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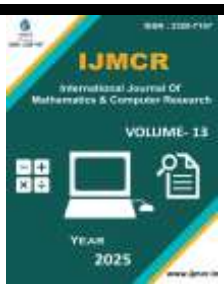

Pre-Service Mathematics Teacher Perception of Teaching Fraction

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ABSTRACT

This study aims to examine pre-service mathematics teachers' perceptions of fraction teaching. A total of 235 mathematics education students from three universities in Indonesia participated in this study. Data were collected through an online questionnaire covering perceptions regarding the importance of fraction teaching, conceptual understanding, and the chosen learning approach. Data analysis was conducted quantitatively through descriptive and inferential analysis. The results showed that most pre-service teachers had positive perceptions of the importance of fraction teaching as a foundation for advanced mathematical understanding. They also showed a tendency to choose a teaching approach based on visual modeling and the use of real contexts to help students understand the concept of fractions. In addition, more positive perceptions were correlated with a tendency to apply varied and conceptual understanding-oriented learning strategies. However, further findings showed a discrepancy between normative perceptions and pre-service teachers' personal beliefs regarding their ability to use visual representations, especially in teaching multiplication and division of fractions. Although they believed in the importance of a visual representation-based approach, most respondents felt that they were not yet proficient enough in implementing the strategy effectively. These findings indicate the importance of strengthening practical competence in the use of visual representations during pre-service education. This research contributes to the development of mathematics teacher education curriculum, especially in strengthening conceptual understanding, pedagogical competence of content, and implementation skills of prospective teachers in teaching fractions, so that they are in line with the learning needs of students in the classroom.

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KEYWORDS: Pre-service mathematics teachers, Teaching fractions, Representational competence, Pedagogical content knowledge, Mathematics teacher education

I. INTRODUCTION

The concept of fractions is one of the fundamental topics in the elementary and secondary school mathematics curriculum. A strong understanding of fractions is not only essential for success in more complex areas of mathematics, such as proportion, ratio, and algebra, but also has a significant impact on general numeracy literacy (Viegut et al., 2024). However, studies show that many students have significant difficulties in conceptually understanding fractions, and this is often related to ineffective teaching methods (Jayanthi et al., 2021; Lee & Lee, 2023). Therefore, the competence of teachers, especially pre-service mathematics teachers, in teaching fractions is a crucial aspect to be improved.

In line with (Seyfried & Pohlenz, 2020) statement that "the quality of an education system cannot exceed the quality of its teachers", it is important to understand how pre-service mathematics teachers' perceptions of fraction teaching are formed during their education process. These perceptions include beliefs about the importance of fraction concepts, teaching approaches that are considered effective, and pedagogical understandings that they will apply in the classroom. Previous research has shown that teachers' perceptions greatly influence the choice of instructional strategies and the quality of students' learning experiences (Bergmark et al., 2018; Powell & Bodur, 2019; Akram et al., 2022). Therefore, examining pre-service teachers' perceptions

of fraction teaching can provide important insights for improving teacher education curricula.

Furthermore, current teacher education programs face challenges in bridging the gap between prospective teachers' conceptual understanding of mathematics and its application in teaching practice (Goos & Bennison, 2018; Resch & Schrittesser, 2023). In the context of fraction teaching, this is often reflected in prospective teachers' difficulties in selecting appropriate visual representations, developing meaningful learning contexts, and addressing students' misconceptions (Morano & Riccomini, 2020; Lee & Lee, 2021). Therefore, this study aims to examine prospective mathematics teachers' perceptions of fraction teaching, in order to provide recommendations for strengthening pedagogical competencies in mathematics teacher education programs.

The Importance of Teaching Fractions in Mathematics Education

Teaching fraction concepts plays a crucial role in developing students' mathematical understanding. Fractions are the foundation for mastering advanced topics such as proportion, percentage, ratio, and algebra. However, international research shows that teaching fractions often causes conceptual difficulties for students, which are largely due to misconceptions reinforced by inappropriate teaching methods (Namkung & Fuchs, 2019; Hacker et al., 2019). Therefore, the quality of fraction teaching is highly dependent on the competence and perception of teachers. The National Council of Teachers of Mathematics (NCTM, 2000) also emphasizes that effective fraction teaching requires a strong conceptual understanding as well as the ability to relate fraction representations to real-world contexts.

In addition, effective fraction instruction requires approaches that involve multiple representations—such as area representations, number lines, and contextual models—to help students build flexible conceptual understanding (Lamon, 2020). Research shows that students who are accustomed to exploring fractions through multiple representations tend to have deeper understandings and are able to transfer that knowledge to more complex mathematical situations (Bentley & Bossé, 2018; Reinhold et al., 2020). Therefore, teachers—including preservice teachers—need to have adequate pedagogical competence to select, adapt, and combine appropriate representations in the process of teaching fractions. This ability is closely related to their perceptions of fraction instruction and their beliefs about how students learn the concept meaningfully.

Furthermore, meaningful fraction teaching also requires a deep understanding of the cognitive difficulties that students commonly experience. Several studies have shown that many students have persistent misconceptions about the meaning of fractions as parts of a whole, comparisons between fractions, and arithmetic operations on fractions (Bentley & Bossé, 2018; Copur-Gencturk, 2021). These misconceptions are often exacerbated by teaching that overemphasizes algorithmic procedures without providing adequate visual or conceptual understanding (Copur-Gencturk, 2021). Therefore, teachers need not only to master the mathematics content but also to have adequate pedagogical content knowledge (PCK)—the ability to understand how students think about fractions and how to address these misconceptions through the selection of appropriate representations and teaching strategies (Lamon, 2020). In this context, prospective teachers' perceptions about how fractions should be taught become a key element that will influence how they design their students' learning experiences.

Perceptions and Competencies of Prospective Teachers in Teaching Fractions

Teachers' perceptions of fraction teaching have a significant impact on the teaching strategies they choose, the representations they use, and how they manage students' misconceptions (Rosli et al., 2020). These perceptions begin to form during pre-service education and are influenced by their learning experiences and the curriculum they follow (Rosli et al., 2020). Prediger et al., (2023) study showed that pre-service teachers who have positive perceptions of conceptual understanding-based approaches tend to be better able to design rich and meaningful fraction teaching activities. In addition, (Ismail & Jarrah, 2019) study also highlighted that competencies acquired during pre-service education have a long-term influence on later teaching practices.

However, several studies have also shown that there is a mismatch between prospective teachers' positive perceptions about fraction teaching and their readiness to implement appropriate strategies in the classroom (Lee & Lee, 2019; Güler & Çelik, 2019). Although many prospective teachers believe in the importance of conceptual understanding-based approaches and the use of multiple representations, in practice they often have difficulty in choosing appropriate representations, linking concepts to real-world contexts, and overcoming common student misconceptions (Fries et al., 2021). This suggests that positive perceptions alone are not enough, but need to be supported by strong pedagogical content knowledge (PCK). Therefore, it is important for teacher education programs to not only build positive perceptions but also systematically equip prospective teachers with practical skills in planning and implementing effective fraction teaching.

In addition, prospective teachers' perceptions of fraction teaching are also influenced by their epistemological beliefs about how mathematics is learned and taught. Research shows that prospective teachers who view mathematics as a set of procedures tend to have a harder time shifting to a conceptual understanding-oriented teaching approach (Stein et al., 2022). In contrast, those who believe that mathematics is a discipline that can be explored conceptually are more open to the use of multiple representations and context-based teaching strategies (Nepal et al., 2024). Therefore, it is important for teacher education programs to not only build pedagogical and content

knowledge, but also reflect and shape prospective teachers' epistemological beliefs. Otherwise, there is a risk that the positive perceptions indicated in the survey will not be fully reflected in their classroom teaching practices, as they conflict with deep-seated beliefs that have not been reconstructed.

Research Question:

1. How do pre-service mathematics teachers perceive the teaching of fraction concepts in schools?
2. How are these perceptions reflected in the selection of approaches and representations that are considered effective for teaching fractions?

II. METHODS

Research Design

This study uses a descriptive quantitative approach with a survey design. This design was chosen to obtain a broad and systematic picture of the perceptions of prospective mathematics teacher students towards fraction teaching. The survey approach allows researchers to collect data from a large number of respondents efficiently, as well as analyze the patterns of perceptions and general tendencies that emerge. In addition, this design is also in accordance with the objectives of the study, namely to identify the perceptions of prospective mathematics teachers about fraction teaching and the relationship between these perceptions and the teaching strategies they choose.

Participants

Participants in this study were 235 students of mathematics education study programs from several universities in Indonesia. They were final semester students (minimum semester 6), who had taken elementary school mathematics courses and courses related to mathematics pedagogy. The selection of participants was carried out by purposive sampling, with the criteria that they had obtained sufficient knowledge of fraction content and pedagogy to be able to provide reflective perceptions. The composition of participants consisted of 78% women and 22% men, with an age range of 20–24 years

Data Collection

Data collection was conducted through an online questionnaire distributed using the Google Forms platform. Distribution was carried out through coordination with lecturers in charge of related courses and through student forums in each study program. Data were collected during the period February to March 2025. Respondents were asked to fill out the questionnaire voluntarily, and all data collected was guaranteed confidentiality. In addition, participants were given information about the purpose of the study and informed consent before filling out the questionnaire.

Instruments

The research instrument was a closed questionnaire developed based on a literature review related to teachers' perceptions of fraction teaching (Izsák et al., 2019; Rosli et al., 2020; Copur-Gencturk, 2021). The questionnaire consisted of two main parts. The first part contained questions about general perceptions of fraction teaching (the importance of fraction concepts, beliefs about how students learn fractions, the role of teachers). The second part included items related to strategies and representations considered effective in fraction teaching (use of visual representations, real-world contexts, concrete manipulatives, and technology). Each item was measured using a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The content validity of the questionnaire was consulted with three experts in the field of mathematics education. The initial reliability test produced a Cronbach's Alpha coefficient of 0.87, indicating high reliability.

Data Analysis

The collected data were analyzed quantitatively using descriptive analysis and inferential analysis techniques. Descriptive analysis includes calculating the average (Mean), percentage, and standard deviation (SD) for each perception item, in order to obtain a general profile of participants' perceptions of fraction teaching. This analysis provides an overview of the general tendency of perceptions and variations between participants. Furthermore, to identify a deeper relationship between perceptions of fraction teaching and the tendency to choose teaching strategies, a Pearson correlation analysis was conducted. This analysis aims to test the linear relationship between perceptions of the importance of context-based teaching and the tendency to choose an approach involving multiple representations. This correlation test allows researchers to evaluate whether prospective teachers' conceptual perceptions significantly influence their preferences in designing fraction teaching.

All analyses were conducted using IBM SPSS Statistics software version 26. The results of the analyses were used systematically to answer the research questions, providing an empirical basis for interpretation of how preservice teachers' perceptions are reflected in their pedagogical orientations toward fraction teaching. Interpretation of the results focused on pedagogical implications, as well as on understanding the interrelationships between perceptions, conceptual orientations, and teaching strategy preferences.

III. RESULT

This study examines the perceptions of prospective mathematics teacher students towards teaching fractions through two main aspects: (1) general perceptions about the importance and essence of teaching fractions, and (2) perceptions about approaches and representations that are considered effective in teaching fractions.

General Perceptions about Teaching Fractions

The results of the descriptive analysis show that in general, the perceptions of prospective mathematics teacher students towards teaching fractions are in the positive and reflective category. Most respondents believe that mastery of fraction

concepts is an important foundation for understanding advanced mathematics, such as proportion, algebra, and probability. This shows that prospective teachers have good conceptual awareness of the strategic role of fraction concepts in the overall mathematics curriculum.

Furthermore, the positive perceptions were not only declarative, but also reflected in their pedagogical preferences. As shown in Table 1, the perception items that obtained the highest mean scores were "Fraction teaching should be related to students' real-life contexts" (M = 4.52, SD = 0.63), followed by "Teachers need to use multiple visual representations in teaching fractions" (M = 4.48, SD = 0.65). These findings indicate that preservice teachers understand the need to build a bridge between abstract mathematical concepts and students' concrete experiences. This is in line with the principle of mathematics for understanding, as recommended by NCTM (2000), which emphasizes that fraction teaching should help students develop deep conceptual meaning through the use of multiple contexts and representations.

On the other hand, the critical attitude of prospective teachers towards the purely procedural approach is also quite strong. The item "Teaching fractions is sufficient with procedural exercises" obtained the lowest mean score (M = 2.11, SD = 0.89), indicating that the majority of respondents reject the teaching approach that only focuses on algorithms or mechanical calculations. This suggests a shift in the pedagogical paradigm among prospective teachers, from skill-based teaching to concept-based teaching. This finding is important, considering that one of the main sources of students' misconceptions about fractions is teaching that is too procedural without strengthening the understanding of basic concepts.

Interestingly, the combination of awareness of the importance of context, representation, and resistance to procedural approaches in these findings reflects that preservice teachers not only understand what needs to be taught in teaching fractions, but also begin to think about how to teach it effectively. This indicates that their perceptions have evolved to a more reflective and pedagogical level, which is essential for meaningful teaching practice. However, the consistency between these positive perceptions and their implementative abilities in real classroom situations remains an important area that needs to be further explored through more practice-based training.

Table 1. Perceptions of pre-service mathematics teacher students towards teaching fractions

No	Statement	Mean	SD	Perception categories
1	Fraction teaching must be linked to students' real-life contexts.	4.52	0.63	Very positive
2	Teachers need to use visual representations in teaching fractions.	4.48	0.65	Very positive
3	Mastery of the concept of fractions is important for understanding advanced mathematics topics.	4.36	0.70	Very positive
4	Teaching fractions is sufficient with procedural exercises	2.11	0.89	Negative
5	Students need to be given the opportunity to explore fractions using concrete manipulatives.	4.41	0.67	Very positive
6	Students' understanding of the concept of fractions is only assessed through written tests.	2.34	0.92	Negative

Furthermore, although the results of previous studies indicate that prospective teachers have very positive perceptions of the importance of using visual representations in teaching fractions, further findings from this study indicate a mismatch between normative beliefs and personal beliefs about their own competence in implementing the strategy..

When asked through the statement "I feel quite proficient in using pictorial models to explain multiplication and division of fractions", the perceptions of student teachers appear more diverse and tend to be moderate. As shown in Figure 1, as many as 51% of respondents chose scale 3 (neutral), indicating that more than half of the participants were not sure whether they were really able to use pictorial models effectively in teaching multiplication and division of fractions. Meanwhile, 29.4% of respondents chose scale 4 (agree), and only 10.5% stated that they strongly agreed (scale 5) that they felt quite proficient. On the other hand, there were around 9.1% of respondents (1% on scale 1 and around 8% on scale 2) who explicitly felt less able to use visual models in explaining this topic, as shown in Figure 1.

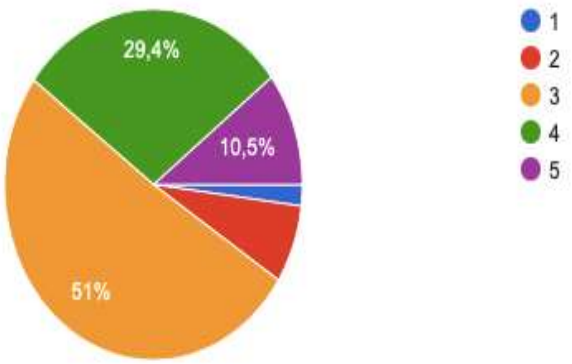

Figure 1. Prospective Teachers' Beliefs about the Ability to Use Visual Representations

Perceptions of Approaches and Representations in Teaching Fractions

The preservice teachers in this study also showed a strong and reflective preference for the use of a multiple representation-based approach in teaching fractions. They viewed the integration of visual models, concrete manipulatives, and contextual applications as not only enriching students' learning but also as key to developing solid conceptual understanding. This finding is consistent with the literature emphasizing that multiple representations help students construct an understanding of fractions as flexible and meaningful concepts, rather than simply as numbers or symbols (Lamon, 2020; Faridah et al., 2024).

Interestingly, prospective teachers' positive perceptions of the use of multiple representations were not partial, but rather closely related to their broader pedagogical views. As shown by the results of the correlation analysis, there was a significant positive relationship ($r = 0.62$, $p < 0.01$) between the perception of the importance of context-based teaching and the frequency of choosing teaching strategies involving multiple representations. This means that prospective teachers who have a high awareness of the importance of real-world contexts in fraction learning also tend to be more active in choosing and combining various types of representations in their teaching. Furthermore, this trend reflects that preservice teachers are beginning to understand that no single representation is capable of fully capturing the meaning of fractions. They demonstrate an understanding that students need exposure to a variety of models (area, length, sets, number lines, real-life contextualizations) in order to develop robust mental representations of fractions (NCTM, 2000). This is a positive indicator that preservice teachers' perceptions have gone beyond mere introduction to teaching techniques; they are beginning to demonstrate an orientation toward actively constructing students' understanding.

However, while this pattern of perceptions is encouraging, it is important to note that a preference for multiple representations does not necessarily translate automatically into mature implementation skills in classroom practice. Previous studies (M. Y. Lee & Lee, 2019); (M. Y. Lee & Lee, 2021) have shown that although beginning teachers have positive perceptions about the use of representations, they often face challenges in selecting appropriate representations for a given learning situation, or in connecting different representations coherently during the teaching process. These findings therefore reinforce the importance of integrating more practical and experiential training into teacher education programs, so that these positive perceptions can develop into real pedagogical competencies in the field.

IV. DISCUSSION

The results of this study revealed two important findings that provide insight into preservice mathematics teachers' perceptions of fraction instruction. First, preservice teachers demonstrated very positive perceptions of the importance of conceptually and meaningfully teaching fractions. Second, they also showed a strong preference for the use of multiple representations and contextual approaches in fraction instruction. The first finding suggests that preservice mathematics teachers view fraction instruction as an essential foundation for advanced mathematical understanding. This is reflected in their belief that fraction instruction should be connected to real-world contexts and based on strengthening conceptual understanding, rather than simply mastering procedures. This finding may be explained by the current trend in teacher education programs that increasingly emphasize the importance of mathematical understanding and teaching for conceptual understanding (NCTM, 2000). In addition, many preservice teachers today have been exposed to competency-based curricula and instructional strategies that promote deep understanding.

This finding is in line with Lamon's (2020) study, which found that pre-service teachers who were exposed to conceptual understanding-based teaching tended to have positive perceptions of this approach. Similarly, Alwast & Vorhölter (2022) also reported that pre-service teachers who underwent pedagogical training that emphasized the use of context and modeling tended to develop similar views. Therefore, the alignment between the findings of this study and previous literature can be understood as a consequence of strengthening the teacher education curriculum based on understanding-oriented teaching. However, not all studies show consistency. Alqahtani et al., (2022) reported that in some contexts, pre-service teachers still tend to hold procedural perceptions, especially if their learning experiences were dominated by algorithmic approaches during school. This difference may be due to variations in the quality of teacher education programs and previous mathematics learning experiences. In the context of this study, it can be assumed that the student participants in the study had relatively strong experiences in conceptual understanding-based learning, so their perceptions tended to be more positive.

The second finding shows that preservice teachers not only value the importance of multiple representations, but also that this awareness is correlated with a preference for using contextual approaches. This relationship suggests that strong conceptual awareness drives the tendency to adopt more diverse and flexible teaching strategies. This finding is important, as the use of multiple representations has been shown to improve student understanding (Mainali, 2021), while context-based instruction helps students see the practical meaning of fraction concepts (Purnomo et al., 2022). These results are consistent with the findings of Irmak & Yilmaz Tüzün (2019) who showed that positive perceptions of conceptual understanding are closely related to the choice of teaching strategies involving multiple representations. This also reinforces the findings of Farra et al., (2024) who

found that teachers who understand the importance of conceptual understanding are more likely to use visual models, concrete manipulatives, and real-world contexts in teaching fractions.

However, there are other studies that show inconsistent results. Munfaridah et al., (2022) & Pierson et al., (2023) reported that although many prospective teachers have positive perceptions of multiple representations, in practice they often feel less confident in choosing the right representation or in connecting various representations coherently. This difference may be due to the imbalance between perception and implementation skills. In this study, although the perceptions of prospective teachers are very positive, it still needs to be further investigated to what extent they are able to implement these perceptions effectively in real teaching. Thus, these two findings indicate that prospective teachers' positive perceptions of fraction teaching have great potential to encourage meaningful and conceptually-based teaching. However, as shown by the literature, implementation challenges are still a concern. Therefore, it is important for teacher education programs to not only build positive perceptions, but also strengthen prospective teachers' practical competence through experiential training and real teaching practices.

The Gap between Positive Perception and Self-Efficacy in the Use of Visual Representation

These findings indicate a significant gap between prospective teachers' conceptual perceptions—that is, the belief that visual representations are important in teaching fractions—and their own beliefs regarding their practical ability to use these representations effectively in the classroom. Although they theoretically understand the benefits and necessity of using visual models, especially to build students' conceptual understanding, many of them still feel less proficient or not confident enough when they have to implement them in real teaching contexts. This is in line with the findings of Danday (2023) and Ayyıldız Altınbaş et al., (2025), which show that positive beliefs about representation-based pedagogy are not always followed by adequate practical abilities. This difference is often influenced by limited direct experience during pre-service education, especially in the context of using complex visual representations.

Furthermore, the reason why this gap occurs can be explained by the fact that mastery of visual representations, especially in teaching multiplication and division of fractions, does require much deeper pedagogical content competence (PCK) than just mastery of concepts. As stated by Birello & Pujolà (2023), effective mastery of visual representations requires repeated practice, reflective processes, and experiences in authentic teaching contexts — things that are often not optimally provided in many teacher education programs. The findings of Morano & Riccomini (2020) also support this, by showing that the difficulty in using visual models for more complex fraction operations (multiplication and division) is higher than for simpler operations such as addition or subtraction. This suggests that although prospective teachers' PCK on fractions is developing, there is still an imbalance in development between subtopics within the fraction domain.

Interestingly, not all studies are entirely in line with these findings. A study by Yuan & Mak (2018), for example, showed that in the context of a teacher education program that explicitly integrated microteaching-based practice components and the use of visual technologies (e.g., GeoGebra), prospective teachers' positive perceptions of the importance of visual representations tended to be more consistent with their levels of self-efficacy and practical skills. This difference is likely due to differences in curriculum design and the degree of emphasis on hands-on practical experiences. The findings of this study, which show a gap between perceptions and self-efficacy, reinforce the urgency that Indonesian teacher education programs need to provide more opportunities for rich and systematic practical experiences, so that prospective teachers not only conceptually understand the importance of visual representations, but are also able and confident to use them effectively in the classroom.

V. CONCLUSION

This study provides a rich picture of pre-service mathematics teacher students' perceptions of fraction teaching. Findings indicate that pre-service teachers have very positive perceptions of the importance of fraction teaching that is conceptually based and relevant to students' real-life contexts. They also show a strong preference for the use of multiple representations in fraction teaching, and there is a significant relationship between perceptions of context-based teaching and the tendency to choose a variety of teaching strategies. However, this study also reveals a significant gap between pre-service teachers' positive perceptions of the use of visual representations and their self-efficacy in their practical ability to implement these strategies, especially in teaching multiplication and division of fractions. These findings suggest that although pre-service teachers' pedagogical orientations are already directed towards meaningful and representation-based teaching, there is still a need to strengthen their implementative competence so that their self-efficacy can develop in line with their conceptual perceptions. The results of this study contribute to strengthening the understanding of how pre-service teachers' perceptions can influence their pedagogical orientations, and underscore the need for teacher education programs that not only build theoretical beliefs but also provide structured and authentic practical experiences. Therefore, strengthening the mathematics teacher education curriculum needs to include components of practical competence development, such as exercises in the use of visual representations in various

fraction teaching contexts. In the future, further research is needed to explore the gap between positive perceptions and implementation capabilities in real teaching situations in more depth. In addition, qualitative studies that focus on the process of prospective teachers' reflection in selecting and integrating visual representations in fraction teaching can provide additional valuable insights.

REFERENCES

1. Akram, H., Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022). Teachers' perceptions of technology integration in teaching-learning practices: A systematic review. *Frontiers in Psychology*, *13*, 920317.
2. Alqahtani, M. M., Hall, J. A., Leventhal, M., & Argila, A. N. (2022). Programming in mathematics classrooms: Changes in pre-service teachers' intentions to integrate robots in teaching. *Digital Experiences in Mathematics Education*, 1–29.
3. Alwast, A., & Vorhölter, K. (2022). Measuring pre-service teachers' noticing competencies within a mathematical modeling context–an analysis of an instrument. *Educational Studies in Mathematics*, *109*(2), 263–285.
4. Ayyıldız Altınbaş, A., Solak, S., & Ertekin, E. (2025). The effect of multiple representations-based and problem-based instruction in linear algebra on pre-service teachers' dimensions of understanding and self-efficacy perceptions. *Journal of Mathematics Teacher Education*, 1–28.
5. Bentley, B., & Bossé, M. J. (2018). College Students' Understanding of Fraction Operations. *International Electronic Journal of Mathematics Education*, *13*(3), 233–247.
6. Bergmark, U., Lundström, S., Manderstedt, L., & Palo, A. (2018). Why become a teacher? Student teachers' perceptions of the teaching profession and motives for career choice. *European Journal of Teacher Education*, *41*(3), 266–281.
7. Birello, M., & Pujolà, J.-T. (2023). Visual metaphors and metonymies in pre-service teachers' reflections: Beliefs and experiences in the learning and teaching of writing. *Teaching and Teacher Education*, *122*, 103971.
8. Copur-Gencturk, Y. (2021). Teachers' conceptual understanding of fraction operations: results from a national sample of elementary school teachers. *Educational Studies in Mathematics*, *107*(3), 525–545.
9. Danday, B. A. (2023). Fostering critical thinking among pre-service teachers through a multiple representation-based collaborative pedagogical approach. In *Brain, decision making and mental health* (pp. 191–217). Springer.
10. Faridah, L., Siswono, T. Y. E., & Sulaiman, R. (2024). The use of multiple representations in improving the understanding of the fraction concept of junior high school students in terms of gender. *AIP Conference Proceedings*, *3046*(1).
11. Farra, N. K. Al, Belbase, S., Tairab, H., Qablan, A., Opoku, M. P., & Safi, S. K. (2024). Impact of using virtual and concrete manipulatives on students' learning of fractions. *Cogent Education*, *11*(1), 2379712.
12. Fries, L., Son, J. Y., Givvin, K. B., & Stigler, J. W. (2021). Practicing connections: A framework to guide instructional design for developing understanding in complex domains. *Educational Psychology Review*, *33*(2), 739–762.
13. Goos, M., & Bennison, A. (2018). Boundary crossing and brokering between disciplines in pre-service mathematics teacher education. *Mathematics Education Research Journal*, *30*, 255–275.
14. Güler, M., & Çelik, D. (2019). How well prepared are the teachers of tomorrow? An examination of prospective mathematics teachers' pedagogical content knowledge. *International Journal of Mathematical Education in Science and Technology*, *50*(1), 82–99.
15. Hacker, D. J., Kiuhara, S. A., & Levin, J. R. (2019). A metacognitive intervention for teaching fractions to students with or at-risk for learning disabilities in mathematics. *ZDM*, *51*, 601–612.
16. Irmak, M., & Yilmaz Tüzün, Ö. (2019). Investigating pre-service science teachers' perceived technological pedagogical content knowledge (TPACK) regarding genetics. *Research in Science & Technological Education*, *37*(2), 127–146.
17. Ismail, S. A. A., & Jarrah, A. M. (2019). Exploring Pre-Service Teachers' Perceptions of Their Pedagogical Preferences, Teaching Competence and Motivation. *International Journal of Instruction*, *12*(1), 493–510.
18. Izsák, A., Jacobson, E., & Bradshaw, L. (2019). Surveying middle-grades teachers' reasoning about fraction arithmetic in terms of measured quantities. *Journal for Research in Mathematics Education*, *50*(2), 156–209.
19. Jayanthi, M., Gersten, R., Schumacher, R. F., Dimino, J., Smolkowski, K., & Spallone, S. (2021). Improving struggling fifth-grade students' understanding of fractions: A randomized controlled trial of an intervention that stresses both concepts and procedures. *Exceptional Children*, *88*(1), 81–100.
20. Lamon, S. J. (2020). *Teaching fractions and ratios*

for understanding: Essential content knowledge and instructional strategies for teachers. Routledge.

21. 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.
22. Lee, M. Y., & Lee, J.-E. (2019). Pre-service teachers' perceptions of the use of representations and suggestions for students' incorrect use. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(9), em1745.
23. Lee, M. Y., & Lee, J.-E. (2021). Pre-service teachers' selection, interpretation, and sequence of fraction examples. *International Journal of Science and Mathematics Education*, *19*, 539–558.
24. Mainali, B. (2021). Representation in teaching and learning mathematics. *International Journal of Education in Mathematics, Science and Technology*, *9*(1), 1–21.
25. Morano, S., & Riccomini, P. J. (2020). Demonstrating conceptual understanding of fraction arithmetic: An analysis of pre-service special and general educators' visual representations. *Teacher Education and Special Education*, *43*(4), 314–331.
26. Munfaridah, N., Avraamidou, L., & Goedhart, M. (2022). Preservice physics teachers' development of physics identities: The role of multiple representations. *Research in Science Education*, *52*(6), 1699–1715.
27. Namkung, J., & Fuchs, L. (2019). Remediating Difficulty with Fractions for Students with Mathematics Learning Difficulties. *Learning Disabilities: A Multidisciplinary Journal*, *24*(2), 36–48.
28. Nepal, K., Basyal, D., & Pokharel, K. (2024). Learning opportunities for solving context-based calculus tasks in Nepal's high school mathematics textbooks. *Investigations in Mathematics Learning*, 1–12.
29. Pierson, A. E., Keifert, D. T., Lee, S. J., Henrie, A., Johnson, H. J., & Enyedy, N. (2023). Multiple representations in elementary science: Building shared understanding while leveraging students' diverse ideas and practices. *Journal of Science Teacher Education*, *34*(7), 707–731.
30. Powell, C. G., & Bodur, Y. (2019). Teachers' perceptions of an online professional development experience: Implications for a design and implementation framework. *Teaching and Teacher Education*, *77*, 19–30. https://doi.org/https://doi.org/10.1016/j.tate.2018.09.004
31. Prediger, S., Dröse, J., Stahnke, R., & Ademmer, C. (2023). Teacher expertise for fostering at-risk students' understanding of basic concepts: conceptual model and evidence for growth. *Journal of Mathematics Teacher Education*, *26*(4), 481–508.
32. Purnomo, Y. W., Aziz, T. A., Shahrill, M., & Prananto, I. W. (2022). Students' Failure to Understand Fraction Multiplication as Part of a Quantity. *Journal on Mathematics Education*, *13*(4), 681–702.
33. Reinhold, F., Hoch, S., Werner, B., Richter-Gebert, J., & Reiss, K. (2020). Learning fractions with and without educational technology: What matters for high-achieving and low-achieving students? *Learning and Instruction*, *65*, 101264.
34. Resch, K., & Schrittesser, I. (2023). Using the Service-Learning approach to bridge the gap between theory and practice in teacher education. *International Journal of Inclusive Education*, *27*(10), 1118–1132.
35. Rosli, R., Goldsby, D., Onwuegbuzie, A. J., Capraro, M. M., Capraro, R. M., & Gonzalez, E. G. Y. (2020). Elementary Preservice Teachers' Knowledge, Perceptions and Attitudes towards Fractions: A Mixed-Analysis. *Journal on Mathematics Education*, *11*(1), 59–76.
36. Seyfried, M., & Pohlenz, P. (2020). Assessing quality assurance in higher education: quality managers' perceptions of effectiveness. In *Impact evaluation of quality management in higher education* (pp. 24–37). Routledge.
37. Stein, M. K., Russell, J. L., Bill, V., Correnti, R., & Speranzo, L. (2022). Coach learning to help teachers learn to enact conceptually rich, student-focused mathematics lessons. *Journal of Mathematics Teacher Education*, 1–26.
38. Viegut, A. A., Stephens, A. C., & Matthews, P. G. (2024). Unpacking the connections between fractions and algebra: The importance of fraction schemes and units coordination. *Investigations in Mathematics Learning*, *16*(3), 180–202.
39. Yuan, R., & Mak, P. (2018). Reflective learning and identity construction in practice, discourse and activity: Experiences of pre-service language teachers in Hong Kong. *Teaching and Teacher Education*, *74*, 205–214.