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Student Proportional Reasoning on Missing Value Problems Based on Multiplicative Concepts

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ABSTRAK

Penalaran proporsional melibatkan pemahaman tentang hubungan keseluruhan multiplikatif antara rasio dan proporsi. Akan tetapi, masalah yang sering dihadapi siswa dalam penalaran proporsional adalah siswa cenderung menggunakan strategi aditif yang dapat menyebabkan siswa memperoleh jawaban yang kurang tepat. Penelitian ini bertujuan untuk menganalisis dan mendeskripsikan penalaran proporsional siswa dalam menyelesaikan masalah missing value berdasarkan konsep multiplikatif. Desain penelitian menggunakan pendekatan kualitatif deng jenis deskriptif eksploratif. Subjek penelitian adalah siswa kelas VII berjumlah 3 siswa. Subjek penelitian dipilih berdasarkan kemampuan komunikasi lisan maupun tulisan dan pertimbangan guru mata pelajaran matematika. Pengumpulan data menggunakan tes pemecahan masalah missing value dan pedoman wawancara. Analisis data berdasarkan hasil pekerjaan siswa dan hasil wawancara yang diarahkan untuk menentukan fokus penelitian berupa karakteristik dan indikator penalaran proporsional. Hasil penelitian ditemukan tiga kategori penalaran proporsional siswa dalam menyelesaikan masalah missing value, yaitu kategori "aditif", siswa mengamati objek menggunakan konsep penjumlahan. Kategori multiplikatif tipe "within ratio", siswa mengamati objek menggunakan konsep multiplikatif antara unsur-unsur dalam rasio yang sama. Kategori multiplikatif tipe "between ratios", siswa mengamati objek menggunakan konsep perkalian antara unsur-unsur dalam rasio yang berbeda.

ABSTRACT

Proportional reasoning involves an understanding of the relationship of the overall multiplicative partitions between ratios and proportions. However, the problem that is often faced by students in proportional reasoning is that students tend to use additive strategies which can cause students to get incorrect answers. This study aims to analyze and describe students' proportional reasoning in solving the missing value problem based on the multiplicative concept. The research design used a qualitative approach with exploratory descriptive type. The research subjects were 3 students of grade VII. Research subjects were selected based on their oral and written communication skills and the considerations of mathematics teachers. Collecting data using the missing value problem solving test and interview guidelines. Data analysis based on the results of student work and the results of interviews directed to determine the research focus in the form of characteristics and indicators of proportional reasoning. The results of the study found three categories of students' proportional reasoning in solving the missing value problem, namely the "additive" category, students observing objects using the sum concept. The multiplicative category of the "within ratio" type, students observe objects using the multiplicative concept between elements in the same ratio. Multiplicative category of type "between ratios", students observe objects using the concept of multiplication between elements in different ratios.

1. INTRODUCTION

Proportional reasoning is mathematical reasoning that has a strategic position in mathematics learning (Muttaqin et al., 2017; Permatasari et al., 2017). Proportional reasoning involves the understanding of various concepts and thoughts. Proportional reasoning can be described as the ability to understand ratios and proportions (Babai et al., 2018; Johar & Yusniarti, 2018).. In addition, proportional reasoning as a qualitative structure allows the understanding of complex physical systems that contain many factors (Johar & Yusniarti, 2018). The intended understanding of complex physical systems is an understanding related to proportions and ratios. Ratios and proportions are two fundamental concepts that must be given an appropriate place in the mathematics curriculum. Ratios and proportions make up the entire curriculum at elementary and secondary levels of education and play a very important role in the professionals' routines on a daily basis (Dubovi et al., 2018). Mathematically, a ratio is a number that

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represents a multiplication relationship that can be used in the second situation where the quantity or size is relatively the same as in the initial situation (Dubovi et al., 2018; Nur & Sari, 2022b). Similarly, the concept of proportions is often used to solve problems in mathematics and various other fields.

Proportional reasoning is the ability to construct and solve proportional problems. Proportion plays a crucial part in primary and secondary mathematics education. Proportion is a basic concept underlying students' understanding of various topics in mathematics (Dougherty et al., 2016). Many topics in mathematics, including probability, trigonometry, field geometry and algebra require knowledge and understanding of proportions (Şen & Güler, 2017)(Dougherty et al., 2016). Proportion is also expressed as part of a multiplicative conceptual field that is interrelated with many mathematical concepts such as scale, drawing, recipe ingredients, price comparison, money value, number of children, weight, and speed (Jacobson et al., 2018; Khotimah & Shodikin, 2021). Proportion is seen as a multiplicative relation between quantities in two measure spaces. Space size can be considered as a range of values that can be measured from certain aspects of a situation. For instance, distance and time can be seen as two measure spaces in a constant speed situation. Students can understand a concept from a measurement space (for example by calculating the ratio between distances and between times) or coordinate the amount in the entire measure space like forming the ratio of distances from time to time (Jacobson et al., 2018).

Proportional reasoning involves an understanding of the relationship of the overall multiplicative partitions between ratios and proportions. These studies have indicated that the ratios and proportions are grounds for other mathematical thinking, and they point out that the misconceptions of this concept should be solved first (Çelen, 2018; Chaim et al., 2012). It thus provides the basis for solving many problems in mathematics. Students who are able to reason proportionally can build their knowledge of good mathematics, but students who fail to develop proportional reasoning are more likely to face problems in understanding higher-level mathematics (Chaim et al., 2012). One of the students' errors in proportional reasoning is using additive strategies rather than multiplicative strategies in solving proportion problems. Students who lack mastery in proportional reasoning tend to start back to additive reasoning when presented with proportion problems. Students still have difficulty in distinguishing proportional and non-proportional problem statements (Sari & Mampouw, 2019). The level of students' proportional reasoning skills is still low before being taught problem-solving strategies (Şen & Güler, 2017).

Researchers conducted a preliminary study on 26 students of SMP Negeri 4 Ternate City. Researchers provide missing value questions in the form of story questions to find out how students' proportional reasoning is. The results of the preliminary study obtained 10 students or 38% answered complete questions, 16 students or 62% answered incomplete questions. The missing value problem can be presented as follows. Anna skated 3 laps, Rachel coasted 12 laps. If, Anna has completed 6 laps, how many laps has Rachel skipped?. Proportional reasoning of students who experience errors in solving missing value questions, however students solve them using the addition method. Students receive information in the form of word problems and process information such as determining how many laps Rachel has passed. Students make mistakes in writing 12 rounds plus 12 rounds equals 24 rounds, 3 rounds plus 3 rounds equals 6 rounds. This shows that students are unable to remember the concept of proportion so that students solve the missing value problem using addition. The results of the students' work were mixed up, that is, the problem should have been solved using multiplication, but students solved it using additive.

Based on the initial findings in the preliminary study above, it is important to examine students' proportional reasoning using the addition concept. Student errors occur because when uncovering a problem-solving plan, students tend to have difficulty distinguishing multiplication and additive. Besides that, student errors in solving the missing value problem are partly because the concept of proportion is not well embedded in students' memories. Solving the missing value problem, teachers should explain using multiplication involving proportion situations. Students using multiplication in solving proportion problems have advantages that can be widely applied in all contexts. The problem studied in this study is the problem of missing values which can be used to reveal the occurrence of students' proportional reasoning. It is important to examine students' proportional reasoning in solving the missing value problem based on the multiplicative concept.

Developing proportional reasoning is a challenging long-running process. This should be supported by a quality learning experience where students are given the opportunity to explore, discuss, and experiment with situations of proportion. It is important to provide students with a learning environment that can stimulate them to develop proportional reasoning based on their learning experiences (Şen & Güler, 2017). In solving proportion problems, teachers often explain proportions using a multiplicative concept and a cross-time strategy that involve proportional situations. Students using the cross-time strategy in solving proportion problems have an efficient advantage that can be widely applied

in all contexts and domains. It is important for educators to understand various aspects of proportions, implement teaching strategies to promote student proportional reasoning, and enhance the underlying basic concepts (Hilton & Hilton, 2019). To develop proportional reasoning, students must understand the relationship between two quantities and how variations of one quantity correspond to variations of the other quantity, develop many strategies to resolve proportions or compare ratios, and understand ratios as separate entities that declare a relationship different from the quantities (Nur & Sari, 2022a).

Proportional reasoning occurs when students are faced with a problem related to the missing value (Prayitno et al., 2018). In this type of problem, students are given three numerical information and asked to look for an unknown value (Cruz, 2016). Missing value problem is the most common proportional reasoning problem. In a missing value problem, three values are known so that four of the numbers are proportionally related. For instance, students are given three values a, b and c, and asked to find the unknown value of x as in a/b = c/x. Among the structural components of the missing value problem, that are the top left (a), bottom left (b), top right (c), and bottom right (x), x represents the missing value (Khumairoh et al., 2020; Muttaqin et al., 2017). For example, "the total distance Aryo made in 2 trips is 10 km. How many trips will Aryo make for a total of 30 km?". The location of the missing value in this type of problem is in the lower left. Missing values that are located at the bottom are more easily solved than those at the top right. Besides the location of the missing value, other factors that influence student work outcomes are the magnitude and direction of the ratio scale.

One of the basic abilities that can help students solve missing value problems is to understand the multiplicative "within" and "between" ratios' relationships. A "within ratio" relationship indicates a multiplicative relationship between elements in the same ratio, while a "between ratios" relationship refers to a multiplicative relationship between the corresponding parts of different ratios. an of "within ratio" and "between ratios" relationships. The contains four quantities, A, B, C and D. The "within ratio" relationship is the one that can perfectly describe the multiplicative relationship between A and B and between C and D and the "between ratios" relationship indicates the relationship between A and C and between B and D. Understanding the multiplicative relationship between two given ratios is the key to developing proportional reasoning. Proportional reasoning involves the ability to identify the relationship between two ratios (Chaim et al., 2012). Students with this ability will usually be able to solve mathematical problems correctly. The missing value problems given to the participants of this study were intended to unveil their proportional reasoning process.

This research has differences with studies (Prayitno et al., 2018). As for the differences in research, that is 1) the subject of this study was students of class VII while the subject of previous research was students of class VIII, 2) The types of questions in this study are missing value problems based on the concept of multiplication, while previous studies are missing values based on proportional reasoning levels, 3) this research approach is a qualitative approach with exploratory descriptive type while the previous research approach was descriptive qualitative. The differences between this research and previous studies are the research subjects and research methods. The research subject was conducted on elementary school students and the research method used was a quantitative method. Based on the studies and results of previous research, the researcher came up with an idea for a research plan with the main focus on students' proportional reasoning. Therefore, the purpose of this study was to analyze and describe the proportional reasoning of class VII students of SMP Negeri 4 Ternate City in solving the problem of missing values based on the multiplicative concept.

2. METHOD

This study aimed to examine junior high school students' proportional reasoning in solving missing value problems based on multiplicative concepts. This study was designed using a qualitative approach. In a qualitative approach, problems explored to find in-depth understanding (Creswell, 2014). The participants of this study consisted of the seven-grade students from Ternate, Indonesia. Among the participants, six were selected as the main subjects of the study based on their potentials to solve comparison problems and to communicate the results effectively. These characteristics were determined through direct observations. The selection of the participants was also based on teacher recommendations. The students had studied "comparison" at the previous meeting. In the school curriculum, comparison materials are delivered to seventh grade students. Therefore, it can be assumed that most of the seventh grade students had understood comparisons, especially the concepts of ratio and proportion.

Two missing value tests were administered to reveal the participants' proportional reasoning. They were given 50 minutes to work on the missing value tasks. There were no further test instructions and the participants were not allowed to use a calculator or other calculation aids. After they worked on the missing value tasks, interviews were conducted. In the interview session, several unstructured

questions were asked to explore the extent to which the participants understood the missing value problems based on multiplicative concepts. The tests were conducted under the supervision of the researcher and one of the school's mathematics teachers.

The missing value problems presented to the participants during the essay tests and the interviews contained every day contexts and numbers involving the multiplications of integers 2 and 4. The participants were already familiar with the contexts of the problems. Missing value problem-solving showed in Table 1.

Table 1. Missing Value Problem-Solving

Problem	Missing value location	Ratio scale	Direction of ratio
Peter and Tom are loading boxes in a truck. They put it together but Tom moves faster than Peter. By the time Peter puts 40 boxes, Tom has finished loading 160 boxes. If Peter can put 80 boxes into the truck, how many boxes can Tom load in the truck?	Bottom right	Integers	Within ratio Between ratios
Rian and Afdal want to paint together. They want to use the exact same color. Rian uses 3 cans of yellow paint and 6 cans of red paint. Afdal uses 7 cans of yellow paint. How many cans of red paint does Afdal need?	Bottom right	Integers	Between ratios

As explained earlier, given three values a, b and c, the participants were asked to find the unknown value of x in the form of a/b = c/x. Among the components of the missing value problems, namely the upper left (a), lower left (b), upper right (c), and lower right (x), the value of x referred to the location of the missing value. The location of the missing value in both types of problems was in the lower right. In addition to the location of the missing value, MVP1 involved "within ratio" and "between ratios" relationships, while MVP2 involved a "between ratios" relationship. All ratios used in these two problems were the multiplication of integers. Problems with integer ratios are more easily solved by students. Multiplication and division with whole numbers form a web of interconnected topics because of their connections with fractions, measurement, ratios and rates, and proportional reasoning (Hino & Kato, 2019). Task-based interviews were conducted to collect the data. The participants were required to solve a problem related to direct proportions that involved students' proportional reasoning. They were asked to explain their thoughts in details. The students' behaviors were recorded using a camcorder. Every important detail during the think aloud process was also documented in a written form. Each research subject was interviewed to maintain data consistency or the conformity of the verbal, written, and interviews data.

Data analysis was performed to the results of the participants' problem-solving tests and interviews. The analysis was directed to examine the characteristics and indicators of the participants' proportional reasoning. The participants' problem-solving results were classified as proportional reasoning if they met the following components. The first component was that the participants understood that two quantities were connected so that when one quantity changed, the other also changed in a certain way with respect to the first quantity. The second component was that the participants were able to implement multiplicative strategies. The activities undertaken by the participants related to the second component included representing quantities into ratios that made up the proportions and using multiplication operations to obtain the value in question. The third component was when the participants, in solving the problems, presented quantities between sizes of space by involving direct proportions, in the form a/b = c/d, where a and b represented the quantities of the same space size (for example, in the first situation Peter can put 40 boxes while in the second situation he can load 80 boxes) and b and c also represented the quantities of the same space size (in the first situation, Tom has put 160 boxes, while in the second situation, he is able to put 320 boxes).

3. RESULT AND DISCUSSION

Result

Students' proportional reasoning in solving missing value questions based on the multiplication concept found three categories, that is: (1) the "additive" category, where students observe objects using the concept of addition, (2) the multiplicative type "within ratio" category, where students observe objects using the multiplicative concept between elements in the same ratio, (3) the "multiplicative type between

ratio" category, where students observe objects using the concept of multiplication between elements in different ratios.

The first finding is proportional reasoning obtained by ES subjects, hereinafter referred to as subjects in the "additive" category in solving missing value questions. While the second finding, proportional reasoning was obtained by UA subjects hereinafter referred to as subjects in the multiplicative category of the "within ratio" type in solving the missing value problem. The third finding, proportional reasoning obtained by the AR subject is hereinafter referred to as a subject in the multiplicative category of the type "between ratios" in solving the missing value problem. Three categories of students' proportional reasoning were found in solving the missing value problem which can be shown in Table 2.

Table 2. Categories of Students' Proportional Reasoning in Solving Missing Value Problems

Subject	Proportional Reasoning Category	Description
ES	Additives	In this category, where students observe objects using the concept of addition.
UA	Multiplicative type within ratio	In this category, where students observe objects using multiplicative concepts between elements in the same ratio.
AR	Multiplikatif type between ratios	In this category, where students observe objects using the concept of multiplication between elements in different ratios.

Additive category data that can be described is based on interview data, field notes and subject answer sheets in completing the missing value task. In this category, where students observe objects using the concept of additive. Student (ES) is an example of the participants who was unable to provide the right reasons and arguments in solving the missing value problems based on additive concepts. In missing value problem 1 (MVP1), ES failed to understand the problem so that he could not provide the right solution to the problem, while in missing value problem 2 (MVP2), ES was unable to provide reasons and arguments indicated by his blank answer sheets. It was known that student ES received information in the form of story questions and processed that information by determining the number of boxes Tom can put in the second situation after it is known that in the first situation, Tom is able to put 160 boxes. However, the student made a mistake in determining the number of boxes Tom can put in the second situation, indicating that the student was unable to recall the concept of proportion. As a result, the student used additive concepts instead of multiplication concepts to solve the problem. That student ES experienced errors in solving missing value problem 1 (MVP1) because he was unable to show proportional reasoning activities in applying multiplicative concepts and failed to understand the proper procedures for presenting ratios in the form of ratios. In the next section, the results of the work carried out on UA and AR students are discussed. These two students were selected as student representatives who were able to provide correct answers and arguments in the problem solving test. Students are considered capable of applying the proportional reasoning process in solving missing value problems based on the multiplication concept.

Multiplicative category data "within ratio" types that can be described based on interview data, field notes and subject answer sheets in completing the missing value task. In this category, where students observe objects using multiplicative concepts between elements in the same ratio. In the missing value problem tests (MVP1 and MVP2), Student (UA) demonstrated the ability to understand the problems and solve them by considering the multiplicative concept between the two quantities involved. As a result, the students were able to provide the correct answer to each problem. To solve missing value problem 1 (MVP1), student (UA) involved multiplicative concepts between two quantities to discover the value in question. Student UA put forward various reasons and arguments such as “In the first situation, Peter puts 40 boxes in the truck and then in the second situation he will put as many as $40 \times 2 = 80$ boxes in the truck. Meanwhile, Tom loads 160 boxes in the first situation; thus in the second situation, he can put as many as $160 \times 2 = 320$ boxes in the truck”. The UA’s test results thus indicated the use of “within ratio” multiplicative concepts in missing value problem-solving.

In addition to the questions outlined earlier, the researcher also asked the student whether there were other possible methods or ways that can be used to solve this problem. However, the student stated that he did not know of any method other than using the multiplication method to solve the problem. Student UA was able solve the problem based on multiplicative concepts by using a cross- multiplication method that involves proportional situations. According to him the multiplication method was the most appropriate way to solve the problem and minimize errors in answering the question.

Student (UA) used the concept of multiplicative relationships in solving the missing value problems. The student gave the reason that "Rian uses 3 cans of yellow paint and 6 cans of red paint when Afdal uses 7 cans of yellow paint. If so, then the number of red paint cans that can be used by Afdal is 14, resulting from the multiplication of 7 × 2 = 14". Student (UA) was aware that the relationship between 3 cans of yellow paint and 6 cans of red paint used by Rian represents the multiplication of 2. Therefore, he used the multiplication of 2 to figure out the number of cans of yellow paint that can be used by Afdal. Student (UA) was able to understand the relationship between two ratios and the reason for using it. He then applied a multiplicative method, that was by cross- multiplying the proportions to solve the problem. This showed that student UA performed proportional reasoning in solving missing value problem 2 (MVP2).

Multiplicative category data " between ratios" types that can be described based on interview data, field notes and subject answer sheets in completing the missing value task. In this category, where students observe objects using the concept of multiplication between elements in different ratios. Student AR's solutions to the missing value problems were considered accurate. In missing value problem 1 (MVP1) and missing value problem (MVP2), student (AR) was able to understand the problems and used multiplicative concepts to solve them. The student's work process in solving MVP1 was appropriate. Student AR could understand the problem and solve it by considering the multiplicative concept between the two quantities involved. Student AR further argued that "Tom has loaded 160/40 = 4. If Peter puts 80 boxes in the truck, Tom can load as many as 80 × 4 = 320 boxes in the truck". Student AR used a form of mathematical modelling and understood the terms for using ratios and proportion. Consequently, the student was able to do the correct calculation on the end. The multiplicative concept used by student AR in solving the problem is "between ratios" multiplicative concept.

The interview excerpts showed that student AR was able to understand the concepts of ratio and proportion taught in the previous meeting. Therefore, prior solving the problem, the student reduced the size of 160/40 into its smallest term 1/4 and multiplied it by 80. Student (AR) was able to provide the right answer to missing value problem 2 (MVP2). However, the students lacked reasons and clear arguments. It cannot be ascertained whether the student could actually make comparisons using multiplicative concepts or the process only happened by accident. One of the examples of the student's arguments included "3 cans of yellow paint and 6 cans of red paint when scaled down will become 1 can of yellow paint and 2 cans of red paint. Afdal needs 7 cans of yellow paint and 14 cans of red paint". It can be seen that the student's answer was not in harmony with the arguments put forward. On the worksheet, student AR did not multiply 3 by 2 to produce 6 cans of pain that belong to Rian, although he multiplied 7 by 2 to obtain 14 cans of paint that belong to Afdal. This underlies the possibility that the student (AR) only answered based on his experience, because he was aware that this problem involved the multiplication of 2. Although this reasoning is not enough to be debated in a comparative situation, it shows that he could pay attention to the relationship between two proportionally formed ratios. Student (AR) understood this problem but he was unable to describe it on the answer sheet. On the other hand, the student was able to express the reasons for the answers proposed.

Discussion

This section will only explain the results of the missing value problem-solving from students (ES), (UA) and (AR). Student (ES) who had good understanding of the missing value problem (MVP1) solved the problem using the concept of addition. Student (ES) began the problem-solving process with reading the problem. After understanding the problem, Student (ES) thought of ways that can be used to solve the problem. After finding a suitable way to solve the problem, student (ES) explained how he found the number of boxes that Tom loaded to the truck in the second situation after he was given information that Tom put 160 boxes in the first situation. In short, students who can grasp any information related to the missing value problem (MVP1) solve the problem using the concept of addition (additive relationship). The test result of Student (ES) is an example of answers that contain incorrect rationales and inaccurate arguments in solving a missing value problem (MVP1). Student (ES), for example, mentioned that if in the first situation Peter put as many as 40 boxes in the truck then in the second situation Peter will load 40 + 40 = 80 boxes, and if in the first situation, Tom put 160 boxes in the truck then in the second situation he will load as many as 160 + 160 = 320 boxes into the truck. The result was obtained by adding the number of boxes that Peter or Tom could load into the truck, which are 40 and 160 boxes, respectively. The error made in understanding the problem, such as what happened to Student (ES), was due to the inability of the student in performing proportional reasoning in applying the concept of multiplication and the lack of understanding of procedures for presenting ratio quantities in solving a missing value problem.

Students who do not understand the concept of division are not able to solve proportion problems. Understanding of division is not adequate to solve proportion problems; it sometimes leads to misunderstandings. Bad experiences were also shown by some students who participated in this study, where they failed to remember the concept of proportion when solving missing value problems. Students are apt to do mistakes in solving two problems that have the same structure, such as in solving multiplication and addition problems that are presented simultaneously. For example, even though the problem can be solved using the multiplicative concept, the students in this study solved it using the additive concept. Students commonly show a tendency to use additive concept instead of multiplicative concept (Hariyanti et al., 2017; Khumairoh et al., 2020). This shows that students are unable able to recall the concept of proportion that has been taught to them before. It also indicates that students apply the concept of addition in solving multiplication problems. Forgetfulness can be one of the factors that can hinder the development of student's problem-solving ability (Cheng, 2016; Nur & Sari, 2022a).

When solving a missing value problem, students fail to remember to apply the concept of proportion because the concept is not well embedded in the students' memory. Therefore, considering the importance of the concept of proportion for students, teachers need to pay serious attention to building their proportional reasoning (Permatasari et al., 2017; Sari & Mampouw, 2019). Instead of presenting them simultaneously, the majority of mathematics teachers present the types of proportion problems separately while ideally in helping students solve proportion problems, teachers should explain proportions using a multiplication strategy that involves a situation of proportions. Students should use multiplication strategy to solve proportion problems more efficiently. Multiplication strategy is also broadly applicable in all contexts. Students who do not understand the use of ratios and proportions cannot work on missing value problems. Students have difficulty solving one type of proportion problems, that is missing value problems (Pelen & Artut, 2016). Students with a low level of mathematical ability cannot reason according to the context of the problem given. It is important to note that students must be involved to solve problems that force them to think and to explore ideas appropriately. Mathematical problems are crucial for the development of mathematical science (Habsyi & Nur, 2022; Hidajat et al., 2019). The importance of solving problems that are owned by students, because it is a fundamental ability and must be mastered by students (Jayanti et al., 2018; Setiawan et al., 2020).

Mathematical problems play an important role in helping students participate in problem solving and thinking activities so that they can stimulate their learning abilities. If students' thinking processes can be identified, the mistakes made by students can also be identified. The teacher also plays an important role in supporting the development of students' mathematical thinking (Sapti et al., 2019; Sari & Mampouw, 2019). It is important for the teacher to improve teaching and class preparation by continuing to present students with the concepts of ratio and proportion that were learned at previous meetings. Educators should rely on this information in order to plan better teaching programs and provide useful learning activities and assignments. So, in the learning sequence missing value problems must be given to students after they are able to understand the terms of using ratios and proportions.

On the other hand, students (UA) and (AR) used multiplicative concept in solving the missing value problem (MVP1). The two students were selected as representatives of the students who provided the correct answer and accurate reasons and arguments. When solving the missing value problem (MVP1), Student (UA) read the question carefully. After reading the question repeatedly, the student finally understood the problem given. After understanding the problem, the student began to think of ways that can be used to solve the problem. After finding a suitable way to solve the problem, the student began to explain that (MVP1) could be solved using multiplicative concept. Student (UA) applied within-ratio multiplicative, which shows the multiplicative relationship between elements in the same ratio. If in the first situation Peter can put 40 boxes into the truck, then in the second situation he will load 40×2 = 80 boxes, and if in the first situation Tom could load 160 boxes, then in the second situation he will be able to put 160×2 =320 boxes into the truck.

Meanwhile, Student (AR) used multiplicative strategy to solve the (MVP1). After deciding on the proper strategy to solve the problem, student (AR) applied between-ratios multiplicative, which shows the multiplicative relationship between elements in the different ratio. Situation where Tom loaded 160/40=4 boxes, at the time Peter loaded 80 boxes, Tom had put 80×4=320 boxes". Both students, (UA) and (AR), represent cases that were rarely found in other students. Proportional reasoning as in "within variable" and "between variable" differ in terms of scalar reasoning (building a relationship within the same variable) and functional reasoning (building a relationship between different variables). The importance of the difference between these two relationships for students because they involve different cognitive processes.

Both of the students (UA and AR) also demonstrated a good ability in solving missing value problem 2 (MVP2), but student (AR) was not completely sure about multiplicative concept he used to

solve the problem. He further mentioned that he did not use any specific procedures nor specific steps to completing the task. For example, student (AR) mentioned that if in the first situation, Rian needed 3 cans of yellow paint and Afdal needed 7 cans of yellow cans, then in the second situation Rian would need 6 cans of red paint while Afdal would need 14 cans of red paint. Such understanding was not adequate to solve the problems and it actually has led to a misunderstanding of the problems. Students' ability to solve problems is closely related to their level of ability. Thus the problems given to students, the level of difficulty must be adjusted to their level of development (Nur & Sari, 2022a). From the beginning, Student (AR) answer was not very convincing, therefore an interview was conducted to explore the student's answer. The interview result showed that student (AR) understood the relationship between two ratios formed proportionally but he forgot to write it on the paper. Although student (AR) failed to explain the relationship on the paper systematically, he was still able to interpret the problems and provide a strong argument to support his answer. Students are able to connect problems with their own experience since the problem context is familiar to them. The problem solving strategies chosen by students are always based on the experiences and routine habits of students in solving simple problems rather than solving complex problems (Chai & Kong, 2017; Mardika & Mahmudi, 2021).

In missing value problem 2 (MVP2), student (UA) used multiplicative concept. The first thing the student (UA) did was to thoroughly read the problem. After reading the problem repeatedly, the student finally understood the problem. After understanding the problem, the student started to think of ways that can be used to solve the problem. After finding a suitable way to solve this problem, he began to explain that the problem of missing value could be solved by using a multiplicative relationship. Student (UA) understood that Rian used 3 cans of yellow paint and 6 cans of red paint. If Afdal used 7 cans of yellow paint, then the number of red paint cans Afdal will use is 14, by multiplying 7 by 2. According to student (UA), an easy way to find the answer is to multiply $7 \times 2 = 14$. Student (UA) was aware that the number of paint cans used by Rian and Afdal resulted from the multiplication of two. Besides, the student was also aware that all ratios involved in these two situations are the multiplication of an integer. In solving missing value problem 2 (MVP2), student (UA) involved multiplicative concept. Students who can identify such multiplicative relationships are also able to solve proportion problems accurately (Chaim et al., 2012; Hariyanti et al., 2017).

In an interview, student (UA) expressed the same reasons for explaining his answer. Student (UA) already have experienced using the concept of proportion to solve missing value problems. To expand students' proportional reasoning on missing value problems, the problem context in each learning activity must be designed differently. Different contexts may encourage students' proportional reasoning because missing value problems are not sufficient to increase students' ability to reason proportionally. Therefore, it is important to improve teaching and classroom preparation by continuing to present students with proportional relationships and mathematical relationships they have learned in previous meetings.

Researchers are aware of the limitations of conducting this research, which include: 1) the research subjects were only 6 people who were still relatively small; 2) giving the problem of missing value only consists of two items and is less varied; 4) the problem in this study is only limited to the missing value. It is hoped that future teachers and researchers will need to carry out various aspects of proportional reasoning. One way that helps students in developing strategies to solve the missing value problem is through the use of ratio tables. In addition to conducting research at the level of proportional reasoning, using cognitive processes and considering the number of students. Because in this study only six students were given

4. CONCLUSION

Based on the formulation of the research problem, students' proportional reasoning in solving missing value problems based on the multiplication concept can be found in three categories of proportional reasoning, that is the "additive" category, the multiplication category of the "within ratio" type, and the multiplication category of the "between ratios" type. The "additive" category in solving missing value problems, where students observe objects using the concept of addition. The multiplicative category is of the type "within ratio", where students observe objects using the multiplicative concept between elements in the same ratio. The multiplicative category is of the type "between ratio", where students observe objects using the concept of multiplication between elements in different ratios. Thus, the use of the multiplication concept can help students to solve the missing value problem. Students must be able to understand the condition of using ratios before starting to solve this type of missing value problem. Because in the learning sequence, the type of missing value problem must be given after students understand the terms of using the ratio.

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