

## ***ANALYSIS OF STUDENTS' PROPORTIONAL REASONING IN SOLVING PROBLEM RATIO***

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### **ABSTRACT**

This study aims to describe the characteristics of proportional reasoning of class VIII students of SMP Negeri Model Terpadu Madani Palu based on high-ability gender. This type of research is a case study using a qualitative approach. The research subjects were selected based on purposive sampling, while the main characteristics that became important in choosing the subject were "high-ability students". Two students were selected, namely male students (M) and female students (F) who had high abilities. This research resulted in three categories and one sub-category. The categories and sub-categories include: (1) Qualitative with one sub-category, namely: (a) making a comparison (2) Additives, (3) Multiplicative. Based on these categories and sub-categories, it is concluded that the Subject of M in solving problem the ratio has the characteristics of proportional reasoning in the qualitative and multiplicative categories. Meanwhile, the subject of F in solving problem the ratio has the characteristics of proportional reasoning in the additive and multiplicative categories. The description characteristics of proportional reasoning allowed the teacher to designing strategy learning to improve students' proportional reasoning in the learning mathematic.

**Keywords:** proportional reasoning; gender ; ratio; additive ; multiplicative

### **1. Introduction**

Mathematical material and reasoning are two things that cannot be separated. Mathematical material is understood through reasoning (Larson, 2013) and reasoning is understood and trained through learning mathematics. Learning mathematic requires reasoning skill (Hasanah et al., 2019; Ozturk at al., 2021). Reasoning is the thought process that organizes knowledge to attract conclusion (Lohman & Lakin, 2009; Lithner, 2007; Suriasumantri, 2010).

Giving reason and think proportionally is an important factor in developing a student's ability to understand mathematics. While students may have memorized how to solve a proportion problem, this does not mean they can think proportionally.

Proportional reasoning is one of the essential reasoning in learning mathematics. (Dole, at. al, 2012). Proportional reasoning foundation to abstract mathematical understanding. Proportional reasoning relies heavily on comparisons of quantities and values.

Proportional reasoning can be helpful in other materials areas such as science, music, and geography. Everyday activity people use proportional reasoning to calculate taxes, investments, best deals at the stores, or even to adjust recipes.

Proportional reasoning involves thinking about parts and wholes, i.e., about fractional Quantities (Möhring, at.al., 2015; Boyer & Levine, 2012; Kontogianni & Tatsis, 2019). One indication of proportional reasoning is the ability to understand the difference between using additive strategy and multiplicative relationships (Walle, 2013; Boyer et al.,2008, Misnasanti at al., 2017).

Based on the preliminary study conducted by the researcher in the form of a written test given to class VIII students, the researcher was motivated to conduct a study on high-skilled students, with the aim that the data to be sought could be obtained. Students who are highly

capable are also easy to express their thoughts through writing and orally.

Based on the research results that have been stated and opinion Lamon (2012) that proportional reasoning is everything related to ratio and proportion, so that in this research, the material to be studied is the ratio. This study aims to describe the characteristics of proportional reasoning of class VIII students of SMP Negeri Model Terpadu Madani Palu based on high-ability gender. The description characteristics of proportional reasoning allowed the teacher to designing strategy learning to improve students' proportional reasoning in the learning mathematic.

## 2. Research Methods

This type of research is a case study using a qualitative approach. The subjects of this study were students of class VIII SMP Negeri Model Terpadu Madani Palu. Students are grouped into two groups, namely male students with high abilities and female students with high abilities. The data collection technique in this study was to provide written assignments and task-based semi-structured interviews. The research instrument is the main instrument, namely the researcher himself and the auxiliary instrument, namely the written test (for the selection of research subjects). Data analysis in this study is by checking the credibility of the data and searching for patterns or themes (categories) using qualitative content analysis (Graneheim & Lundman, 2004; Creswell, 2012).

## 3. Results and Discussion

Grouping of students based on high-skill gender, namely one male subject with high ability labeled M, one female subject with high ability labeled F. The credibility of the data is checked by using time triangulation and member-checks.

The problem-solving test instrument used to reveal the characteristics of proportional reasoning of student M and F is presented in Figure 1.

A rectangular photo measuring 6 cm x 8 cm, after that the photo is enlarged with the width changed from 8cm to 12 cm. then how long is the photo with the new size?

**Figure 1.** The Problem-solving test instruments

Based on the research data analysis process, there are a number of data that are relevant to the research focus but do not match the existing categories in the coding frame, so that a new sub-category (data-driven) is generated that is in accordance with the data found to complement the existing coding scheme. The results of the analysis Research data on each research subject, namely male students with high abilities (M) and female students with high abilities (F) obtained three categories and one sub-category. The categories and sub-categories include: (1) Qualitative with one sub-category, namely: (a) making a comparison (2) Additives, (3) Multiplicative.

The results of the qualitative content analysis that have been carried out will be presented according to the categories and sub-categories covered therein, as well as an explanation of the nature (concept driven and data-driven) of the intended categories as follows:

### 1. Qualitative Reasoning

The category “qualitative reasoning” includes one sub-category. This category is concept-driven. Meanwhile, the sub-categories generated from this category are data-driven, because these sub-categories emerge through data obtained by researchers. The sub-category raised from male students (M) is “make a comparison”. In addition, the theme is obtained followed by a description or explanation of the meaning of the theme formulation. In detail the results of the qualitative content analysis of the “Qualitative” category are shown in table 1 as follows:

**Table 1.** Results of the Subject Qualitative Content Analysis (M) Category Qualitative Reasoning

Category/ Sub- Category	Subjects of Research	Themes in Sub- Categories
Category Qualitative reasoning Sub- Category make a comparison	M	Unpatterned counting strategy

### 2. Additive Reasoning

The "Additive" category is found in the results of data analysis of female students (F). This category is concept-driven. Furthermore, through the "additive reasoning" category, a theme is

obtained, followed by a description or explanation of the meaning of the formulation of the theme. In detail, the results of the qualitative content analysis in the “Additives” category are shown in table 2 as follows:

**Table 2.** Results of Subject Qualitative Content Analysis (F) Category Additive Reasoning

Category/ Sub- Category	Subjects of Research	Themes in Sub- Categories
Additive reasoning	F	Addition

### 3. Multiplicative Reasoning

The "multiplicative" category is found in the results of data analysis of male students (M) and female students (F). This category is concept-driven. Furthermore, through the multiplicative category, the theme is obtained, followed by a description or explanation of the meaning of the theme formulation. In detail, the results of the qualitative content analysis of male student and female student in the "Multiplicative" category are shown in table 3 below:

**Table 3.** Results of Subject Qualitative Content Analysis (M and F) Category Multiplicative Reasoning

Category/Sub-Category	Subjects of Research	Themes in Sub-Categories
Multiplicative reasoning	M	Theme cross multiplication
Multiplicative reasoning	F	Theme cross multiplication

This section will discuss the results of research on students' proportional reasoning on the ratio material based on gender with high abilities. The discussion is carried out based on the categories used in the results of research data in Table 1, 2 and 3.

### Male Students' Proportional Reasoning

#### 1. Qualitative Reasoning

The “Qualitative Reasoning” category is a concept-driven category. The category

"Qualitative Reasoning" relates to students' reasoning which is only based on qualitative relationships, such as increasing or decreasing, without explaining how much or how to "add" or "subtract". Through this category emerged a sub-category which is data-driven. The sub-category is “make a comparison”.

Based on the results of the qualitative content analysis for the subject (M), one sub-category was obtained which then resulted in a theme from the sub-category, namely the strategy of non-patterned counting. The themes and descriptions of the themes for the non-patterned calculation strategy can be seen from the following interview excerpts

- R01-029 so You don't know what this is about. Okay, well, try to explain how you do this problem.
- SM01-30 First created  $x/6$ . Well, the 6 are from here [points to the question]. After that  $12/8$  also from here [points to the question]
- R01-31 Why you created  $x/6$
- SM01-32 This is the formula indeed
- R01-33 Ok what formula is this
- SM01-34 I don't know [shaking head]
- R01-35 Oh, okay, explain further.
- SM01-36 It's made  $x/6$ . Well, the 6 are from here [points to the question]. After that  $12/8$  also from here [points to the question]. Then cross multiply.

Based on the theme and interview excerpts above, it can be concluded that the subject M has been able to solve the problem, namely looking for unknown values. The strategy used by the subject M is the equation strategy. However, the subject M could not explain the reasons for using this strategy. This indicates that the subject M does not fully understand conceptually about ratios. So, it can be said that the subject M uses qualitative reasoning in completing tasks related to ratios.

The activity shown by the subject M coincides with the opinion Norton's (2005), research result Mardika & Mahmudi (2021) and Berk at al. (2009). The use of multiplication and division operations to solve problems involving proportional situations does not necessarily develop a deeper understanding of proportional reasoning. Students who can solve proportional problems do not necessarily fulfill all indicators of proportional reasoning ability (express, analyze,

and explain answers related to a proportional relationship). Prospective elementary school teacher students who able to solve problems involving proportional situations, unable to give an argument why he solved the problem in this way (Berk at al., 2009)

## 2. Multiplicative Reasoning

The “multiplicative reasoning” category is a concept-driven category. The category of "multiplicative reasoning" relates to reasoning based on multiplicative relationships, both to solve the problem of finding an unknown value in an equivalent comparison, or to compare ratios.

Based on the results of the qualitative content analysis for the subject M, a theme was obtained, namely cross-multiplication. Excerpts from research data in the "multiplicative" category in student answers are as follows:

- R01-59 How do you double check your answer
- SM01-60 look, Sis, this 9 is entered here in x [points to answer]. After that it is cross multiplied. So, 9 times 8 gets 72 [pointing to the left side] here too 72 [pointing to the right side]. So, it's the same

Based on the theme and excerpts of the interview, it was concluded that the subject M to re-check the answers to the questions given, the subject M used comparisons and did cross multiplication.

## Female Students' Proportional Reasoning

### 1. Additive Reasoning

The “additive reasoning” category is a concept-driven category. The category "additive reasoning" relates to reasoning that uses additive relationships (summation) in determining relationships between quantities.

Based on the results of qualitative content analysis for the subject F, a theme was obtained, namely addition. Excerpts from research data in the "additive" category in student answers are as follows:

- R01-19 Oh so read it, so after reading what do you get?
- SF01-20 What I get is how it works, so it uses an equivalent comparison, so if one variable increases, the other variable also increases.
- R01-21 What variable do you mean?

- SF01-22 This one sis [points to the answer], if the length increases, the width also increases.

Based on the theme and interview quotes above, it can be concluded that the subject of F uses a quantitative relationship between two quantities, namely in the form of  $a-b = c-d$  (additive). The subject of homework in solving the task still uses the addition method (adaptive change). By calculating the ratio of width to length with the same sequential pattern. This explains that students have not fulfilled the ability to translate questions into multiplicative form. But the answers given have been systematic and precise. At least students can form the right ratio.

## 2. Multiplicative Reasoning

The “multiplicative” category is a concept-driven category. The “multiplicative” category relates to reasoning based on multiplicative relationships, both to solve the problem of finding an unknown value in an equivalent comparison, or to compare ratios.

Based on the results of qualitative content analysis for the subject of F, a theme is obtained, namely cross multiplication. Excerpts from research data in the "multiplicative" category in student answers are as follows:

- R01-29 Please explain how you came to get this answer?
- SF01-30 First it's x to  $12=6$  to 8 [ $x/12 = 6/8$ ] [points to answer]
- R01-31 how come x vs 12 [ $x/12$ ]
- SF01-32 Because what you want to find after being changed, now 12 is the value 8 which after being changed, that's why I compare it with before. This is the same as  $x/12 = 6/8$ . After that I cross multiply so I got  $8x=12.6$ . after that  $x = (12.6)/8$ . so after dividing the result  $x = 9$ . So, the length after being enlarged is 9 cm
- R01-33 Why is it cross multiplied?
- SF01-34 Because that's the way, bro, when it comes to comparisons, you must cross multiply

Based on the themes and interview quotes above, it can be concluded that the subject F is able to solve the ratio problem correctly using the equation strategy. The subject of F explained that to solve the comparison problem one must use cross multiplication. The subject of F understands

the relationship between the questions and the instructions given. Students also use multiplication and then division (multiplicative changes) in solving this problem. When finding the comparison, students cross multiplied the number in question with the known opponent's number. This is in line with Lamon's opinion (2012) which states that "Proportional reasoning involves the deliberate use of multiplicative relationships to compare quantities and to predict the value of one quantity based on the values of another". to compare quantities and to predict the value of one quantity based on another.

It can be concluded that the proportional reasoning of subject is good. However, the results of students' proportional reasoning can still be said to be different. Students are also at different levels of proportional reasoning. This can be seen when students are able to solve mathematical problems. Students can make examples and use equation strategies to solve them. Then, when interviewed about the solution strategy, students answered that they were able to use this method because they could understand it well and understand the conceptual basis.

#### 4. Conclusions

Based on the results, it can be concluded that the characteristics of students' proportional reasoning in solving problem ratio based on gender with high abilities are as follows:

- 1) Male subjects with high ability in completing ratio tasks have proportional reasoning characteristics in the qualitative and multiplicative categories. In the qualitative category, the subject M was able to complete the task correctly. However, the subject could not provide a reason for doing the
- 2) Female subjects with high ability in completing ratio tasks have proportional reasoning characteristics in the additive and multiplicative categories. In the additive category, the subject F thinks that when one variable increases, the other variables also increase. Thus, the subject F in this category is included in the additive category.

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