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Students Proportional Reasoning Level in Solving Ill Structured Problem on Proportion Material in Terms of Gregorc's Thinking Style

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ABSTRACT

This study examines the levels of proportional reasoning in students when solving ill-structured problems related to proportions, analyzed in the context of Gregorc's cognitive styles. A qualitative approach was employed, involving eight participants from grade VIII-B of MTsN Kota Batu. The analysis reveals that students' cognitive styles significantly influence their understanding of proportional reasoning. Students with a concrete sequential (CS) thinking style faced difficulties in understanding the concept of proportionality and relied on trial-and-error methods, indicating they are at Level 0 (Non-proportional Reasoning). Students with abstract sequential (AS) and concrete random (CR) thinking styles utilized some visual or concrete aids but had not fully transitioned to a more systematic mathematical approach, placing them at Level 1 (Manipulative Proportional Reasoning). In contrast, students with an abstract random (AR) thinking style were able to use mathematical models to solve proportional problems, but still struggled with consistently applying the correct method, placing them at Level 3 (Pre-multiplicative Proportional Reasoning). These differences in cognitive styles affect how students understand and apply proportional reasoning, particularly in selecting the appropriate methods and maintaining consistency in their application.

Keywords: *proportional reasoning, ill-structured problem, gregorc thinking style.*

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INTRODUCTION

In the math and science curriculum at school, many topics require proportional reasoning skills (Dole et al., 2012:195; Lobato & Ellis, 2010:1; Weiland et al., 2021:180). According to John A. Van De Walle (in Rizal, 2019:2) "proportional reasoning represents the ability to begin to understand multiplication relationships where most arithmetic concepts are usually based on addition". Proportional reasoning is a thought process that helps a person understand how a change in one quantity is relates to a change in another quantity through a multiplicative relationship (Wahyuni, 2022, p. 7). Multiplicative reasoning, in this case, is related to the multiplication operation in mathematics. Kilpatrick et al. (2001:7) argue that a person's ability to think proportionally depends on a strong and deep understanding of basic mathematical operations such as multiplication and division. Therefore, proportional reasoning is a fundanmental skill that students need to master in learning mathematics.

Proportional reasoning skills are crucial in learning mathematics because many topics in mathematics require this ability. In line with that Dole et al. (2012:195) argue that there are various mathematical materials related to proportional reasoning, such as scale, chance, percentage, average, trigonometry, congruence, measurement in plane and space geometry, and algebra. Langrall & Swafford (2000:261) also stated that "proportional reasoning is used in various areas of mathematics such as geometry, rational numbers, and others". Although proportional reasoning is a vital concept in mathematics, many students do not understand it well. Holzrichter (2016:6) suggests that most students have not fully mastered or understood how to reason proportionally. According to Febriani & Rosyidi (2013:1) an appropriate learning strategy is needed to develop students' reasoning skills.

Many studies have examined students' proportional reasoning. Some of them focus on the proportional reasoning of students in terms of gender (Indillah et al., 2019; Khotimah & Shodikin, 2021; Öztürk et al., 2021; Permatasari et al., 2017), field dependent and field independent cognitive styles (Suryadi, 2008; Putri & Ekawati, 2018), systematic dan intuitive cognitive styles (Fadillla & Siswono, 2022; Hidayat et al., 2017), auditory learning style (Putra et al., 2020), and adversity quotient (Khumairoh et al., 2020). These studies provide valuable insights into the various factors that influence students' proportional reasoning. Although some studies have examined the effect of cognitive style on proportional reasoning, not many have investigated how Gregorc's thinking style affects the reasoning.

Different thinking styles can affect the way students reason and understand mathematical concepts. Fauzi et al. (2020:98) argue that differences in thinking styles affect the way students process information, which impacts their learning abilities, including in the aspect of reasoning. According to Kariadinata (2012:2) reasoning is one aspect of high-level mathematical thinking skills that must be mastered by students. This emphasizes the importance of further research on how thinking styles can affect students' reasoning in the context of mathematics. Thinking style refers to the way the brain processes information obtained from various sources (Fitri et al., 2023, p. 132). According to Gregorc, "the ability to process and organize information is divided into four combinations of behavioral groups known as thinking styles". These four thinking styles are concrete sequential (SK), abstract sequential (SA), concrete random (AK), and abstract random (AA) (Hawk & Shah, 2007, p. 5).

The characteristics of Gregorc's four thinking styles are as follow: 1) Concrete sequential thinkers (CS) can easily pay attention and remember, organize tasks step by step, and strive to achieve; 2) Abstract sequential thinkers (AS) can think in concepts and analyze information; 3) Concrete random thinkers (CR) are focused on reality and have an attitude of wanting to try; 4) Abstract random thinkers (AR) organize information through reflection and think in a disorganized, people-oriented environment (DePorter and Harnacki 2005:128).

In addition, many studies have examined students' proportional reasoning from the form of the problem, including students' proportional reasoning in solving pre-multiplicative problems (Fuat & Wulan, 2021), missing value problem (Permatasari et al., 2017; Prayitno et al., 2018, 2019), multiplicative (Hariyanti, 2016; Hariyanti et al., 2017), and proportion (Laili, 2023; Zulkarnaen, 2017). Most existing studies tend to focus on structured problems or more general and basic mathematical topics. Research on students' proportional reasoning in the context of ill-structured problems is still lacking and needs to be conducted.

Based on interviews with mathematics teachers at MTsN Kota Batu and analysis of student grades, it was found that students' proportional reasoning varied significantly. When given a proportion problem, some students were able to solve it quickly and accurately, while many others still had difficulty understanding the basic concepts of proportion and required additional help. This is reflected in students' math scores, where only about 35% of students meet the Minimum Completion Criteria (KKM), while the remaining 65% have not reached the KKM. This corroborates the findings from the interviews, which indicate significant variation in the level of proportional reasoning among students.

Knowing the level of students' proportional reasoning is important so that educators can adjust the right teaching methods. Prayitno et al. (2019:178) argue that understanding students' proportional reasoning level can help in developing appropriate learning plans. Some researchers have studied the level of proportional reasoning of students at various levels, including at the junior high school level (Eka & Susanah, 2013; Laili, 2023; Nurlela et al., 2022; Prayitno et al., 2018) and senior high school (Risdianti, 2016; Sari, 2019).

Based on the information above, it can be concluded that proportional reasoning is a very important skill for students. Previous research shows that students' proportional reasoning ability varies depending on individual characteristics and the types of problems they encounter. Therefore, this study aims to examine students' proportional reasoning level in solving ill-structured proportion problems in terms of Gregorc's thinking styles.

METHOD

This research uses a qualitative approach to describe students' proportional reasoning levels in solving ill-structured problems related to proportion material, in terms of Gregorc's thinking style. According to Sugiyono (2019:18), qualitative research examines objects in their natural context, with researchers as the primary instrument. It employs triangulation (combined) data collection techniques and emphasizes inductive analysis to understand deep meaning.

The research was conducted at MTsN Kota Batu. The selection of this school was based on interviews with teachers, which indicated that students' proportional reasoning abilities vary. This variability is evident when students are given proportion problems some are able to solve them quickly and accurately, while others still struggle with understanding the basic concepts of proportion and require additional assistance. Therefore, the researcher is interested in exploring the level of reasoning among students at this school.

The research components used can be seen in Table 1 below:

Table 1. Research Components

Data	Subject and Data Source	Instrument	Data Collection Technique
Proportional reasoning (written)	1. Data source: Students of class VIII-B consisting of 30 students. 2. Subject: 8 students from class VIII-B with 2 students each representing the cognitive styles: concrete sequential (CS), abstract sequential (AS), concrete random (CR), and abstract random (AR).	Proportional reasoning level test sheet, consisting of one ill-structured problem on proportion material in the form of a description (essay).	Written test
Proportional reasoning (oral)		Unstructured interview guideline sheet.	Interview

To verify the validity of the data, researchers used triangulation techniques, which involve collecting data from the same source using various methods (Sugiyono, 2019). Technical triangulation was employed by comparing the results of students' proportional reasoning level tests with the results of interviews. The researcher applied the Miles and Huberman data analysis model, consisting of three main stages: data reduction, data presentation, and conclusion drawing (Sugiyono, 2019).

Students' proportional reasoning levels were analyzed based on indicators adapted from (Nurlela et al., 2022) which are detailed in Table 2 below:

Table 2. Levels and Indicators of Proportional Reasoning

No	Level		Indicator		Sub Indicator	code
1	Level 0 (*Non-proportional reasoning*)	1.1	Students have not been able to solve proportional problems.	1.1.1	Students are unable to recognize situations involving proportion.	L01a
				1.1.2	Students cannot use ratios or proportions correctly.	L01b
		1.2	Students can only solve the unknown	1.2.1	Students use addition or subtraction operations to solve for the unknown	L02a

			value by using the addition or subtraction method.		value.	
				1.2.2	Students did not use multiplication or division in the context of the problem.	L02b
		1.3	The solutions that students use are not patterned.	1.3.1	Students do not follow logical or organized steps, leading to inconsistent or incorrect final results.	L03a
				1.3.2	Students use a trial-and-error approach without a clear pattern.	L03b
2	Level 1 (*Manipulative proportional reasoning*)	2.1	Students can use drawings, models, or manipulations of the problem to be solved.	2.1.1	Students use concrete manipulations, such as using pictures, models, or physical objects to describe ratios or relationships between quantities.	L11a
				2.1.2	Students construct a simple table or list to visually show the relationship between two proportional quantities.	L11b
3	Level 2 (*Replicative proportional reasoning*)	3.1	Students can use unit values or scale factors to solve unknown value problems.	3.1.1	Students use repeated addition to find unknown values in a proportion context.	L21a
				3.1.2	Students double the known units to estimate the unknown quantity based on the previous example.	L21b
4	Level 3 (*Pre multiplicative proportional reasoning*)	4.1	Siswa dapat menggunakan nilai satuan atau skala faktor untuk menyelesaikan masalah nilai yang tidak diketahui.	4.1.1	Students calculate the unit value of a given quantity, in various problem situations involving proportion.	L31a
				4.1.2	Students use scale factors to determine the time required or the amount required.	L31b
				4.1.3	Students apply mathematical models such as writing $\frac{x}{y}=\frac{3}{4}$ to model the proportion of two variables, although the results are not always correct.	L31c
5	Level 4 (*Multiplicative proportional reasoning*)	5.1	Students can use cross multiplication or equivalent fractions to solve for unknown values.	5.1.1	Students use the crossmultiplication method to accurately find the unknown value.	L41a
				5.1.2	Students use equivalent fractions (equivalent values) to solve problems involving proportions.	L41b
				5.1.3	Students solve problems accurately using the cross-multiplication method or equivalent fractions without errors in reasoning.	L41c

RESULTS AND DISCUSSION

Based on the Gregorc thinking style questionnaire modified by John Parks Le Tellier (DePorter and Harnacki 2005:125) given to 30 students in class VIII-B MTsN Kota Batu, the results showed that there were 4 students with concrete sequential thinking style (CS), 3 students with abstract sequential thinking style (AS), 9 students with concrete random thinking style (CR), and 14 students with abstract random thinking style (AR).

The researcher selected 8

students as research subjects consisting of 2 students with concrete sequential (CS), 2 students with abstract sequential (AS), 2 students with concrete random (CR), and 2 students with abstract random (AR). The selected students must meet the criteria of being willing to be interviewed, can explain the answers they write on the answer sheet and solve the problems independently. The students selected as research subjects can be seen in Table 3 below:

Table 3. Result of Research Subjects

No	Thinking Style	Selecterd Subjects
1	Concrete Sequential (CS)	ER, FA
2	Abstract Sequential (AS)	KA, RA
3	Concrete Random (CR)	AA, AC
4	Abstract Random (AR)	AM, PA

In the next stage, students are given a test consisting of one ill structured problem on proportion material in the form of a essay. The test questions were then validated by 2 validators. Then students will be interviewed so that they can go deeper into the students' proportional reasoning level, as well as compare between the results of the proportional reasoning level test using student interviews.

The following is a description of the analysis of the proportional reasoning level of subject AM with an abstract random thinking style.

The proportional reasoning process carried out by AM started with understanding the problem from the given problem. To achieve a deeper understanding, AM read the problem several times, then showed his understanding by writing down the known information completely, both written and oral. In the first problem, AM identified that 6 students needed 15 days to complete the 30 juz khataman, and was asked to determine the time needed for 10 students. In the second problem, AM understood that the target must be completed within 7 days, so he needed to estimate the number of students needed. This process shows that AM has been able to understand the problem well and can identify relevant information.

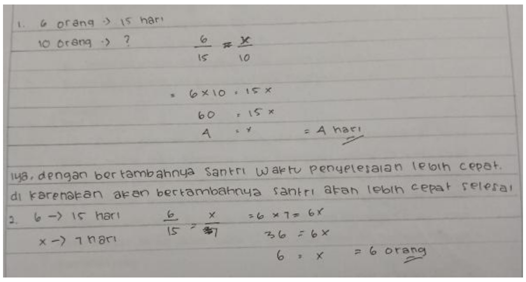

Figure 1. AM's Answer

After understanding the problem, AM tried to find a solution method by applying the cross-multiplication method, which showed his understanding of the proportional approach in solving problems. However, AM made a mistake in choosing the right type of proportion. AM used direct proportion instead of inverse proportion.

In the first problem, AM tried to determine the time needed for 10 students by using direct proportion, namely $\frac{6}{15} = \frac{x}{10}$ which resulted in an incorrect answer of 4 days. In fact, the context of this problem requires an inverse proportion approach. This error shows that AM has not fully understood the difference between inverse proportion and direct proportion.

Although AM showed an initial understanding of the concept of proportionality, her application was not in accordance with indicator L31a, which is calculating unit values in the correct context. Calculating the unit value should involve recognizing that as the number of students increases, the time needed decreases, but AM has not applied this concept correctly because she chose the wrong type of proportion.

In the second question, AM also used direct proportion to estimate the number of students needed in 7 days, namely with the model of $\frac{6}{15} = \frac{x}{7}$, resulting in an incorrect answer of 6 students. Actually, this problem also requires inverse proportion. In this part, AM tried to use scale factors to determine the number of students needed to reach the target within 7 days (L31b), but was not accurate in determining the appropriate type of proportion. This shows that although AM has understood the basic concept of proportion, she has not been able to apply inverse proportion in the context of problems that require such understanding.

AM then tried to write a mathematical model to model the proportion between time and number of students. AM wrote the model like $\frac{6}{15} = \frac{x}{10}$ for the first problem and $\frac{6}{15} = \frac{x}{7}$, for the second problem. This shows that AM applied a mathematical model in the form of a proportion to model the relationship between time and the number of students (L31c), but the error in choosing the type of proportion (direct instead of inverse) led to inaccurate results.

Based on the interview, AM mentioned that she chose the crossmultiplication method because it is simple and often taught. She also has an intuitive understanding that increasing the number of Image 1. AM's answer students will speed up the completion time of khatam. However, although AM understands the inverse relationship between the number of students and time, she has not applied it mathematically as an inverse proportion. This interview shows that AM has an understanding of the concept of proportion, but she still needs more practice to distinguish between straight and inverse proportions in different contexts.

Based on the analysis of the answers and interviews, AM is at Level 3 (Premultiplicative Proportional Reasoning). At this level, AM has tried to use the proportional model to solve the problem, but still experienced errors in its application. In accordance with indicator L31c, AM began to recognize ratios and tried to use unit values, although he still faced difficulties in the consistency of applying the right proportional model.

The following is Table 4 which shows a summary of the proportional reasoning levels for all research subjects. The level of proportional reasoning is obtained based on the thinking style identified in each subject.

Table 4. Student's Proportional Reasoning Level

No	Thinking Style	Selected Subjects	Proportional Reasoning Level
1	Concrete Sequential (CS)	a. ER b. FA	a. Level 0 (*Non-proportiona reasoning*) b. Level 0 (*Non-proportiona reasoning*)
2	Abstract Sequential (AS)	a. KA b. RA	a. Level 1 (*Manipulative Proportional Reasoning*) b. Level 1 (*Manipulative Proportional Reasoning*)
3	Concrete Random (CR)	a. AA b. AC	a. Level 1 (*Manipulative Proportional Reasoning*) b. Level 1 (*Manipulative Proportional Reasoning*)
4	Abstract Random (AR)	a. AM b. PA	a. Level 3 (*Pre-multiplicative Proportional Reasoning*) b. Level 3 (*Pre-multiplicative Proportional Reasoning*)

Based on the results of the analysis that has been carried out on 8 research subjects, several important points are obtained regarding the level of proportional reasoning of students in solving ill structured problems on proportion material, in terms of Gregorc's thinking style.

a. Students with Concrete Sequential Thinking Style

Students with Concrete Sequential (CS) thinking style, ER and FK, are at Level 0 (Non-proportional reasoning). This shows that they have not been able to understand the concept of proportion. They tend to use simple addition or subtraction operations without considering the appropriate ratio or proportion. Prayitno et al. (2019, : 179) argued that students who are at level 0 have not shown proportional reasoning skills in solving problems. In line with this, research conducted by Nurlela et al. (2022) showed that students at level 0 did not show consistent problem-solving patterns, which is a typical characteristic of students at this level. At level 0, students often use a trial and error approach and do not recognize ratios as a tool for solving proportion problems (Langrall & Swafford, 2000, p. 256).

Their difficulty in identifying ratios is in line with the characteristics of concrete sequential thinking style. Students with CS thinking style have a tendency to process information structurally, concretely and linearly. They are more comfortable with data that is concrete or things that can be directly observed (DePorter & Harnacki, 2005, p. 129). As a result, they tend to stick to simple procedures and have difficulty applying deeper concepts of proportionality. This is in line with research conducted by Dwirahayu & Firdausi (2016:219) which suggests that concrete thinking styles tend to be less than optimal in solving math problems because of the abstract characteristics of mathematics.

Based on this explanation, students with Concrete Sequential thinking style have limitations in developing a more complex understanding of ratio and proportion. This is in line with the findings in the study which showed that students with concrete thinking styles tend to have a structured approach in solving mathematical problems (Dwirahayu & Firdausi, 2016, p. 219). Dalam konteks ini, mereka cenderung In this context, they tend to use an approach that does not involve understanding the relationship between proportional variables, which should be the foundation in solving more complex proportion problems.

b. Students with Abstract Sequential and Concrete Random Thinking Style

On the other hand, students with Abstract Sequential (AS) and Concrete Random (CR) thinking styles, showed to be at Level 1 (Manipulative Proportional Reasoning). At this level, they are able to utilize images, models, or concrete manipulations to understand the problem. As explained by Prayitno et al. (2019:179) at Level 1 show an initial understanding of proportional concepts through the use of visual or physical aids, but are not yet able to move on to more complex mathematical approaches such as cross multiplication. Langrall & Swafford (2000:256) argues that students at level 1 use drawings, models or manipulations to create depictions of existing problem-solving.

Students with a Concrete Random (CR) thinking style show an experimental attitude in solving problems, often accompanied by a trial and error approach (Patimah & Murni, n.d., p. 108). This attitude makes their problem-solving less structured and often off target. As expressed by DePorter & Harnacki (2005:130) students with CR thinking style have a tendency to explore widely without following clear or systematic steps. This causes them to try more possibilities without referring to a definite procedure, which ultimately has an impact on inaccuracy in finding solutions, especially when problems require precise and analytical proportional understanding.

Meanwhile, students with SA thinking style tend to prioritize structure and analysis in their problem-solving process. They are more comfortable when they can follow clear and orderly steps, although there is still a tendency to adjust the order of steps based on the needs of the problem (DePorter & Harnacki, 2005, p. 134). According to Patimah & Murni (n.d.:108) students with AS thinking style have a logical thinking process (something that can be accepted by reason and that is in accordance with logic) rational (based on logical thoughts and considerations) and intellectual (clear thinking based on science).

In the context of proportional problem-solving, CR students are at level 1 where they utilize drawings and concrete manipulations, but their less structured approach hinders their effectiveness in finding the right solution. On the other hand, students with AS style showed a more purposeful understanding, although still at the manipulative level, with a tendency to follow structured steps in using concrete aids. This finding suggests that although AS and CR students are at the same level, SA's more structured approach gives them an edge in problem-solving accuracy, in contrast to CR students who still often try various possibilities without a certain pattern.

c. Student with Abstract Random Thinking Style

In contrast, students with Abstract Random thinking style (AR), namely AM and PA, are at Level 3 (Pre-multiplicative Proportional Reasoning). At this level, they have started using unit values and mathematical models in the form of proportion. According to Nurlela et al. (2022) at level 3, students begin to recognize ratios and use unit values, although they may still have difficulty in the consistency of their application. This can be seen in AM and PA, who despite having a better understanding of the concept of proportion, still had difficulty in determining the appropriate type of proportion for a particular situation. This difficulty led to final results that were not in line with the problem-solving objectives.

Students with an abstract random thinking style tend to be more intuitive and can relate various concepts flexibly. They are not tied to rigid logical steps and prefer to see the big picture rather than small details (Hobri et al., 2021, p. 30). AR subjects tend to write down incomplete information and do not complete tasks. This is supported by the results of research Fauzi et al. (2020:18) which states that subject AA does not write information sequentially, but can explain.

However, the weakness of the AA thinking style is the inaccuracy in following procedures strictly and sometimes causes confusion in choosing the right approach. In line with this, research conducted by Fauzi et al. (2020:105) students with AA thinking style are able to mention the steps of problem-solving, but the steps are often incomplete or not done consistently. This inconsistent understanding indicates that although students with AA thinking style have the potential to understand more in-depth proportional concepts, they need reinforcement in applying these concepts correctly in various problem contexts. This is in line with research by Permatasari et al. (2017:200) which states that proportional reasoning is one of the important reasoning in learning mathematics. Proportional reasoning must be applied appropriately so that students can develop higher mathematical thinking skills.

The results of this study show that there are variations in students' proportional reasoning levels which are closely related to their thinking styles. Subjects with a more abstract thinking style tend to have a higher level of reasoning compared to subjects with a concrete thinking style.

CONCLUSION

Based on the results of the analysis, it can be concluded that students' thinking styles significantly affect their level of understanding in proportional reasoning. Students with a concrete sequential (CS) thinking style demonstrated difficulties in understanding proportional concepts and relied heavily on trial-and-error approaches, placing them at Level 0 (Nonproportional Reasoning). Students with abstract sequential (AS) and concrete random (CR) thinking styles utilized some visual or concrete aids, though they had not fully transitioned to more systematic mathematical approaches, which placed them at Level 1 (Manipulative Proportional Reasoning). Meanwhile, students with an abstract random (AR) thinking style were capable of using mathematical models to solve proportional problems but faced challenges in consistently applying appropriate methods, leading them to Level 3 (Pre-multiplicative Proportional Reasoning). The differences in students' thinking styles influence how they understand and apply proportional concepts, particularly in selecting suitable methods and maintaining consistency in their application. Therefore, it is crucial to tailor learning strategies that accommodate diverse thinking styles to help students progress to higher levels of understanding. Therefore, future research should explore specific teaching methods or interventions, such as incorporating manipulatives or real-world contexts, to support students, particularly those at lower levels, in advancing their proportional reasoning skills.

REFERENCE

DePorter, B., & Harnacki, M. (2005). Quantum Learning: Membiasakan Belajar Nyaman dan Menyenangkan. In *Quantum Learning* (1st ed.). Penerbit Kaifa.

Dole, S., Clarke, D., Wright, T., & Hilton, G. (2012). Student's Proportional Reasoning in Mathematics and Science. *Proceedings of the 36th Conference of the International Group for the Psychology of Mathematics Education*, *2*, 195–202. https://espace.library.uq.edu.au/view/UQ:279214

Dwirahayu, G., & Firdausi. (2016). *Pengaruh Gaya Berpikir Terhadap Kemampuan Koneksi Matematis Mahasiswa*. *9*(2), 210–221. https://repository.uinjkt.ac.id/dspace/bitstream/123456789/46363/1/15

Eka, R., & Susanah. (2013). Penalaran Proporsional Siswa Kelas VII SMP Negeri II Beji Pasuruan Berdasarkan Tingkat Kemampuan Matematika. *Jurnal Pendidikan Matematika*, *2*(1), 15–21. https://jurnalmahasiswa.unesa.ac.id/index.php/3/article/view/1209

Fadillla, D. M. N., & Siswono, T. Y. E. (2022). Penalaran Proporsional Siswa Bergaya Kognitif Sistematis dan Intutif dalam Menyelesaikan Masalah Numerasi. *Jurnal Ilmiah Pendidikan Matematika*, *11*(3).

Fauzi, F. A., Ratnaningsih, N., & Nimah, K. (2020). Analisis Kemampuan Berpikir Kritis Matematis Peserta Didik Ditinjau Dari Gaya Berpikir Gregorc. *Journal of Authentic Research on Mathematics Education (JARME)*, *2*(2), 96–107. http://jurnal.unsil.ac.id/index.php/jarme/article/view/1734

Febriani, C., & Rosyidi, A. H. (2013). Identifikasi Penalaran Induktif Siswa dalam Memecahkan Masalah Matematika. *Mathedunesa*, *2*(1), 1–6.

Fitri, S. N., Liana, M., & T, L. R. (2023). Penalaran Matematis Siswa Ditinjau dari Gaya Berpikir menurut Gregorc. *AKSIOMA: Jurnal Matematika Dan Pendidikan Matematika*, *14*(2), 131–146.

Fuat, F., & Wulan, M. P. (2021). Kemampuan Penalaran Proporsional Siswa dalam Menyelesaikan Masalah Pra-Multiplikatif. *JKPM (Jurnal Kajian Pendidikan Matematika)*, *6*(2), 179. https://doi.org/10.30998/jkpm.v6i2.9047

Hariyanti, U. (2016). *Penalaran Proposional Dalam Menyelesaikan Masalah Multiplikatif Bagi Siswa Kelas VIII SMP*. Universitas Negeri Malang.

Hariyanti, U., Irawan, E. B., & Widayanti, E. (2017). Penalaran Proporsional dalam Menyelesaikan Masalah Multiplikatif Tipe Product of Measurement. *Jurnal Kajian Pembelajaran Matematika*, *1*(April), 1. http://journal2.um.ac.id/index.php/jkpm

Hawk, T. F., & Shah, A. J. (2007). Using Learning Style Instruments to Enhance Student Learning. *Decision Sciences Journal of*

Innovative Education, *5*(1), 1–19. https://doi.org/10.1111/j.1540-4609.2007.00125.x

Hidayat, A. F., Amin, S. M., & Fuad, Y. (2017). Profil Penalaran Proporsional Siswa SMP dalam Memecahkan Masalah Matematika Berdasarkan Gaya Kognitif Sistematis dan Intuitif. *Jurnal Matematika Kreatif-Inovatif*, *2*, 162–170. https://doi.org/http://dx.doi.org/10.15294/kreano.v8i2.9635

Hobri, H., Arifin, S., Murtikusuma, R. P., Oktavianingtyas, E., & Setya Putri, I. W. (2021). Students' Critical Thinking Process in Solving Jumping Task According to Gregorc's Thinking Style. *Jurnal Didaktik Matematika*, *8*(1), 15–31. https://doi.org/10.24815/jdm.v8i1.19776

Holzrichter, R. (2016). *Proportional Reasoning in Middle Level Mathematics TextBooks*. https://scholarworks.uni.edu/hpt/221

Indillah, Z. E. C., Agustina, E. N. S., & Susilo, T. A. B. (2019). *Penalaran Proporsional Siswa SMP Kelas VIII Dalam Menyelesaikan Soal Matematika Ditinjau Dari Jenis Kelamin*.

Kariadinata, R. (2012). Menumbuhkan Daya Nalar (Power Of Reason) Siswa Melalui Pembelajaran Analogi Matematika. *Jurnal Ilmiah Program Studi Matematika STKIP Siliwangi Bandung*, *1*(1).

Khotimah, K., & Shodikin, A. (2021). An Analysis of Proportional Reasoning Ability of Secondary School Students on Opportunity Material Viewed from Gender Prespective. *Hipotenusa: Jurnal of Mathematical Society*, *3*(1). https://doi.org/10.18326/hipotenusa.v3i1.111-128

Khumairoh, B., Amin, S. M., & Wijayanti, P. (2020). Penalaran Proporsional Siswa Kelas Menengah dalam Menyelesaikan Masalah Matematika Ditinjau dari Adversity Quotient. *Pedagogia : Jurnal Pendidikan*, *9*(1), 67–80. https://doi.org/10.21070/pedagogia.v9i1.259

Kilpatrick, J., Swafford, J., & Findell, B. (2001). Adding It Up: Helping Children Learn Mathematics. In *National Academy Press*. ftp://129.132.148.131/EMIS/journals/ZDM/zdm026r1.pdf

Laili, A. N. (2023). *Level Penalaran Proporsional Siswa Dalam Menyelesaikan Masalah Proporsi Ditinjau Dari Tingkat Kemampuan Koneksi Matematis Siswa Kelas VII MTS Al Amien Ambulu Jember* [Universitas Islam Negeri Kiai Haji Achmad Siddiq Jember]. http://digilib.uinkhas.ac.id/31848/1/Tanti Arsy Asriana_T20191212.pdf

Langrall, C. W., & Swafford, J. (2000). Three Balloons for Two Dollars: Developing Proportional Reasoning. *The National Council of Teachers of Mathematics*, *6*(4), 254.

Lobato, J., & Ellis, A. (2010). *Developing Essential Understanding of Ratios, Proportions & Proportional Reasoning*.

Nurlela, N., Sumarni, S., Riyadi, M., Adiastuty, N., & Syafari, R. (2022). *Proportional Reasoning Level Based on Student Self-Efficacy Review*. https://doi.org/10.4108/eai.2-12-2021.2320311

Öztürk, M., Demir, Ü., & Akkan, Y. (2021). Investigation of Proportional Reasoning Problem

Solving Processes of Seventh Grade Students : A Mixed Method. *International Journal on Social and Education Sciences*, *3*(1), 48–67. https://doi.org/https://doi.org/10.4632/ijonses.66

Patimah, D., & Murni. (n.d.). Analisis Kualitatif Gaya Berpikir Siswa dalam Memecahkan Masalah Fisika Pada Materi Gerak Parabola. *Inovasi Dan Pembelajaran Fisika*, 106–118.

Permatasari, D. I., Amin, S. M., & Wijayanti, P. (2017). Penalaran Proporsional Siswa SMP Kelas IX dalam Menyelesaikan Masalah Matematika Ditinjau dari Gender. *Jurnal Matematika Kreatif-Inovatif*, *8*(2), 199–207.

Prayitno, A., Rossa, A., & Widayanti, F. D. (2019). Level penalaran proporsional siswa dalam memecahkan missing value problem. *Jurnal Riset Pendidikan Matematika*, *6*(2), 177–187. https://doi.org/10.21831/jrpm.v6i2.19728

Prayitno, A., Rossa, A., Widayanti, F. D., Rahayuningsih, S., Hamid, A., & Baidawi, M. (2018). Characteristics of Students' Proportional Reasoning in Solving Missing Value Problem. *Journal of Physics: Conference Series*, *1114*(1). https://doi.org/10.1088/1742-6596/1114/1/012021

Putra, A., Tensa, Y., & Erita, S. (2020). Analisis Penalaran Proporsional Siswa dengan Gaya Belajar Auditori dalam Menyelesaikan Soal Perbandingan. *Journal on Education*, *2*(4), 323–330. https://doi.org/10.31004/joe.v2i4.326

Risdianti, A. (2016). *Analisis Kemampuan Penalaran Proporsional Siswa Kelas X Dalam Pembelajaran Discovery Learning Ditinjau Dari Gaya Belajar Menurut Kolb*. Universitas Negeri Semarang.

Rizal, A. H. (2019). *Analisis Penalaran Proporsional Siswa Dalam Menyelesaikan Soal Perbandingan*. Universitas Islam Negeri (UIN) Mataram.

Sari, D. N. (2019). Analisis Kemampuan Penalaran Proporsional Siswa SMA dalam Memecahkan Masalah Matematika. *Jurnal Math Didactic : Jurnal Pendidikan Matematika*, *5*(2). https://repository.uksw.edu//handle/123456789/19274

Sugiyono. (2019). *Metode Penelitian Kualitatif Kuantitatif dan R&D* (Sutopo (ed.); Kedua).

Suryadi. (2008). Analisis Penalaran Proporsional Siswa Kelas VIII Berdasarkan Gaya Kognitif Field Dependent dan Field Independent Pada Materi Bangun Ruang. *Jurnal Ekuivalen*, 222–227. http://ejournal.umpwr.ac.id/index.php/ekuivalen/article/view/4235

Wahyuni, I. (2022). *Pelanaran Proporsional* (U. Farihah (ed.)). Lembaga Ladang Kata.

Weiland, T., Orrill, C. H., Nagar, G. G., Brown, R. E., & Burke, J. (2021). Framing a robust understanding of proportional reasoning for teachers. *Journal of Mathematics Teacher Education*, *24*(2), 179–202. https://doi.org/10.1007/s10857-019-09453-0

Zulkarnaen, R. (2017). Kesalahan Siswa Dalam Menyelesaikan Soal Penalaran Proposional. *Seminar Matematika Dan Pendidikan Matematika UNY*, *M–8*, 49–54.