The connection between prospective teachers' procedural and conceptual knowledge with problem-posing skills of fractions

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ABSTRACT

This study examined the connections between procedural and conceptual knowledge of addition and subtraction of fractions with the problem-posing skills of prospective primary teachers. The applied method was a correlational study with structural equation modeling-partial least square (SEM-PLS) analysis. The sample in this research was 101 third-year students from a primary teacher education study program of a public university in Riau, Indonesia. The results showed that prospective primary teachers have high procedural knowledge and problem-posing skills on addition and subtraction. However, they have poor performance on problems related to conceptual knowledge of addition and subtraction of fractions. Then, the results also revealed a significant connection between procedural and conceptual knowledge with problem-posing skills on addition and subtraction of fractions of prospective primary teachers. Improving prospective primary teachers' procedural and conceptual knowledge could raise their problem-posing skills on adding and subtracting fractions.

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1. INTRODUCTION

Procedural and conceptual knowledge is an essential knowledge that prospective primary teachers must possess, and it is an interconnected aspect of solving mathematical problems [1]. However, many studies have shown that prospective primary teachers have some challenges in understanding mathematical concepts, especially fractions [2]–[7]. For instance, Young and Zientek [8] discovered that some prospective teachers developed several error patterns that appear to evolve many error patterns from confused memories of standard procedures that they had learned in previous times. Sometimes, explaining how such a procedure works to solve fractions becomes challenging for some prospective and in-service teachers [3], [9].

For more than 20 years, since Ma's study [10] on prospective and in-service teachers' understanding of division of fractions, several studies have tried to reveal to what extent teachers' knowledge of fractions. One of among recent studies is using problem posing as an approach to investigate primary teachers' knowledge of fractions [11]–[13]. Toluk-Uçar [12] found that problem-posing instructional learning could support prospective primary teachers' knowledge of symbolic and algorithms of fractions. Meanwhile, according to Kar [14], problem-posing can be used as an alternative evaluation tool to determine conceptual understanding skills, misunderstandings, and errors in learning. Therefore, problem-posing has a vital role in learning mathematics.

Previous studies believe that prospective teachers should master problem-posing skills [11], [14]. However, based on the research conducted by Xie and Masingila [15], prospective teachers have difficulties in problem-posing and problem-solving involving fractions. Another statement from Leung and Carbone [16] that many prospective teachers show difficulty in interpreting each problem, including fractions as a natural grouping of objects that are counted and discrete.

As prospective primary teachers, who have studied fraction operations when attending lectures in the beginning of their study program, upon completion of their education, they are indeed expected to be well prepared to teach these fractions to students later in primary school. One form of their readiness is their ability to ask questions about fraction operations or problem-posing because mathematics learning is closely related to problem-solving activities (contextual problems and abstract mathematical problems). Besides, prospective primary teachers need to have sufficient procedural and conceptual knowledge of fractions. However, there are still very limited studies that investigate the connection between teachers' procedural and conceptual knowledge and their mathematical problem-posing skills of fractions. Some studies tend to focus only on conceptual and procedural knowledge of fractions [6], [17] or problem-posing [12] or solving [15] skills. Therefore, in the present study, we are interested in investigating the connection between prospective primary teachers' procedural and conceptual knowledge and their mathematical problem-posing skills. This study focuses on the addition and subtraction of fractions because this topic is quite challenging for some students, especially in understanding conceptual aspects through diagram representation [18]. These issues led to an interest in seeing how the connection between procedural and conceptual knowledge of prospective primary school teachers about fractions against their problem-posing abilities related to addition and subtraction of fractions.

2. LITERATURE REVIEW

Procedural knowledge involves understanding mathematical rules and routines [19]. Procedural knowledge can also explain how to do something [20] or knowledge about the steps that we should refer to in solving a problem and mention or justify a way to solve mathematical problems [21]. Another opinion says that procedural knowledge is knowledge of specific skills, algorithms, techniques, and methods in a subject or discipline [22]. From some of these expert opinions, we conclude that procedural knowledge is knowledge of the steps that solve a problem using specific skills, algorithms, techniques and methods in a subject or scientific discipline.

Procedural knowledge on fractions often takes a form from a series of steps that are followed [23]. Procedural knowledge on adding and subtracting fractions can function as a method we apply to solve a mathematical task. The task is primarily given in a free contextual situation, such as to solve 2/5 - 1/6. The technique can solve it by changing both fractions into fractions with a common denominator and then adding the numerator to give the given answers. Many adults could understand this technique because they have already learnt this technique by memorizing.

Conceptual knowledge involves understanding mathematical connections [19]. Conceptual knowledge can also be comprehensive knowledge of a basic concept [21] and a well-arranged particular subject, which relates to a more systematic way [23]. Conceptual knowledge links pieces of information that include facts, skills, concepts, and principles, resulting in which it can play a role as a network of knowledge that connects one another [23]. Thus, we conclude that conceptual knowledge is the knowledge possessed by a person regarding a significant subject related to the connection between information, skills, basic concepts, and principles, including categories, classifications, and the relationship between two or more categories.

Concerning conceptual knowledge of fractions, Li [18] stated that fractions are often associated with diagrams. The pictorial representation provides a visual presentation and emphasizes certain aspects of the meaning represented by a fraction. Thus, this study indicates the conceptual knowledge of addition and subtraction of fractions, namely expressing the concept using a diagrammatic representation. Therefore, the task given to prospective elementary teachers is related to their understanding of which diagram representations could represent a type of fraction task, such as 5/6 - 3/4.

Problem-posing is an activity of designing problems using various contexts and student abilities [24]. Problem posing is asking a problem or formulating a question about a given situation or task before, during, or after solving the problem [25], [26]. Problem posing is also known as asking questions and problem formulation based on a particular situation using several changes related to the conditions that have resolved to find alternative problem solutions [27]. Therefore, problem-posing is an effective mathematical activity to increase mathematical knowledge.

There are three types of problem posing [16], [28]: free situations, semi-structured situations, and structured problem-posing situations. Problem-posing in a free situation serves to design or create a problem without having any restrictions and rules in creating questions. There are no standards that we should follow in making the questions. Prospective teachers can make free questions such as making complex or straightforward questions or making questions that they like. For example, prospective teachers require to create a contextual problem about subtracting fractions.

Problem posing in semi-structured situations is designing or making questions following the problem/situation given or making questions based on the description given. So that prospective teachers can make questions from open questions that involve mathematical investigative activities, make questions based on the pictures given, make questions based on the questions given, make questions in the same context as the questions given, or make questions related to certain theorems. For example, prospective teachers pose a problem $\frac{1}{2}+\frac{1}{4}$ and then ask them to make a contextual problem based on that problem.

Problem posing in structured situations is designing or making problems by changing or varying the conditions or questions of the questions given or formulating the problems. So prospective teachers make questions based on general questions by changing available data or information. For example, prospective teachers should create a variety of problems from the given problem in the task of semi-structured situations.

3. RESEARCH METHOD

In this study, a survey method was employed. This method collect data at a specific point in time in order to describe the existence of the current situation, or to identify standards that can be used to compare the existing conditions, or to establish a relationship that exists between a specific event [29]. Particularly, researchers used internet-based survey using Google Form and sent the invitation to the respondents through social media. The survey was informed to the respondents during a synchronize course conducting by the second author. We assure them that the information they provide in the survey will not impact their course grades, and that the information gathered will be used exclusively for research purposes.

Participants for this study consisted of student teachers from a primary education study program from a public university in Riau, Indonesia. These participants were third-year students and have already completed four compulsory mathematics and mathematics education courses. There were 113 student teachers, but only 101 student teachers participated in this study. Of these, 95% of participants were female, and the other 5% were male.

The instrument of this study consisted of 18 problems on the adding and subtracting. Six problems aimed to measure prospective elementary teachers' procedural knowledge. There were four routine problems without context involved two addition and two subtraction problems of fractions as shown in Figure 1. While the other two problems provided contextual situations, and the participants choose correct answers and their procedure. These procedural problems aimed to cover various types of problems found in elementary mathematics school textbooks.

Six problems were measuring prospective elementary teachers' conceptual knowledge of adding and subtracting fractions. These problems were adapted from Li [18]. Four problems in these types of tasks were presented in diagrams that represented two adding and subtracting fraction tasks. Figure 1 illustrates an example of the tasks. Meanwhile, the other two problems were asked to represent diagram representations to fraction addition and subtraction.

The last six problems were intended to measure prospective primary teachers' problem-posing skills. The problems were divided into three categories based on the problem-posing types: i) Two tasks of free situations; ii) Two tasks of semi-structured situations; and iii) Two tasks of structured problem-posing situations as shown in Figure 1.

The 18 problems were scored using a three-level scoring system (0 to 2 points). Two points were awarded to correct answers and reasoning. One point was granted for a correct answer and minor mistake of reasoning or without reasoning. No points were weighed for incorrect answers and incorrect reasoning. Then, the average score serves to determine the level of prospective primary teachers' procedural and conceptual knowledge and problem-posing skills. The criteria of prospective primary teachers' procedural, conceptual, and problem-posing skills is presented in Table 1 [30].

The survey was assigned to the respondents on constant order: the procedural tasks, conceptual tasks, and problem-posing tasks. The problems in procedural and conceptual tasks were given randomly to avoid respondents' collaborative work. The provided allocated time to complete all tasks was 90 minutes.

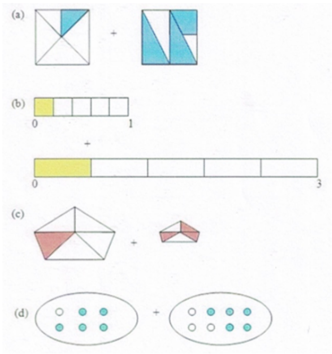
An example of procedural problems of fractions

Answer the following questions and write down the steps to solve it!

$\frac{2}{5}+\frac{1}{6}=\cdots$

An example of conceptual problems of fractions

Choose the correct diagram to represent $\frac{1}{5}+\frac{3}{5}$ and then give a reason for your answer!



An example of problem-posing tasks of fractions

1. Create a contextual problem for the addition of the fractions of $\frac{2}{5}+\frac{1}{3}$!
2. Create a different but still related contextual problem for the addition of fractions of $\frac{2}{5}+\frac{1}{3}$!

Figure 1. Procedural, conceptual, and problem-posing tasks of adding and subtracting fractions

Table 1. Criteria of prospective elementary teachers' knowledge

Criteria	Interval
Very high	1.50–2.00
High	1.01–1.50
Low	0.51–1.00
Very low	0.00–0.50

The data analysis utilized the structural equation modelling-partial least square (SEM-PLS) analysis through the SmartPLS software application version 3.2.9. The reason to use SEM-PLS analysis because it has many advantages: i) It can test the relationship of causality, validity, and reliability at the same time; ii) It can be used to see the direct and indirect effects between variables; iii) Tests several dependent variables at once with several independent variables; iv) It can measure how much the indicator variable affects the respective factor variables; and v) It can measure factor variables that cannot be measured directly through the indicator variable [31].

The SEM-PLS research procedure conducted in several stages: i) Identifying the variables in the form of tests; ii) Designing a structural model of the relationship (inner model) to define the relationship between latent variables; iii) Creating a measurement model (outer model) to define the relationship between latent variables and their indicators; iv) Constructing a path diagram based on the outer model and inner model; v) Estimating of evaluation parameters, namely conducting several tests on variables, including convergent validity to test the correlation between constructs and latent variables, discriminant validity to obtain the validity of latent variables, and composite reliability and Cronbach alpha to show the level of confidence of the measuring instruments used; vi) Test the hypothesis with the test statistic used is the t-test to determine whether or not there is a relationship between latent variables and their indicators; vii) Obtain analysis results [32].

SEM-PLS analysis evaluates the measurement model (outer model) and evaluates the structural model (inner model). Furthermore, analysis tests are carried out, namely: i) Evaluation of the outer model consisting of: convergent validity with a loading factor value>0.6, discriminant validity with the loading value of the intended construct must be greater than the loading value of other constructs, composite reliability>0.7, average variance extracted (AVE)>0.5; ii) Evaluation of the inner model consists of: r-square (R^2) to measure the influence of variables and hypothesis testing with a p-value<0.05 and a t-statistic value>t-table value [33].

4. RESULTS

4.1. Prospective teachers' procedural knowledge of fractions

Prospective primary teachers' procedural knowledge of adding and subtracting fractions was measured using six problems. The results of prospective primary teachers' procedural knowledge are presented in Table 2. The table shows the procedural variables for fractions' addition and subtraction operations in the high criteria with a value of 1.46 (scale 2). Three items achieve very high criteria, and prospective elementary teachers have better procedural knowledge of subtracting fractions than adding fractions, while the meagre value is on the task of adding fraction with unlike denominator on a story problem of 1.28.

Table 2. Procedural knowledge of addition and subtraction fractions

Code	Item	Mean	Criteria
X1.1	Adding fractions with like denominators	1.53	Very high
X1.2	Adding fractions with unlike denominators	1.48	High
X1.3	Subtracting fractions with like denominators	1.52	Very high
X1.4	Subtracting fractions with unlike denominators	1.37	High
X1.5	Adding fractions with unlike denominators on a story problem	1.28	High
X1.6	Subtracting fractions with unlike denominators on a story problem	1.53	Very high

4.2. Prospective teachers' conceptual knowledge of fractions

Prospective elementary teachers' conceptual knowledge of adding and subtracting fractions was measured using six problems. The results of prospective elementary teachers' conceptual knowledge are shown in Table 3. The table presents the conceptual variables of addition and subtraction of fractions insufficient criteria with a value of 0.51 (scale 2). The test with the highest value is on the question with presenting adding fractions with unlike denominators using diagram representations of 0.94, while the meagre value is on the question of adding fractions with like denominators of 0.04.

Table 3. Conceptual knowledge on addition and subtraction fraction

Code	Item	Mean	Criteria
X2.1	Adding fractions with like denominators	0.04	Very low
X2.2	Adding fractions with unlike denominators	0.45	Very low
X2.3	Subtracting fractions with like denominators	0.13	Very low
X2.4	Subtracting fractions with unlike denominators	0.68	Low
X2.5	Presenting adding fractions with unlike denominators using diagram representations	0.94	Low
X2.6	Presenting adding fractions with unlike denominators using diagram representations	0.85	Low

4.3. Prospective teachers' problem-posing skills

Prospective elementary teachers' problem-posing skills on adding and subtracting fractions were measured using six problems. The results of prospective elementary teachers' problem-posing skills are presented in Table 4. The table shows the variable problem posing ability in high criteria with a value of 1.22. The test with the highest value is on the question with the structured problem-posing situation on subtraction fraction of 1.55, while the meagre value is on the question with semi-structured situation addition fraction of 0.99.

Table 4. Problem posing abilities

Code	Item	Mean	Criteria
Y1	Semi-structured situation addition fraction	0.99	Low
Y2	Structured problem-posing situation addition fraction	1.03	High
Y3	Semi-structured situation subtraction fraction	1.45	High
Y4	Structured problem-posing situation subtraction fraction	1.55	Very high
Y5	Free-situation addition fraction	1.22	High
Y6	Free-situation subtraction fraction	1.07	High

4.4. Outer model evaluation

4.4.1. Convergent validity

The results of loading factors are procedural knowledge, conceptual knowledge, and problem-posing abilities. Of the 18 items, 15 had a value greater than 0.6 and 3 items had a value 0.6. So, that these three items (X1.1, X2.1 and X2.4) are eliminated. The re-estimation results can be seen in Figure 2. The figure shows the results of re-estimating the loading factor of the item values generated by the construct of procedural knowledge, conceptual knowledge, and problem-posing abilities that have met the standard value of convergent validity because all the factors are more than 0.6 Thus, it can be concluded that all constructs are valid.

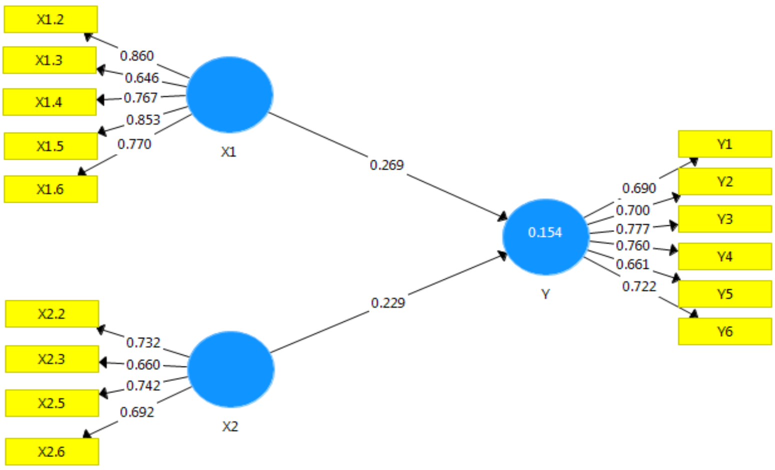


Figure 2. Outer loading test re-estimation results

4.4.2. Discriminant validity

The discriminant validity of the data on the cross-loading factor test is presented in Table 5. The results show that the cross-loading value for each construct has a more excellent loading value than the loading value for other constructs so that the manifest variables in this study correctly explain the latent variables and prove that all items are valid.

Table 5. Cross loading result

	X1	X2	Y
X1.2	0.860	0.158	0.244
X1.3	0.646	0.201	0.249
X1.4	0.767	0.109	0.145
X1.5	0.853	0.219	0.352
X1.6	0.770	0.204	0.164
X2.2	0.075	0.732	0.241
X2.3	0.146	0.660	0.230
X2.5	0.251	0.742	0.192
X2.6	0.268	0.692	0.112
Y1	0.187	0.202	0.690
Y2	0.231	0.228	0.700
Y3	0.326	0.249	0.777
Y4	0.199	0.207	0.760
Y5	0.148	0.154	0.661
Y6	0.248	0.202	0.722

4.4.3. Composite reliability

Table 6 describes the composite reliability of the data. The results show that all variable values in reliability testing using Cronbach's alpha having a value>0.6, and the composite reliability being processed has a value>0.8. Validity testing using AVE>0.5. Therefore, it can be concluded that the tested variables are valid and reliable, so that structural model testing can be done.

Table 6. Composite reliability result

Variable	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Procedural knowledge (X1)	0.844	0.887	0.613
Conceptual knowledge (X2)	0.683	0.800	0.500
Problem posing (Y)	0.815	0.865	0.518

4.5. Inner model evaluation
4.5.1. R-square

Table 7 presents the result of the R-Squares. The R-Squares value is 0.154. This value shows that the variables of procedural and conceptual knowledge of addition and subtraction of fractions affect the variable of problem-posing ability by 15.4%, and the rest is influenced by other variables outside the variables in this study.

Table 7. R-Square test result

Item	R-Square	R-Square adjusted
Y	0.154	0.137

4.5.2. Hypothesis test

Table 8 explains the determination of whether the hypothesis is accepted or rejected, namely: The procedural knowledge construct of addition and subtraction operations has a t-statistic value of 3.025>1.96 and a p-value of 0.000<0.05. Therefore, the first hypothesis proves a relationship between the procedural knowledge of the operation of addition and subtraction of fractions with the problem-posing ability of prospective elementary school teachers. The conceptual knowledge construct of fractions addition and subtraction has a t-statistic value of 2.909>1.96 and a p-value of 0.000<0.05. Therefore, the second hypothesis proves a connection between the conceptual knowledge of addition and subtraction of fractions with the problem-posing ability of prospective elementary school teachers.

Table 8. T-Statistic result

Item	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
X1 -> Y	0.269	0.308	0.089	3.025	0.000
X2 -> Y	0.229	0.250	0.079	2.909	0.000

5. DISCUSSION

This study indicated that the prospective primary teachers' have high procedural knowledge but not conceptual knowledge of addition and subtraction of fractions. They could use algorithms to solve procedural tasks such as adding two fractions, but they have many difficulties explaining diagram representations. They tend to unaware of a typical size of diagram representation when adding and subtracting two fractions. Austin, Carbone, and Webb [34] confirm these similar findings in which some prospective elementary teachers were not aware that for units to be comparable. This is in line with the research of Toluk-Uçar [12], which states that prospective teachers are good at performing procedures, but most have difficulty producing conceptually correct views of the fraction statements given. This research has in common that prospective teachers have a better mastery of procedural knowledge than conceptual knowledge.

In relation to procedural and conceptual knowledge of prospective elementary teachers, this study revealed that prospective primary teachers have more challenging on adding fractions than those for subtracting fractions. The results of this study contradict many previous research findings which show that both students and teachers have better procedural and conceptual knowledge in addition rather than subtraction of fractions [17], [18], [35]. Therefore, this findings reflect some factors that could affect this differences such as what Siegler and Lortie-Forgues [5] describe some culturally contingent sources of difficulty to understand rational numbers for students and teachers. One of our conjectures for Indonesian prospective elementary teachers' better performances on subtracting of fractions is the result of subtracting of two proper fractions always giving a fraction less than one. When comparing to adding two fractions, it could give the result of an improper fraction, and some prospective elementary teachers may have challenges to represent this fraction such as using a diagram representation.

The results indicate that prospective elementary teachers have high problem-posing skills on adding and subtracting fractions concerning problem posing. Prospective elementary teachers could provide good problems on addition and subtraction of fractions. However, posing problems on the addition of fractions was more challenging than those on subtracting fractions. This finding is in contrast to some previous studies that have found that prospective elementary teachers performed better on addition than the subtraction of fractions [17], [35].

The research test results prove a relationship between procedural and conceptual knowledge of the addition and subtraction of fractions with the problem-posing skills of prospective primary teachers. Prospective primary teachers' procedural and conceptual knowledge of addition and subtraction of fractions affect problem-posing skills by 15.4%. This finding is in line with previous study by Toluk-Uçar [12], which states that problem-posing is related to procedural and conceptual knowledge of prospective teacher fractions. This research has in common, namely that procedural and conceptual knowledge with problem-posing has a relationship between one another.

6. CONCLUSION

This study has revealed that procedural and conceptual knowledge is an essential aspect for prospective elementary teachers. It has a relationship with prospective elementary teachers' problem-posing skills. Their problem-posing skills will also increase by supporting prospective elementary teachers' procedural and conceptual knowledge. However, this study indicated that prospective elementary teachers struggle to solve problems related to their conceptual knowledge. So, researchers advise prospective elementary teachers to improve their conceptual knowledge of addition and subtraction of fractions to support pupils' understanding of this subject better. Further studies to examine the connection between procedural and conceptual knowledge with problem-posing skills in multiplication and division of fractions are highly recommended. This domain is more challenging for many students and teachers.

Concerning the research method chosen in this study, SEM-PLS provides the direct effects between procedural and conceptual knowledge and problem-posing skills on the addition and subtraction of fractions of prospective primary teachers. It also could measure how much the procedural and conceptual knowledge affects prospective primary teachers' problem-posing skills on the addition and subtraction of fractions. Compared to other methods, such as ordinary least squares (OLQ) regression, SEM-PLS does not need an assumption that the data is normally distributed, and there is no multicollinearity problem between exogenous variables. In addition, SEM-PLS can be used on data with a small sample size.

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REFERENCES

[1] G. A. Bobos, "Measurement Approach to Teaching Fractions: A Design Experiment in a Pre-Service Course for Elementary Teacher," *International Journal for Mathematics Teaching and Learning*, vol. 18, no. 2, pp. 203–239, 2017.

[2] F. Depaepe *et al.*, "Teachers' content and pedagogical content knowledge on rational numbers: A comparison of prospective elementary and lower secondary school teachers," *Teaching and Teacher Education*, vol. 47, pp. 82–92, Apr. 2015, doi: 10.1016/j.tate.2014.12.009.

[3] Z. H. Putra, "Praxeological change and the density of rational numbers: The case of pre-service teachers in Denmark and Indonesia," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 15, no. 5, 2019, doi: 10.29333/ejmste/105867.

[4] Z. H. Putra, "Didactic transposition of rational numbers: A case from a textbook analysis and prospective elementary teachers' mathematical and didactic knowledge," *Journal of Elementary Education*, vol. 13, no. 4, pp. 365–394, 2020, doi: 10.18690/rei.13.4.365-394.2020.

[5] R. S. Siegler and H. Lortie-Forgues, "Hard Lessons: Why Rational Number Arithmetic Is So Difficult for So Many People," *Current Directions in Psychological Science*, vol. 26, no. 4, pp. 346–351, 2017, doi: 10.1177/0963721417700129.

[6] H. van Steenbrugge, E. Lesage, M. Valcke, and A. Desoete, "Preservice elementary school teachers' knowledge of fractions: A mirror of students' knowledge?" *Journal of Curriculum Studies*, vol. 46, no. 1, pp. 138–161, 2014, doi: 10.1080/00220272.2013.839003.

[7] Y. Deringöl, "Misconceptions of primary school students about the subject of fractions," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 8, no. 1, pp. 29–38, 2019, doi: 10.11591/ijere.v8i1.16290.

[8] E. Young and L. R. Zientek, "Fraction Operations: An Examination of Prospective Teachers' Errors, Confidence, and Bias," *Investigations in Mathematics Learning*, vol. 4, no. 1, pp. 1–23, 2011, doi: 10.1080/24727466.2011.11790307.

[9] R. K. Sembiring, S. Hadi, and M. Dolk, "Reforming mathematics learning in Indonesian classrooms through RME," *ZDM - International Journal on Mathematics Education*, vol. 40, no. 6, pp. 927–939, 2008, doi: 10.1007/s11858-008-0125-9.

[10] L. Ma, *Knowing and Teaching Elementary Mathematics: Teachers' Understanding of Fundamental Mathematics in China and the United States, Anniversary Edition*, 2nd ed. Routledge, 2010, doi: 10.4324/9780203856345.

[11] C. Kilic, "Analyzing pre-service primary teachers' fraction knowledge structures through problem posing," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 11, no. 6, pp. 1603–1619, 2015, doi: 10.12973/eurasia.2015.1425a.

[12] Z. Toluk-Uçar, "Developing pre-service teachers understanding of fractions through problem posing," *Teaching and Teacher Education*, vol. 25, no. 1, pp. 166–175, 2009, doi: 10.1016/j.tate.2008.08.003.
[13] H. P. Osana and D. A. Royea, "Obstacles and challenges in preservice teachers' explorations with fractions: A view from a small-scale intervention study," *Journal of Mathematical Behavior*, vol. 30, no. 4, pp. 333–352, 2011, doi: 10.1016/j.jmathb.2011.07.001.
[14] T. Kar, "Analysis of problems posed by sixth-grade middle school students for the addition of fractions in terms of semantic structures," *International Journal of Mathematical Education in Science and Technology*, vol. 46, no. 6, pp. 879–894, 2015, doi: 10.1080/0020739X.2015.1021394.
[15] J. Xie and J. O. Masingila, "Examining Interactions between Problem Posing and Problem Solving with Prospective Primary Teachers: A Case of Using Fractions," *Educational Studies in Mathematics*, vol. 96, no. 1, pp. 101–118, 2017, doi: 10.1007/s10649-017-9760-9.
[16] I. K. C. Leung and R. E. Carbone, "Pre-service teachers' knowledge about fraction division reflected through problem posing," *The Mathematics Educator*, vol. 14, no. 1–2, pp. 80–92, 2013.
[17] K. J. Newton, "An extensive analysis of preservice elementary teachers' knowledge of fractions," *American Educational Research Journal*, vol. 45, no. 4, pp. 1080–1110, 2008, doi: 10.3102/0002831208320851.
[18] H. C. Li, "A comparative analysis of British and Taiwanese students' conceptual and procedural knowledge of fraction addition," *International Journal of Mathematical Education in Science and Technology*, vol. 45, no. 7, pp. 968–979, 2014, doi: 10.1080/0020739X.2014.892163.
[19] M. Chinnappan and T. Forrester, "Generating procedural and conceptual knowledge of fractions by pre-service teachers," *Mathematics Education Research Journal*, vol. 26, no. 4, pp. 871–896, 2014, doi: 10.1007/s13394-014-0131-x.
[20] S. Fatmawati, "The formulation of learning objectives and cognitive questions is oriented towards the revision of Bloom's taxonomy in physics learning," (in Indonesian), *Edu Sains: Jurnal Pendidikan Sains dan Matematika*, vol. 1, no. 2, pp. 1–16, 2013, doi: 10.23971/eds.v1i2.13.
[21] L. Khamid, "Conceptual Understanding and Procedural Knowledge of Class VIII Students in Solving Mathematical Problems on Two Variable Linear Equation Systems Materials at SMPN 7 Kediri," (in Indonesian), *Prosiding SI MaNIs (Seminar Nasional Integrasi Matematika dan Nilai-Nilai Islami)*, vol. 01, no. 01, 2017, pp. 621–616.
[22] S. Prafitriyani, "Exploration of Procedural Knowledge in Solving Arithmetic Operation in Fraction of Grade Xi Students At SMAN 17 in Makassar," *Jurnal Daya Matematis*, vol. 4, no. 2, p. 101, 2017, doi: 10.26858/jds.v4i2.2891.
[23] Y. Arnidha, "Analysis of Conceptual and Procedural Knowledge Ability of Elementary School Students in the Subject of Fractions," (in Indonesian), *JPGMI (Jurnal Pendidikan Guru Madrasah Ibtidaiyah Al-Multazam)*, vol. 2, no. 1, pp. 54–60, 2017, [Online]. Available: https://ojs.stitmultazam.ac.id/index.php/JPGMI/article/view/23.
[24] M. Kopparla *et al.*, "The effects of problem-posing intervention types on elementary students' problem-solving," *Educational Studies*, vol. 45, no. 6, pp. 708–725, 2019.
[25] E. Retnowati, Y. Fathoni, and O. Chen, "Mathematics problem solving skill acquisition: Learning by problem posing or by problem solving," *Cakrawala Pendidikan*, vol. 37, no. 1, pp. 1–10, 2018, doi: 10.21831/cp.v37i1.18787.
[26] K. Kadir and M. Sadzali, "Analysis of Students' Mathematical Problem Posing Ability in NHT. Cooperative Learning Model," *ALGORITMA: Journal of Mathematics Education*, vol. 1, no. 1, pp. 22–34, 2019, doi: 10.15408/ajme.v1i1.11683.
[27] D. Daryati, Nugraha, and N. Sutarni, "The effect of using the problem posing method on the ability to solve problems," *Jurnal Pendidikan Ilmu Sosial (JPIS)*, vol. 27, no. 1, pp. 31–42, 2018.
[28] W. N. Shanti, D. A. Sholihah, and A. Martyanti, "Improve critical thinking skills through problem posing," *LITERASI (Jurnal Ilmu Pendidikan)*, vol. 8, no. 1, p. 48, 2017, doi: 10.21927/literasi.2017.8(1).48-58.
[29] L. Cohen, L. Manion, and K. Morrison, *Research Methods in Education*, 8th ed. Routledge, 2017, doi: 10.4324/9781315456539.
[30] Z. H. Putra, G. Witri, and T. Yulita, "Development of powerpoint-based learning media in integrated thematic instruction of elementary school," *International Journal of Scientific and Technology Research*, vol. 8, no. 10, pp. 697–702, 2019.
[31] E. N. Sasongko, M. Mustafid, and A. Rusgiyono, "Application of Structural Equation Modeling Method for Analysis of Academic Information System User Satisfaction on Website Quality (Case Study on Website sia.undip.ac.id)," (in Indonesian), *Jurnal Gaussian*, vol. 5, no. 3, pp. 395–404, 2016, doi: 10.14710/j.gauss.v5i3.14695.
[32] I. Irwan and K. Adam, "Partial Least Square (PLS) Method and Its Application (Case Study: Analysis of Customer Satisfaction with PDAM Camming Unit Services, Bone Regency)," (in Indonesian), *TEKNOSAINS Media Inf. Sains dan Teknol.*, vol. 9, no. 1, pp. 53–68, 2015, doi: 10.24252/teknosains.v9i1.1856.
[33] H. Latan and I. Ghozali, *Partial Least Squares Concepts, Techniques and Applications Using the SmartPLS 3.0 Program for Empirical Research*. Semarang, Badan Penerbit Universitas Diponegoro (in Indonesian), 2015.
[34] P. Austin, R. E. Carbone, and P. Webb, "Prospective primary school teachers' attempts to pose acceptable word problems on the addition of fractions: Some insights from south Africa and the United States of America," *African Journal of Research in Mathematics, Science and Technology Education*, vol. 15, no. 2, pp. 168–178, 2011, doi: 10.1080/10288457.2011.10740710.
[35] Z. H. Putra, "Knowledge of Elementary School Teacher Education Students in Representing Fraction Operations with Rectangle Models," *Jurnal Elemen*, vol. 2, no. 1, pp. 1–13, 2016, doi: 10.29408/jel.v2i1.174.

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