Solve the problem of learning fractions in mathematics through scaffolding

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Abstract. Literature study of fraction learning problem in mathematics and scaffolding strategies aims to reveal the results of previous research and offer solutions to solve the problem through scaffolding. This literature studies are sourced from the IOP conference series journal, science direct, and springer link journal articles, to expand the study taken from other sources, both journal articles and source books. The basis of the scaffolding theory refers to Vygotsky's opinion which includes two main ideas, namely the zone of proximal development (ZPD) and scaffolding. The conclusions from the literature study are; (1) difficulties in understanding the concept and fraction calculation operations in mathematics experienced by elementary school students, junior high school students, and primary school teacher education students, (2) to help overcome difficulties understanding fraction concepts and fraction calculation operations, it is necessary to provide learning time according to student needs until achieving a complete understanding, (3) solutions to help learning fractions concepts and fraction calculation operations can be pursued through the ZPD scaffolding strategy by combining teacher-student dialogical interactions, collaborative, contextual, enriching metaphors, and dynamic communication.

1. Introduction
Fractions are one of the topics of mathematics subject to be studied by elementary school students. As it happened, fractions were recognized by most students as a complex and difficult topic. The author's experience when assisting elementary school students proved that they had difficulty in solving addition, subtraction, multiplication, and division of fractions. The difficulties in solving fraction division problems were found in the research that the tendency of students’ procedural knowledge dominated to their conceptual knowledge in solving the fraction division problem and students’ conceptual knowledge was incomplete [1], and also stated that students seemed to apply processes they do not fully understand [2]. Findings about fraction problems experienced by elementary school students need attention and solutions to solve them, considering that understanding the concept of fractions is a prerequisite for understanding advanced mathematical concepts at higher grade levels.

Teaching fractions is not only about transferring mathematical ideas, methods and concepts, but rather a way to define fractions as a process of origin, occurrence, and gradual development [3]. Learning fractions in elementary schools include; (1) the concept of fractions implanted in the minds of students not paying attention to the stages of contextual genesis, (2) the conceptual complexity associated with using fractions in modeling problems, (3) the rules of the four arithmetic operations fractions are not associated with the usual four operations on positive integers that are familiar to students, (4) how to learn realistic, contextual, fun fractions with physical models or visualization [3].
Based on the problem of fractions as the topic of elementary school mathematics material above, it can be identified, namely: (1) students have difficulty doing fraction calculating operations because did not understand the concepts and procedures for solving fraction problems, (2) the fraction learning process has not been optimal in helping students understand the concepts and fraction count operation.

The factor of understanding the concept of fractions is needed for elementary school students who gradually need to be introduced to the procedure for solving fraction calculation operations. Studying concepts in the discipline of mathematics occupies an important position, because it will be applied in every problem of life. In order to better provide learning concepts, it is important to know students' prior knowledge and develop new strategies that are appropriate with their knowledge [4]. Conceiving concepts and solving problems or fractions calculation operations in mathematics learning cannot go through a dogmatic or mechanical process, because elementary school age students are rapidly developing memory and cognitive skills, including metacognitive skills as the ability to think about their own thinking and to learn how to learn [5]. Referring to the level of cognitive development of elementary school students, in order to help them overcome fraction learning difficulties, the author is interested in studying Vygotsky's theory of the zone of proximal development (ZPD) and scaffolding, namely the difference between what can be done independently by students and what can be done with the help of others [6]. With the premise that the difficulties experienced by students need help from others to solve, help is not always given, but gradually students are directed to independently solve the problems they are experiencing. The assumption of the role of scaffolding is that the role of assistance given when needed is meaningful.

The scope of this literature study is: (1) what problems students face in studying fractions in mathematics, and (2) how ZPD and scaffolding play a role in helping students who have difficulty learning fractions in mathematics.

2. Methods
The method of this research is literature study. Researchers searched various written sources, both from books and research results related to the problem of learning fractions in elementary school mathematics and the ZPD scaffolding concept. This study is the type of reviews, researchers intends to describe the various problems experienced by elementary students in studying fractions based on the results of previous research and offer solutions to help them through Vygotsky's theory of ZPD scaffolding.

3. Results and discussion
Literature studies were carried out by searching for international open access journal articles and several books. The source of review journal articles is limited to publication in 2015 to 2020. Researchers found a number of journal articles sourced from science direct, IOP, and springer link. However, to be able to complement the study sources, other journal sources were also selected for article topics that were relevant. The topics selected were about elementary school math fractions and mathematics learning by applying scaffolding. The purpose of the literature study is to reveal the results of research on the difficulties of elementary school students in fractions and the role of scaffolding in mathematics learning. A review of several article topics on fractions, found various problems of elementary school students about fractions, both in understanding the concept of fractions and the operations of calculating addition, subtraction, multiplication, and division of fractions.

3.1. Problems learning fractions in mathematics faced by elementary school students
The following are some research findings on the difficulties of elementary school students in learning fractions. The students at grade 7 of junior high school had difficulty solving fraction test questions because students did not understand the concept of fractions that had been learned while in elementary school. The results of the study concluded that there was a fairly positive correlation between understanding the concept of fractions with prerequisite grade 7 junior high school students [7]. Judging from the order and scope of the curriculum material, the concept of fractions studied in elementary schools is closely related to the fractions studied in junior high school. To do well in fraction,
prerequisite knowledge as basic as knowing how to add, subtract, multiply, and divide natural numbers must be mastered first and foremost [8]. These research findings show that a solid basic knowledge of the concept of fractions is needed, and will further equip students to connect their understanding of the concept with other topics about fractions in mathematics.

The research that conducted a test on the addition and multiplication of fractions to fifth grade elementary school students, found that students had difficulty doing the addition and multiplication of fractions, both the denominator is the same or not. The conclusion was that students experienced difficulties in fraction arithmetic procedures, especially in addition and multiplication operations [9]. Research designed of fraction learning with realistic illustrations to understand the operation of adding fractions to fifth grade elementary school students, with real teaching aids using the context of the pizza circle, triggers students to understand the concept of fractions. The addition operation learning stage is designed with a hypothetical learning trajectory (HLT), which is understanding the value of fractions as part of the whole, comparing the values of two fractions, determining the value of fractions, performing the sum operation for fractions of a value, and performing the operation of adding fractions with no value [10]. This HLT learning design can be said to help students understand the concept of fractions, making it easier to perform fraction addition operations.

The results of fraction division operation test for fifth grade elementary students, the number of students who answered the fraction division questions correctly was less than the students who answered incorrectly. The results of the analysis concluded that the students' difficulties were due to their lack of understanding of the concept of fractions, thus there was a relationship between understanding the concept and procedural knowledge of the division of fractions [1]. The other results of research showed that students’ error answers caused by students changing their way of thinking to solve multiplication and division operations on the same procedures, the changing of mix fraction to common fractions made students confused, and students are careless in doing calculation [11].

In most traditional mathematics classrooms, students are frequently expected to learn facts, concepts, and skills divorced from real context. They are drilled in arithmetic without applying the skills to problems that mean anything to them [12]. Related with this research, exploration of the understanding of the concept of fractions in 4th semester elementary school teacher education students, they do not understand the concept of fractions as part of a whole or part of a set, and assume that fractions are the result of the same division of a whole [13]. These findings indicate that the fraction concept understood by elementary school teacher education students is closely related to their previous learning experience of fractions. Based on this case, the students need to be given the opportunity to deepen the concept of fractions so that there are no continuous misconceptions. If the misconception is sustainable, it will affect the planting of concepts to elementary school students. The relationship of teacher's content knowledge on fraction topic toward student performance, concluded that teachers content knowledge in fraction were affected to student performance tests on fraction [14]. The case of weak content knowledge of teachers about the concept of fractions is the impact of continuous misconceptions since learned in elementary school teacher education. Thus, the problem of fractions in mathematics, it was identified that the difficulties in understanding the concepts and operations of calculating fractions is not only experienced by elementary school students but also experienced by elementary school teacher education students. Therefore, mathematical learning involves acquiring both conceptual knowledge or understanding relationships among pieces of information, and procedural knowledge or understanding symbols of representation and rule for completing math tasks [15].

3.2. How does the concept of scaffolding help students’ difficulties learning fractions in mathematics?

The two main ideas of Vygotsky's theory are the zone of proximal development (ZPD) and scaffolding. He described that a child when he is on a developmental task is not able to work independently but still needs help from other people who are more capable, both from adults and peers in learning. The belief that underlies Vygotsky's thought is that the mental function of individual increases when there is dialogue and collaboration between individuals [5]. He argued, acquired initially under guidance from others in social practices and became available for independent use and control of one’s own actions
and behavior [16]. Research findings on how scaffolding helps students who have difficulty learning mathematics has been found. The teacher’s scaffolding intention affected his gaze targets significantly and that mobile gaze tracking can provide novel insight to situational processes of teacher-student interaction [17]. The other finding described that scaffolding has a potential to be useful integrative concept with mathematics education [18]. The effectiveness of scaffolding, depending on the time of independent group work and the effort of students’ task effort [19]. These findings mean that scaffolding is help given to the learner, after becoming independent, the help will be reduced gradually so that the learner feels that they are already able to be independent and will keep growing based on their ability [20]. Therefore, scaffolding is to provide as much assistance as possible to individuals who have learning difficulties and reduce assistance gradually when individuals already have responsibility and are able to complete tasks without the help of others. It is a learning aid provided according to student needs by enriching metaphors and creating dialogical communication during the learning process. Referring to Vygotsky's theory, providing learning aids to students is adjusted according to the time needed. Providing assistance can be done through interaction with adults and peers who are more capable, so that students independently solve the problem.

Based on the literature study of the problem of fractions in mathematics and the ZPD scaffolding theory, the learning strategy solution suggests eight stages of applying scaffolding [21]. The steps that must be taken by the teacher are as follows.

- Provides clear direction, offering a step by step instructions to explain what the students must do to achieve their learning activities.
- Describes the targets/objectives, so students do not meet a gap that gives nothing. Their works must have goals which are focused entirely on the plan.
- Leads students continuously on a given task, by providing a kind of route to be followed for students completing their duties.
- Provides the assessment to clarify what is expected, in the form of rubrics or standards of work quality expected and delivered since the beginning.
- Explains the starting point for students to access other sources of information useful for solving problems.
- Reduces uncertainty, surprise and discontent.
- Produces efficiency because it is focused and there is clarity of duty and time.
- Creates momentum, through the search process, ask, ponder, consider in stimulating inspiration.

4. Conclusion
The results of the literature review can be concluded that the difficulties experienced by both elementary and junior high school students, and also elementary school teacher education students regarding understanding the complete concept of fractions and the operation of fraction calculation. The factor causing these difficulties is because when students faced difficulties at the beginning of understanding the concept, they have not been given assistance according to their needs. As the scaffolding theory, that individuals need time to learn. Comprehensive understanding of fraction concepts and operation of fraction calculation since elementary school, has an impact up to higher levels. In dealing with difficulties in understanding the concept and operation of fraction calculation, basically the ZPD scaffolding strategy can be pursued by combining dialogical, collaborative interactions, enriching metaphors, and dynamic communication.

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References
[1] Purnomo Y W, Widowati C and Ulfah S 2019 Incomprehension of The Indonesian Elementary
School Students on Fraction Division Problem *Infinity Journal of Mathematics Education* **8** 1 57-74

[2] Gabriel F C, Coché F, Szucs D, Carette V, Rey B and Content A 2013 A componental view of children’s difficulties in learning fractions *Frontiers in psychology* **4** 715

[3] Mariani S 2010 Pengajaran Konsep Pecahan dan Kabataku Pecahan di Sekolah Dasar *Kreano, Jurnal Matematika Kreatif-Inovatif* **12** 2 119-129

[4] Ay Y 2017 A review of research on the misconceptions in mathematics education *Education Research Highlights in Mathematics, Science and Technology* **12** 1 21-31

[5] Slavin R E 2009 *Educational Psychology Theory and Practice* Ninth Edition (New Jersey: Pearson International Edition)

[6] Schunk D H 2012 *Learning Theories an Educational Perspective* (Yogyakarta: Pustaka Pelajar)

[7] Yuniara R and Abidin Z 2020 The students’ mastery of fraction and its relation to the students’ abilities on its prerequisites *Journal of Physics: Conference Series* **1460** 1 012018

[8] Shahrrill M and Prahmana R C I 2020 Understanding primary school children’s learning on addition of fractions *Journal of Physics: Conference Series* **1613** 1 012046

[9] Trivena V, Ningsih A R and Jupri A 2017 Misconception on addition and subtraction of fraction at primary school students in fifth-grade *Journal of Physics: Conference Series* **895** 012139

[10] Warsiito, Darhim D and Herman T 2018 Improving students’ mathematical representational ability through RME-based progressive mathematization *Journal of Physics: Conference Series* **948** 012038

[11] Maelasari E and Jupri A 2017 Analysis of Student Errors on Division of Fractions *J. Phys.: Conf. Ser.* **812** 012033

[12] Dagoc D A and Tan D A 2018 Effects of Metacognitive Scaffolding on the Mathematics Performance of Grade 6 Pupils in a Cooperative Learning Environment *International Journal of English and Education* **5**

[13] Nurlaelah E, Herman T and Anaguna N 2019 Exploration of primary school teacher students’ understanding in fraction concept *Journal of Physics: Conference Series* **1211** 1 012060

[14] Kutub A H W, Wijayanti P and Manuharawati 2019 Relationship of Teacher’s Content Knowledge on Fraction Topic Toward Student Performance *Journal of Physics: Conference Series* **1417** 1 012054

[15] Brower R L, Woods C S, Jones T B, Park T J, Hu S, Tandberg D A and Martindale S K 2018 Scaffolding mathematics remediation for academically at-risk students following developmental education reform in Florida *Community College Journal of Research and Practice* **42** 2 112-128

[16] Gade S 2010 Cooperation and collaboration as zones of proximal development within the mathematics classroom *Nordic Studies in Mathematics Education* **15**

[17] Haataja E, Moreno-Esteva E G, Salonen V, Laine A, Toivanen M and Hannula M S 2019 Teacher’s visual attention when scaffolding collaborative mathematical problem solving *Teaching and Teacher Education* **86** 102877

[18] Bakker A, Smit J and Wegerif R 2015 Scaffolding and Dialogic Teaching in Mathematics Education: Introduction and Review *ZDM Mathematics Education* **47**

[19] van de Pol J, Volman M, Oort F and Beishuizen J 2015 The effects of scaffolding in the classroom: support contingency and student independent working time in relation to student achievement, task effort and appreciation of support *Instructional Science* **43** 5 615-641

[20] Tinangki G M 2019 Zone Proximal Development Gives a New Meaning to the Students’ in Statistical Method Lesson *Journal of Honai Math* **2**

[21] McKenzie J 1999 Scaffolding for Success. From Now On *The Educational Journal* **9** 4