice teachers, especially in moving from symbolic expressions to visual models that support the construction of meaning. This obstacle is often caused by limited experience using various forms of representation during teacher training and low sensitivity to the stages of students' thinking in fractions. Novice teachers tend to see visual models as illustrations, not as a medium for mathematical thinking and argumentation, as shown in the study by Appova & Taylor (2019), which states that visual representations require pedagogical content knowledge that cannot be developed only through procedural exercises.

However, these results differ from the findings of Zhou (2024), who found that preservice teachers who participated in simulation-based training and microteaching showed significant improvements in their ability to select, interpret, and adapt visual representations in the context of mathematics teaching. This difference is likely due to the different learning approaches used in the teacher training program. Simulation-based programs allow preservice teachers to interact directly with authentic classroom contexts and engage in pedagogical reflection on their representation choices two things that are not always present in conventional learning.

Furthermore, DePiper & Driscoll (2018) and Munter & Wilhelm (2021) showed that strong mathematical knowledge for teaching (MKT) needs to be complemented by the ability to analyze and respond to visual representations used by students in solving problems. If teacher training does not systematically train these skills, it is natural that prospective teachers have difficulty in implementing visual representations effectively. This emphasizes integrating case-based learning experiences, pedagogical reflection, and multi-representational exploration into teacher education curricula. Thus, the contrast between the findings in this study and the study by Zhou (2024) can be understood as a reflection of the differences in the structure and intensity of practical experiences provided in teacher education programs. These findings also strengthen the argument that improving prospective teachers' implementation competence is about increasing conceptual knowledge and how teaching experiences are systematically and contextually structured to foster self-confidence, representational flexibility, and deep pedagogical acumen.

3. RQ3. is There a Gap Between Conceptual Perceptions, Self-Efficacy, and Implementation Competencies of Prospective Mathematics Teachers in Using Visual Representations for Teaching Fractions?

The combined analysis of the survey, fraction teaching reasoning test, and in-depth interviews revealed a clear and significant gap between prospective mathematics teachers' conceptual perceptions of the importance of visual representations, their level of self-efficacy in using them, and their actual implementation competence in the context of fraction teaching. Although more than 82% of respondents showed high scores on the scale of perceptions of the urgency of using visual representations in fraction teaching (Mean = 4.31; SD = 0.47), only about 39% had high levels of self-efficacy in implementing them (Mean = 3.21; SD = 0.68). When tested through a scenario-based pedagogical reasoning test instrument, only 27.8% of the participants showed adequate implementation skills in selecting and explaining pedagogically appropriate visual models. The rest showed symbolic or descriptive answers that were not equipped with strong representational considerations.

As an illustration, one participant chose the correct statement in a fraction division problem and answered correctly that students could draw a model and divide it into five equivalent parts. However, the further explanation was minimal, only stating "drawing a fraction model and then dividing it into five equivalent parts" without including a concrete description or pedagogical justification that reflects an understanding of the stages of student thinking or the relationship between fractions and division. Answers like this indicate that participants generally understand the concept but cannot fully transform it into effective visual-based teaching practices. Furthermore, interviews with seven selected participants confirmed this gap. Most of them stated that they *'understand the importance of fraction pictures or models'* but feel unsure about how to use them appropriately in the classroom. One participant said, *"When I was learning the theory, I felt I understood it. However, when asked to draw and explain it, I was confused about whether my method was right"* (EM). *"I know that the area and number line models are often used to teach fractions. But when I tried myself for fractional multiplication material, I was even confused from where and what to explain"*(AR).

This statement reflects unstable self-efficacy and weak pedagogical content knowledge in translating visual representations into meaningful learning tools. These findings consistently show that although conceptual perceptions of the importance of visual representation in fraction learning are high, prospective teachers' self-efficacy and implementation skills lag significantly behind. This imbalance confirms that conceptual knowledge does not immediately transform into applicable pedagogical skills, especially in learning contexts requiring visual representation flexibility. One of the primary explanations for this condition is that many teacher education programs still emphasize declarative and theoretical aspects without providing enough space for explicit exercises, practice-based learning, and reflective integration into classroom practice (Moody et al., 2022).

This gap reflects the ineffectiveness of theoretical curricula and the need to contextualize learning through real experiences in authentic teaching situations. This is in line with the findings of Chapman (2017), which showed that teachers with good mathematical understanding cannot transfer it effectively in representation-based learning due to the lack of skills in responding to students' needs visually and concretely. Likewise, Rau (2017) emphasized that representational fluency - the ability to move between forms of representation (visual, symbolic, verbal), can only be developed through explicit instructional design, direct teaching experience, and reflection on student interactions. In addition, research by Bessette & Paris (2020) showed that prospective teachers often get stuck in symbolic procedures because they are less accustomed to interpreting and utilizing visual representations as cognitive tools in facilitating student understanding. In a study by van Garderen et al. (2021), although preservice teachers understood that visual representations were important, they still struggled to apply them to bridge students' conceptual gaps especially in topics such as fraction operations, which are abstract and prone to misconceptions.

However, these results differ from the study by Levin & Flavian (2022), which showed that prospective teachers who participated in simulation-based teaching training and video-based case studies significantly improved the selection and use of visual representations. This difference strengthens the hypothesis that the main factor mediating the success of visual representation implementation is cognitive capacity and the quality of the learning experience experienced by prospective teachers, including the intensity of practice-based training, exposure to diverse student responses, and habituation to pedagogical reflection. Thus, the findings of this study require a paradigm shift in teacher education from merely reinforcing content knowledge to a comprehensive integration of content, pedagogy, and representational practices. Teacher education curriculum reform needs to ensure that prospective teachers know what, why, and how to concretely integrate visual representations into learning designs and practices responsive to student thinking in real classrooms.

D. CONCLUSION AND SUGGESTIONS

This study contributes conceptually to teacher education by comprehensively mapping the gap between perception, self-efficacy, and competency implementation of visual representation of fractions to prospective mathematics teachers. The results confirm that high conceptual understanding is not enough- self-efficacy and practice skills are determining pedagogical readiness. This mapping can be used as a diagnostic framework for teacher educational institutions to assess the weak points of prospective teachers in a sharper manner. To bridge the gap, we recommend the following practical-based program: (1) Case-based micro teaching cycle with five stages-Briefing, Enactment, Video-based Reflection, Peer Feedback, and Re-Teaching-with scenarios of teaching deliberately containing student misconceptions; (2) Interactive Classroom Simulation so that prospective teachers can practice selecting and modifying visual models according to context. The integration of the two intervention models into related courses is believed to increase self-confidence as well as significant implementation skills. Research limitations include the scope of samples that only come from three state universities in Indonesia. Therefore, further research is advised to use a longitudinal and controlled experimental approach to assess the effect of case-student-based intervention on changes in self-efficacy and performance in class.

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REFERENCES

Aalto, E., Tarnanen, M., & Heikkinen, H. L. T. (2019). Constructing a pedagogical practice across disciplines in preservice teacher education. *Teaching and Teacher Education*, *85*, 69–80. https://doi.org/10.1016/j.tate.2019.06.006

Almanasreh, E., Moles, R., & Chen, T. F. (2019). Evaluation of methods used for estimating content validity. *Research in social and administrative pharmacy*, *15*(2), 214-221. https://doi.org/10.1016/j.sapharm.2018.03.066

Appova, A., & Taylor, C. E. (2019). Expert mathematics teacher educators' purposes and practices for providing prospective teachers with opportunities to develop pedagogical content knowledge in content courses. *Journal of Mathematics Teacher Education*, *22*, 179–204. https://doi.org/10.1007/s10857-017-9385-z

Bandura, A. (2023). Cultivate self-efficacy for personal and organizational effectiveness. *Principles of Organizational Behavior: The Handbook of Evidence-Based Management 3rd Edition*, 113–135. https://doi.org/10.1002/9781405164047.ch9

Barbieri, C. A., & Rodrigues, J. (2025). Leveraging cognitive load theory to support students with mathematics difficulty. *Educational Psychologist*, 1-

25. https://doi.org/10.1080/00461520.2025.2486138

Bessette, H. J., & Paris, N. A. (2020). Using visual and textual metaphors to explore teachers' professional roles and identities. *International Journal of Research & Method in Education*, *43*(2), 173–188. https://doi.org/10.1080/1743727X.2019.1611759

Bowman, J. A., McDonnell, J., Ryan, J. H., & Fudge-Coleman, O. (2019). Effective mathematics instruction for students with moderate and severe disabilities: A literature review. *Focus on Autism and Other Developmental Disabilities*, *34*(4), 195–204. https://doi.org/10.1177/1088357619827932

Chapman, O. (2017). Understanding and enhancing teachers' knowledge for teaching mathematics. *Journal of Mathematics Teacher Education*, *20*, 303–307. https://doi.org/10.1007/s10857-017-9377-z

DePiper, J. N., & Driscoll, M. (2018). Teacher knowledge and visual access to mathematics. In *Pedagogical Content Knowledge in STEM: Research to Practice* (pp. 83–102). Springer. https://doi.org/10.1007/978-3-319-97475-0_5

Fraser, S. (2019). Understanding innovative teaching practice in higher education: a framework for reflection. *Higher Education Research & Development*, *38*(7), 1371–1385. https://doi.org/10.1080/07294360.2019.1654439

Gesel, S. A., LeJeune, L. M., Chow, J. C., Sinclair, A. C., & Lemons, C. J. (2021). A meta-analysis of the impact of professional development on teachers' knowledge, skill, and self-efficacy in data-based decision-making. *Journal of Learning Disabilities*, *54*(4), 269–283. https://doi.org/10.1177/0022219420970196

Getenet, S., & Callingham, R. (2021). Teaching interrelated concepts of fractions for understanding and teacher's pedagogical content knowledge. *Mathematics Education Research Journal*, *33*(2), 201–221. https://doi.org/10.1007/s13394-019-00275-0

Henriksen, D., Gretter, S., & Richardson, C. (2020). Design thinking and the practicing teacher: Addressing problems of practice in teacher education. *Teaching Education*, *31*(2), 209–229. https://doi.org/10.1080/10476210.2018.1531841

Hill, H. C., & Chin, M. (2018). Connections between teachers' knowledge of students, instruction, and achievement outcomes. *American Educational Research Journal*, *55*(5), 1076–1112. https://doi.org/10.3102/0002831218769614

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative health research*, *15*(9), 1277-1288. https://doi.org/10.1177/1049732305276687

Jenset, I. S., Klette, K., & Hammerness, K. (2018). Grounding teacher education in practice around the world: An examination of teacher education coursework in teacher education programs in Finland, Norway, and the United States. *Journal of Teacher Education*, *69*(2), 184–197. https://doi.org/10.1177/0022487117728248

Joyner, J., & Reys, B. (2000). Principles and standards for school mathematics: what's in it for you? *Teaching Children Mathematics*, *7*(1), 26–29. https://doi.org/10.5951/TCM.7.1.0026

Lamon, S. J. (2020). *Teaching fractions and ratios for understanding: Essential content knowledge and instructional strategies for teachers*. Routledge. https://doi.org/10.4324/9781003008057

Lee, J.-E., & Lee, M. Y. (2023). How elementary prospective teachers use three fraction models: their perceptions and difficulties. *Journal of Mathematics Teacher Education*, *26*(4), 455–480. https://doi.org/10.1007/s10857-022-09537-4

Lemon, N. (2021). Wellbeing in initial teacher education: using poetic representation to examine pre-service teachers' understanding of their self-care needs. *Cultural Studies of Science Education*, *16*(3), 931-950. https://doi.org/10.1007/s11422-021-10034-y

Levin, O., & Flavian, H. (2022). Simulation-based learning in the context of peer learning from the perspective of preservice teachers: A case study. *European Journal of Teacher Education*, *45*(3), 373–394. https://doi.org/10.1080/02619768.2020.1827391

Lewis, C., & Perry, R. (2017). Lesson study to scale up research-based knowledge: A randomized, controlled trial of fractions learning. *Journal for Research in Mathematics Education*, *48*(3), 261–299. https://doi.org/10.5951/jresematheduc.48.3.0261

Liljedahl, P., & Oesterle, S. (2020). Teacher beliefs, attitudes, and self-efficacy in mathematics education. *Encyclopedia of Mathematics Education*, 825–828. https://doi.org/10.1007/978-94-007-4978-

8_149

Lin, C., Han, C., Huang, Y., Chen, L., & Su, C. C. (2022). Effectiveness of the use of concept maps and simulated cases as a teaching-learning strategy in enhancing the learning confidence of baccalaureate nursing students: A qualitative approach. *Nurse Education Today*, *115*, 105418. https://doi.org/10.1016/j.nedt.2022.105418

Mainali, B. (2021). Representation in teaching and learning mathematics. *International Journal of Education in Mathematics, Science and Technology*, *9*(1), 1–21. https://doi.org/10.46328/ijemst.1111

Mathewson Mitchell, D., & Reid, J.-A. (2017). (Re) turning to practice in teacher education: Embodied knowledge in learning to teach. *Teachers and Teaching*, *23*(1), 42–58. https://doi.org/10.1080/13540602.2016.1203775

Matsumoto-Royo, K., & Ramírez-Montoya, M. S. (2021). Core practices in practice-based teacher education: A systematic literature review of its teaching and assessment process. *Studies in Educational Evaluation*, *70*, 101047. https://doi.org/10.1016/j.stueduc.2021.101047

Moleko, M. M. (2021). Teachers' perspectives on addressing linguistic factors affecting visualisation of mathematics word problems. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(11), em2029. https://doi.org/10.29333/ejmste/11248

Moody, S. M., Kuo, L.-J., & Eslami, Z. R. (2022). Learning to Be Teachers: Preservice Teacher Descriptions of Practice-Based Teacher Education. *Issues in Teacher Education*, *31*(3), 5–25. https://eric.ed.gov/?id=EJ1362796

Morano, S., & Riccomini, P. J. (2020). Demonstrating conceptual understanding of fraction arithmetic: An analysis of preservice special and general educators' visual representations. *Teacher Education and Special Education*, *43*(4), 314–331. https://doi.org/10.1177/0888406419880540

Munter, C., & Wilhelm, A. G. (2021). Mathematics teachers' knowledge, networks, practice, and change in instructional visions. *Journal of Teacher Education*, *72*(3), 342–354. https://doi.org/10.1177/0022487120949836

Norton, S. (2019). Middle school mathematics preservice teachers' content knowledge, confidence and self-efficacy. *Teacher Development*, *23*(5), 529–548. https://doi.org/10.1080/13664530.2019.1668840

O'Keeffe, L., Paige, K., & Osborne, S. (2019). Getting started: Exploring pre-service teachers' confidence and knowledge of culturally responsive pedagogy in teaching mathematics and science. *Asia-Pacific Journal of Teacher Education*, *47*(2), 152-175. https://doi.org/10.1080/1359866X.2018.1531386

Patahuddin, S. M., Usman, H. B., & Ramful, A. (2018). Affordances from number lines in fractions instruction: Students' interpretation of teacher's intentions. *International Journal of Science and Mathematics Education*, *16*, 909–928. https://doi.org/10.1007/s10763-017-9800-z

Rau, M. A. (2017). Conditions for the effectiveness of multiple visual representations in enhancing STEM learning. *Educational Psychology Review*, *29*, 717–761. https://doi.org/10.1007/s10648-016-9365-3

Rau, M. A., & Matthews, P. G. (2017). How to make 'more'better? Principles for effective use of multiple representations to enhance students' learning about fractions. *ZDM*, *49*, 531–544. https://doi.org/10.1007/s11858-017-0846-8

Rittle-Johnson, B., & Siegler, R. S. (2022). The relation between conceptual and procedural knowledge in learning mathematics: A review. *The Development of Mathematical Skills*, 75–110. https://doi.org/10.4324/9781315784755-6

Saralar-Aras, İ., & Güneş, H. (2024). Enhancing preservice mathematics teachers' competencies in distance education: An empirical investigation utilizing micro-teaching and peer assessment. *International Journal of Science and Mathematics Education*, 1–30. https://doi.org/10.1007/s10763-024-10501-2

Scherer, P., & Bertram, J. (2024). Professionalisation for inclusive mathematics—teacher education programs and changes in preservice teachers' beliefs and self-efficacy. *ZDM–Mathematics Education*, *56*(3), 447–459. https://doi.org/10.1007/s11858-024-01580-0

Schütze, B., Rakoczy, K., Klieme, E., Besser, M., & Leiss, D. (2017). Training effects on teachers' feedback practice: The mediating function of feedback knowledge and the moderating role of self-efficacy. *ZDM*, *49*, 475–489. https://doi.org/10.1007/s11858-017-0855-7

Shih, S.-C., Chang, C.-C., Kuo, B.-C., & Huang, Y.-H. (2023). Mathematics intelligent tutoring system for learning multiplication and division of fractions based on diagnostic teaching. *Education and Information Technologies*, *28*(7), 9189–9210. https://doi.org/10.1007/s10639-022-11553-z

Tossavainen, A. (2024). Pedagogical content knowledge in prospective elementary teachers' descriptions of teaching and learning of fractions. *Scandinavian Journal of Educational Research*, 1–15. https://doi.org/10.1080/00313831.2024.2362928

Van Garderen, D., Scheuermann, A., Poch, A., & Murray, M. M. (2018). Visual representation in mathematics: Special education teachers' knowledge and emphasis for instruction. *Teacher Education and Special Education*, *41*(1), 7–23. https://doi.org/10.1177/0888406416665448

van Garderen, D., Scheuermann, A., Sadler, K., Hopkins, S., & Hirt, S. M. (2021). Preparing preservice teachers to use visual representations as strategy to solve mathematics problems: What did they learn? *Teacher Education and Special Education*, *44*(4), 319–339. https://doi.org/10.1177/0888406421996070

Wilcox, K. C., & Lawson, H. A. (2018). Teachers' agency, efficacy, engagement, and emotional resilience during policy innovation implementation. *Journal of Educational Change*, *19*, 181–204. https://doi.org/10.1007/s10833-017-9313-0

Zhou, L. (2024). Fostering preservice teachers' mathematical discourse through virtual simulation teaching. *International Journal of Mathematical Education in Science and Technology*, 1–21. https://doi.org/10.1080/0020739X.2024.2379487