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A GRADED RESPONSE MODEL APPROACH TO ASSESS MATHEMATICAL CRITICAL THINKING ON FRACTION PROBLEMS IN JUNIOR HIGH SCHOOL

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Abstract

Mathematical critical thinking ability (MCTA) plays a crucial role in problem solving and reasoned decision-making, yet many students still struggle with fraction problems, particularly in providing justification, evaluating strategies, and drawing conclusions. This study aims to examine junior high school students' mathematical critical thinking ability in solving fraction problems using a mixed-methods approach. Unlike previous studies, this research integrates qualitative analysis with the Graded Response Model (GRM) to provide a more comprehensive profile of students' critical thinking ability. The participants were 27 seventh-grade students. Data were collected through a mathematical critical thinking test, questionnaires, and semi-structured interviews, and analyzed using the GRM and thematic analysis with methodological triangulation. The findings indicate that most students demonstrated moderate to high levels of mathematical critical thinking. Students with higher ability demonstrated stronger reasoning, justification, and reflection, whereas students across all ability levels struggled to evaluate solution strategies and draw conclusions. These findings highlight the importance of instructional practices that foster mathematical reasoning, evaluation, and justification.

Keywords: *mathematical critical thinking; graded response model; fraction; junior high school students*

Abstrak

Kemampuan berpikir kritis matematis (MCTA) berperan penting dalam pemecahan masalah dan pengambilan keputusan, tetapi siswa masih mengalami kesulitan pada materi pecahan, terutama dalam memberikan justifikasi, mengevaluasi strategi, dan menarik kesimpulan. Penelitian ini bertujuan mengkaji kemampuan berpikir kritis matematis siswa SMP dalam menyelesaikan masalah pecahan menggunakan pendekatan mixed methods. Berbeda dari penelitian sebelumnya, studi ini mengintegrasikan analisis kualitatif dengan Graded Response Model (GRM) untuk menghasilkan profil kemampuan yang lebih komprehensif. Partisipan terdiri atas 27 siswa kelas VII. Data diperoleh melalui tes, angket, dan wawancara semi-terstruktur, kemudian dianalisis menggunakan GRM dan analisis tematik dengan triangulasi metode. Hasil menunjukkan sebagian besar siswa berada pada kategori kemampuan tinggi dan sedang. Siswa berkemampuan tinggi menunjukkan penalaran, justifikasi, dan refleksi yang lebih baik, sedangkan seluruh siswa masih lemah dalam mengevaluasi strategi dan menarik kesimpulan. Temuan ini menegaskan pentingnya pembelajaran yang mendorong penalaran, evaluasi, dan justifikasi matematis.

Kata kunci: berpikir kritis matematis; model respons bertingkat; pecahan; siswa sekolah menengah pertama

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INTRODUCTION

Education plays a crucial role in supporting national development by preparing qualified human resources that can compete and collaborate effectively (Alpian et al., 2019). In order to prepare qualified human resources, one of the important abilities that needs to be improved is critical thinking. Currently, critical thinking is widely recognized as one of the essential competencies for successful professional, academic, and everyday problem solving navigations. Critical thinking helps learners to analyze information, evaluate arguments, justify decisions, and make logical conclusions when facing complex problems (Ennis, 2011; Facione, 2020). In mathematical learning, this ability plays particularly important role as mathematical problem solving not only requires procedure applications, but also interpretation of information, evaluation of solution strategies, and construction of reasonable arguments (Hendriana et al., 2013; Setiawan et al., 2018). Consequently, development of mathematical critical thinking ability (MCTA) becomes an essential goal of contemporary mathematical instructions.

Employing critical thinking framework by Facione (2020), this study conceptualizes MCTA into four dimensions consisting of interpretation, analysis, evaluation, and inference. These dimensions were adapted to serve as an analytical framework for the scoring of students' written responses and the interpretation of interview data. Interpretation will focus on the identification of known and unknown information from a problem; analysis concerns on the establishment relationships of mathematical ideas and relevant concept selected; evaluation refers to the process of examining validity and effectiveness of solution strategies; while inference involves formulating logical conclusions based on the mathematical evidence provided. Hence, these indicators do not function as the theoretical construct only, but also serve as the operational criteria to assess students' MCTA.

Despite of MCTA's importance, various studies reported that students still experience difficulties in displaying MCTA. Previous studies conducted in various educational contexts shown that students were able to identify informations stated in a problem, but they were struggle to reason, evaluate alternative strategies of the solution, and formulate relevant conclusion (Razfy & Pradipta, 2022; Solikhin & Fauziah, 2021; Syarifuddin & Ismail, 2023). Similar results have been reported in the current and post-pandemic learning environment where students mostly demonstrated weakness in higher-order thinking processes, particularly in evaluation and inference abilities (Christodoulakis et al., 2024; Kunaedi et al., 2022; Low et al., 2024; Payadnya & Wibawa, 2021; Pratiwi et al., 2023). Hence, it suggests that although students master procedural knowledge, they often faced difficulties to engage in deeper mathematical reasoning.

One of the mathematical topics that constantly reveals students difficulties in demonstrating MCTA is fractions. The topic is a fundamental foundation for algebra learning, measurement,

proportional reasoning, and other advanced mathematical topics (Hwang & Riccomini, 2021; Muharram et al., 2019). However, fraction problems frequently require students to implement multiple concepts simultaneously, interpret contextual information, and justify their solutions. Previous research consistently found that fractions is one of the most challenging topics for middle school students because of the misconceptions, procedural errors, and difficulties in conceptual understanding (Muharram et al., 2019; Shang et al., 2018; Tamila et al., 2020). Therefore, problem solving of fractions provide a suitable context to examine students' MCTA.

Previous studies have generally investigated MCTA through conventional scoring methods or descriptive qualitative approaches (Fatimah, 2021; Nuryanti et al., 2018; Razfy & Pradipta, 2022; Tamila et al., 2020). While these studies have provided valuable insights into students' critical thinking performance, they primarily focused on categorizing achievement levels or describing students' reasoning processes. Consequently, limited attention has been given to profiling students' responses across ordered performance categories in a manner that captures variations in the quality of their critical thinking. The Graded Response Model (GRM), which is designed for ordered scoring categories, offers an alternative framework for examining students' response patterns and performance profiles across different levels of achievement (Alexandra & Ratu, 2018; Anasari et al., 2023). Nevertheless, studies integrating qualitative exploration of students' critical thinking processes with GRM-based performance profiling in the context of fraction problem solving at the junior high school level remain limited. Therefore, this study combines qualitative analysis and GRM-based exploratory profiling to provide a more comprehensive understanding of students' mathematical critical thinking ability in solving fraction problems.

Based on the above considerations, this study aimed to explore students' mathematical critical thinking ability in solving fraction problems using a Graded Response Model approach. Employing a mixed-method design, the integration of GRM-based ability profiling and the qualitative evidence of students' MCTA provides a more comprehensive understanding of the research purpose. The findings are expected to contribute by providing a more comprehensive description of students' MCTA and contribute to the development of instructional designs and assessment practices that support the improvement of students' critical thinking skills.

METHOD

Research Design

This study employed an explanatory mixed-method design aimed to analyze and describe the real condition of the students' MCTA with GRM approach. The quantitative component utilized the Graded Response Model (GRM) to profile students' ability levels based on their responses to mathematical critical thinking tasks, while the qualitative component explored

students' reasoning processes through written responses and semi-structured interviews. The integration of quantitative and qualitative data enabled a more comprehensive understanding of students' mathematical critical thinking across the dimensions of interpretation, analysis, evaluation, and inference.

Participants

Study was conducted to 7th grade students in one of the junior high schools in Riau Islands Province. Twenty-seven students participated in the mathematical critical thinking test on fraction problems. Then, students completed a questionnaire designed to confirm the seriousness of their responses. Based on the test results and questionnaire responses, students were classified into five levels of mathematical critical thinking ability: very high, high, moderate, low, and very low. Subsequently, four students representing different ability levels were purposively selected for in-depth interviews. The selection considered students' ability categories, completeness of responses, and willingness to participate in the interview process.

Instruments

The researcher acted as the main instrument and was supported by additional instruments consisting of MCTA test, students' seriousness questionnaire, and semi-structured interview instrument. The mathematical critical thinking test consisted of three open-ended fraction problems designed to assess four dimensions of mathematical critical thinking adapted from Facione (2020), namely interpretation, analysis, evaluation, and inference. Each dimension was scored using a rubric ranging from 0 to 4, resulting in ordered response categories suitable for GRM analysis. Table 1 presents the operational definitions of the mathematical critical thinking dimensions used in this study.

Table 1. Operational definitions of MCTA dimensions

Dimension	Operational Definition
Interpretation	Identifying and understanding relevant information presented in a mathematical problem
Analysis	Establishing relationships among mathematical concepts and representations to formulate a solution
Evaluation	Assessing the appropriateness and accuracy of solution strategies and procedures
Inference	Drawing logical conclusions based on mathematical evidence and problem context

Prior to data collection, test instrument was reviewed by three experts in mathematics education to establish content validity. Revisions were made based on their feedback regarding content relevance, clarity, and alignment with critical thinking dimensions. The instrument was subsequently piloted with students outside the research sample. The pilot results indicated that all items satisfied acceptable criteria for validity, reliability, discrimination, and difficulty. The instrument demonstrated acceptable internal consistency with a Cronbach's alpha coefficient of 0.606.

The seriousness questionnaire was administered to verify students' engagement during test completion and to support participant selection for interviews. The semi-structured interview protocol was developed to explore students' reasoning processes and clarify their written responses.

Data Collection Procedure

Data collection was conducted in three stages. First, all participants completed the mathematical critical thinking test on fraction problems. Second, students completed the seriousness questionnaire immediately after the test to explore and confirm the seriousness of students in answering test questions, which became one of the considerations in selecting informants. Third, selected participants for semi-structured interviews to provide deeper explanations of their solution strategies, reasoning processes, and difficulties encountered during problem solving.

Data obtained from questionnaire was grouped so that only eligible students from each criterion was selected for the description of their MCTA. Figure 1 shows the percentage of students' eligibility to become research informants, where there are 41% or 11 students eligible to be selected as informants.

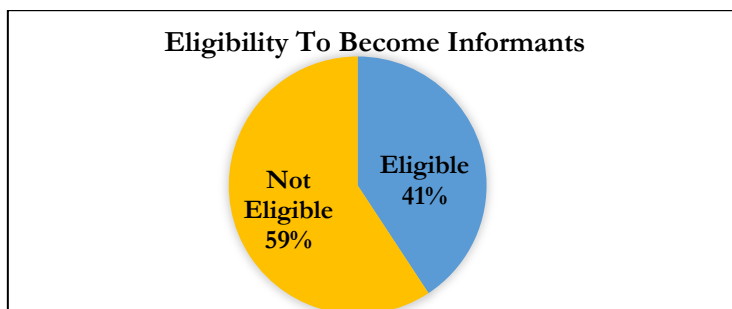


Figure 1. Pie chart of students' eligibility to become research informants

Initially, students from all ability categories were considered as potential interview participants. However, students classified in the very low category were not included in the qualitative phase. The decision was based on the triangulation of test results and questionnaire data. The triangulation results indicated that the very low scores were primarily associated with a lack of engagement during test completion rather than reflecting students' actual MCTA. Consequently, It was considered insufficiently reliable to support an in-depth exploration of mathematical critical thinking processes. Therefore, participants selected for interviews were drawn from the very high, high, moderate, and low ability categories, whose responses were considered more representative of their actual mathematical critical thinking performance. Following the quantitative analysis, from 11 students as potential interview participants, eight students participated in semi-structured interviews. Table 2 shows the list of students as informants.

Table 2. list of students as informants

Testee	Code	Percentage (%)	Criteria
AA	P1	100	Very high
RS	P2	92	
NA	P3	71	High
ASS	P4	71	
BH	P5	46	Moderate
SO	P6	44	
YUD	P7	40	Low
TAA	P8	31	

The interview transcripts and written responses were subsequently reviewed to identify participants who provided the most complete, consistent, and information-rich data. Based on this evaluation, four students whose one from each ability category were selected as focal cases for in-depth qualitative analysis. Therefore, students whose MCTA described in qualitative analysis were P1, P3, P5, and P7.

Data Analysis

Data analysis was conducted through quantitative and qualitative procedures. The quantitative analysis focused on students' responses to the mathematical critical thinking test. Responses were scored using the established rubric and analyzed using the Graded Response Model (GRM). As the scoring rubric produced polytomous data with ordered response categories, the GRM was employed as an exploratory profiling framework to examine students' response patterns across different performance levels. Rather than estimating latent ability parameters, the GRM framework was used to interpret students' performance within ordered score categories and to support the classification of mathematical critical thinking profiles. Students' total scores were converted into percentages and categorized into five levels of mathematical critical thinking ability: very high, high, moderate, low, and very low. These categories were subsequently used to select participants for the qualitative phase.

The qualitative data analysis focused on students written test and interview transcripts which then analyzed through data reduction, data display, and concluding by Miles and Huberman (Alfisyah, 2022). The analysis examined how students demonstrated interpretation, analysis, evaluation, and inference when solving fraction problems. For the analysis, four students were selected through purposive sampling. The selection was based on three criteria: (1) the students represented different levels of mathematical critical thinking ability identified through the GRM framework, (2) their written responses provided sufficient information for further exploration, and (3) they were willing to participate in interviews. This procedure allowed the researchers to obtain rich and varied insights into students' reasoning processes when solving fraction problems.

Finally, quantitative and qualitative findings were integrated during interpretation. The quantitative results provided information regarding students' ability profiles, while the qualitative

findings explained the reasoning processes underlying students' performance. This integration enabled a richer understanding of students' MCTA in fraction problem solving.

The credibility of the data was established through methodological triangulation by comparing information obtained from tests, questionnaires, and semi-structured interviews administered to the same participants. The integration of these data sources allowed the researchers to verify the consistency of the findings and gain a deeper understanding of students' mathematical critical thinking processes (Ibrahim, 2020). In cases where discrepancies emerged among the data sources, further review and clarification were undertaken through follow-up discussions with the participants. This procedure helped ensure that the interpretations accurately reflected students' perspectives and experiences.

RESULTS AND DISCUSSION

The analysis was conducted in two stages. First, students' mathematical critical thinking ability was profiled quantitatively using GRM. Second, qualitative data obtained from students' written responses and interviews were analyzed to explore the characteristics of mathematical critical thinking across different ability levels. The integration of these findings provides a comprehensive understanding of how students interpret, analyze, evaluate, and draw conclusions when solving fraction problems.

Distribution of MCTA

The first stage of analysis aimed to identify students' mathematical critical thinking ability in solving fraction problems. Students' responses were assessed using four dimensions of mathematical critical thinking, namely interpretation, analysis, evaluation, and inference. The maximum possible score was 48.

The results indicate considerable variation in students' mathematical critical thinking ability. Students' scores ranged from 4 to 48, corresponding to percentages between 8% and 100%. The highest score was achieved by AA (100%), while the lowest score was obtained by IM (8%). Based on the percentage scores, students were classified into five categories of mathematical critical thinking ability. The classification results are presented in Table 3.

Table 3. distribution of students' MCTA

Category	Score (%)	Frequency	Percentage
Very High	80–100	2	7.41
High	60–79	10	37.04
Moderate	40–59	8	29.63
Low	20–39	4	14.81
Very Low	<20	3	11.11
	Total	27	100

The findings reveal that most students were classified in the high and moderate categories, accounting for 66.67% of the sample. Only two students reached the very high category, whereas three students were categorized as very low. These results suggest that although many students demonstrated satisfactory mathematical critical thinking ability, a considerable proportion still experienced difficulties in solving fraction problems requiring higher-order thinking processes. To further examine students' performance, the average score for each critical thinking dimension was calculated. The mean score by critical thinking dimension is shown in Table 4.

Table 4. mean score by critical thinking dimension

Dimension	Mean Score	Maximum Score	Percentage
Interpretation (K1)	2.82	4	70.5
Analysis (K2)	3.00	4	75.0
Evaluation (K3)	1.70	4	42.5
Inference (K4)	1.74	4	43.5

The results indicate that analysis and interpretation were the strongest dimensions demonstrated by students. In contrast, evaluation and inference obtained substantially lower scores. This finding suggests that students were generally able to identify relevant information and apply appropriate mathematical procedures but experienced greater difficulty when required to evaluate solution strategies and draw logical conclusions from their results.

Characteristics of Mathematical Critical Thinking Across Ability Levels

To explain the quantitative findings, qualitative analysis was conducted on four students representing different levels of mathematical critical thinking ability. The analysis focused on how students interpreted information, analyzed mathematical relationships, evaluated solution strategies, and formulated conclusions when solving fraction problems.

Description of Students' MCTA with Very High Criteria

Diketahui: 1 loyang kue yg dipotong
 Teman perempuan: $\frac{1}{2}$ bagian
 wati kelas = $\frac{1}{6}$ bagian
 teman laki-laki = sisanya

Ditanya: a). bagian di dapat teman laki-laki?
 b). Satu loyang kue dibagi menjadi 36 potong. Jika teman laki-laki Fatimah ada 9 orang dan masing-masing akan mendapat 2 potong kue, apakah kue yg dibawa mencukupi

Dijawab: a). $1 - \frac{1}{2} = \frac{1}{2} - \frac{1}{6}$
 $= \frac{2}{2} - \frac{1}{6}$
 $= \frac{1}{2}$
 $\frac{1}{2} - \frac{1}{6} = \frac{3}{6} - \frac{1}{6}$
 $= \frac{2}{6}$
 Lem-mata teman laki-laki = $\frac{2}{6}$

b). $\frac{2}{4} \times \frac{3}{6} = 12$
 $2 \times 9 = 18$ Tidak karena kurang potong

Figure 2. P1 answer for question 1

Based on the test results in Figure 2 and in-depth interview of P1, the student was able to understand the information in each question properly as they could write down what was known and asked about the questions correctly and completely. These results indicate that the student has mastered the indicators of MCTA, namely interpretation. The student can also identify the

relationship between information known in the problem and associate concepts related to what is being asked as P1 can make a mathematical model correctly and provide a complete explanation. This shows that the student has mastered analytical ability well. Furthermore, the student can use the right strategy in solving problems as P1 able to perform calculations and comparisons between fractions that are obtained correctly and completely. This shows that P1 has mastered evaluation ability well. The student has also been able to make appropriate conclusions in accordance with the context of the questions given where this shows that student has mastered good inference ability. Therefore, it can be concluded that the student with very high critical thinking ability can master interpretation, analysis, evaluation, and inference ability on the three questions well.

Description of Students' MCTA with High Criteria

Based on test and interviews, student with high MCTA criteria can understand the information given in each question properly as student can write down information known and asked in the questions correctly and completely. This shows that the student has mastered the characteristics of interpretation ability well. Student can relate the information provided in the questions with the mathematical concepts that have been learned as student can answer what is asked in questions 1 and 2 properly. This shows that the student can to master analytical ability well. Student is also able to use the right and complete strategy in solving questions 1 and 2 as student can do the right calculations and able to make the right conclusions based on the context of the problem. This shows that the student has been able to master evaluation and inference ability well in questions 1 and 2. When researcher asked about question 3 which need to be completed, student said that the question could not be solved not because of limited time in answering questions but student did not know how to solve them. After researcher confirmed this, the student was only confused in working on the problem without further explanation. Therefore, researcher concluded that P3 was wrong in writing the right strategy in solving problem 3 so that P3 was only able to write part of it and did not complete the process. Therefore, it can be concluded that the student can master interpretation, analysis, evaluation, and inference ability in questions 1 and 2, but only master interpretation abilities in question 3. The results of the P3 student's MCTA test in question 3 can be seen in Figure 3.

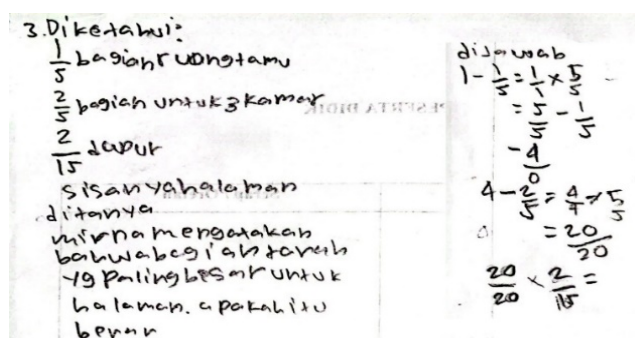


Figure 3. P3 answer for question 3

Description of Students' MCTA with Moderate Criteria

Student in the moderate category (for example P5) demonstrated partial understanding of the problems and were able to apply familiar procedures to solve fraction tasks. However, difficulties emerged when problems required deeper analysis and justification. Several responses showed that students could identify relevant information but struggled to connect it to appropriate mathematical concepts. Interview data revealed uncertainty in explaining why particular procedures were selected. As a result, some solutions were incomplete or contained reasoning errors. Students also demonstrated limited ability to evaluate their work and formulate comprehensive conclusions. These findings suggest that students in the moderate category rely primarily on procedural knowledge and experience difficulties when tasks require higher-order reasoning processes. Figure 4 below shows the results of P5 working in questions 1-3.

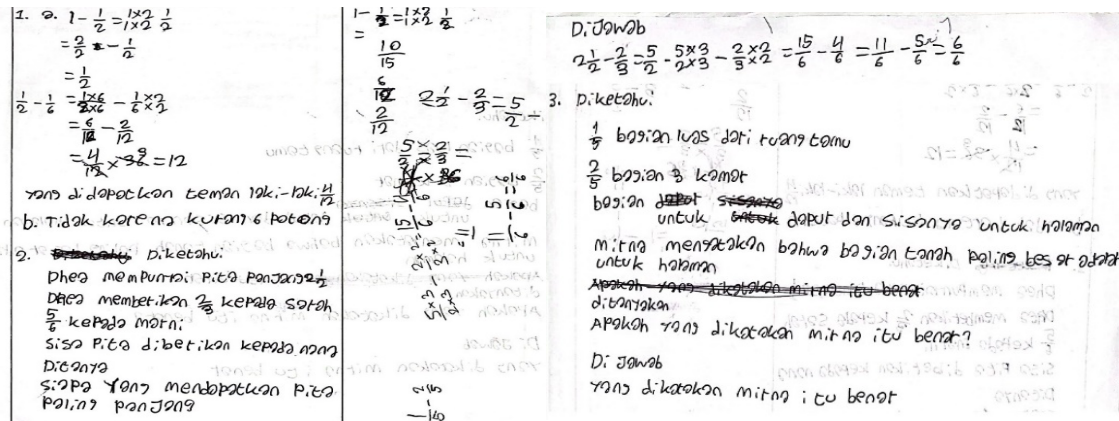


Figure 4. P5 answer for questions 1-3

Description of Students' MCTA with Low Criteria

Descriptions related to the low criteria of MCTA was represented by student P7. The student's answers to questions 1-3 are presented in Figure 5.

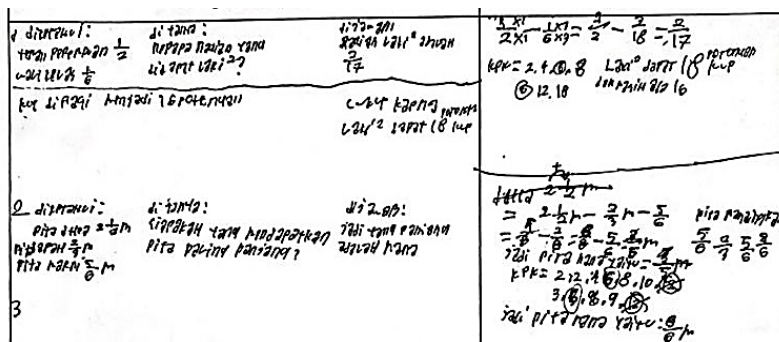


Figure 5. P7 answer for questions 1-3

Based on Figure 5, P7 demonstrated limited mathematical critical thinking ability although their performance was not uniformly low across all dimensions and tasks. Analysis of written responses and interview data revealed that these student were generally able to identify some

relevant information presented in the problems which indicate evidence of interpretation ability in certain situations. However, difficulties became more apparent when the tasks required deeper analysis, evaluation of solution strategies, and formulation of logical conclusions. The findings showed that performance varied across problems and critical thinking dimensions. In several instances, student was able to interpret the problem context and identified known information but were unable to connect that information to appropriate mathematical concepts or procedures. In other cases, students applied a solution strategy but were unable to justify why the strategy was appropriate or evaluate the correctness of their results. Evidence of inference was particularly limited, as conclusions were often incomplete, unsupported, or inconsistent with the obtained solutions. Interview data further indicated that these students frequently relied on procedural attempts without fully understanding the underlying mathematical relationships. As a result, their reasoning tended to be fragmented and less coherent than that demonstrated by students in the higher categories. These findings suggest that students in the low category possess emerging critical thinking abilities, particularly in interpretation, but require additional support in developing analytical, evaluative, and inferential reasoning when solving fraction problems.

Integration of Quantitative and Qualitative Findings

The qualitative findings generally support the quantitative ability profiles. Students classified in higher categories demonstrated stronger reasoning, justification, and reflective thinking than students in lower categories. The most notable differences were observed in evaluation and inference, where higher-performing students consistently assessed the validity of their solutions and formulated logical conclusions.

The integration of both data sources indicates that differences in mathematical critical thinking ability are reflected not only in students' final scores but also in the quality of reasoning processes employed during problem solving. Students with higher ability levels demonstrated deeper conceptual understanding and greater metacognitive awareness, whereas students with lower ability levels relied primarily on procedural approaches and showed limited reflection on their work.

Discussion

The findings reveal substantial variation in students' mathematical critical thinking ability when solving fraction problems. The quantitative results showed that most students were classified in the high and moderate categories, while only a small proportion reached the very high category. The qualitative findings further demonstrated that students at different ability levels exhibited distinct patterns of reasoning, particularly in how they interpreted information, analyzed mathematical relationships, evaluated solution strategies, and formulated conclusions. These

findings suggest that mathematical critical thinking is not reflected solely in the correctness of answers but also in the quality of reasoning underlying the problem-solving process.

One notable finding is that students generally performed better in interpretation and analysis than in evaluation and inference. Students across ability levels were often able to identify relevant information and determine appropriate procedures for solving fraction problems. However, many experienced difficulties when required to justify their reasoning, assess the validity of their strategies, or formulate conclusions supported by mathematical evidence. This pattern indicates that students tend to rely on procedural knowledge rather than reflective reasoning. Such findings are consistent with Facione (2020) framework, which emphasizes that critical thinking extends beyond understanding information and requires individuals to evaluate arguments and draw reasoned conclusions. Similar observations have been reported in mathematics education research, where students frequently demonstrate competence in executing procedures but struggle with higher-order processes involving justification and evaluation (Maciejewski & Star, 2019; Obeng et al., 2024).

The qualitative analysis also revealed that MCTA were not consistently demonstrated across all tasks. Even students in the low category occasionally showed evidence of interpretation and analytical thinking when solving familiar problems, while some students in the high category encountered difficulties when required to evaluate their solutions or explain their reasoning in detail. This finding suggests that mathematical critical thinking should be viewed as a multidimensional construct rather than a fixed attribute. Students may demonstrate certain critical thinking indicators in one context but fail to exhibit the same indicators in another. Therefore, categorizing students into ability levels should not be interpreted as implying uniform mastery or deficiency across all dimensions of critical thinking.

Another important finding concerns the role of fraction problems in eliciting students' critical thinking. Fraction concepts require students to coordinate multiple representations, understand part-whole relationships, and justify mathematical operations conceptually. Consequently, fraction problems can expose weaknesses that may remain hidden in routine procedural tasks. The difficulties observed in evaluation and inference indicate that many students were able to perform calculations but lacked of deeper understanding of why specific procedures were appropriate. This finding supports previous studies suggesting that fraction learning remains a challenging area for many students because it requires both conceptual understanding and flexible reasoning (Gabriel et al., 2023; Simon et al., 2018). When students possess only procedural knowledge, they may obtain answers without being able to evaluate their validity or explain their reasoning.

The integration of quantitative and qualitative findings provides a more comprehensive understanding of students' MCTA. The quantitative analysis identified differences in performance levels among students, while the qualitative findings explained the reasoning characteristics associated with those differences. Students in the very high category consistently demonstrated deeper conceptual understanding, stronger justification, and greater self-monitoring than students in the lower categories. Conversely, students in the moderate and low categories often relied on procedural approaches and demonstrated limited reflection on their work. These results highlight the value of combining quantitative profiling with qualitative exploration to obtain a richer picture of students' mathematical thinking.

From an instructional perspective, the findings suggest that mathematics learning should provide greater opportunities for students to engage in evaluation and inference. Classroom activities often emphasize obtaining correct answers, whereas opportunities to justify reasoning, critique solution strategies, and formulate evidence-based conclusions are less common. Teachers may therefore consider incorporating open-ended problems, mathematical discussions, and reflective questioning into classroom practice. Such activities can encourage students not only to solve problems but also to examine the validity of their reasoning and communicate their mathematical ideas more effectively.

CONCLUSION

This study investigated junior high school students' mathematical critical thinking ability in solving fraction problems through the integration of quantitative and qualitative analyses. The findings revealed variations in students' mathematical critical thinking ability with most students classified in the high and moderate categories. Differences among ability levels were reflected not only in students' scores but also in the quality of their reasoning processes.

The qualitative findings showed that students with higher mathematical critical thinking ability demonstrated more comprehensive reasoning, stronger justification, and greater reflection on their solutions than students in lower categories. Across ability levels, students generally performed better in interpreting information and applying procedures than in evaluating solution strategies and drawing conclusions. Furthermore, the findings indicate that MCTA were not consistently demonstrated across all tasks, suggesting that mathematical critical thinking is multidimensional and influenced by problem context.

The integration of quantitative and qualitative findings provides a more comprehensive understanding of students' mathematical critical thinking in fraction problem solving. These findings highlight the importance of designing mathematics instruction that encourages students to justify their reasoning, evaluate their solutions, and formulate evidence-based conclusions.

Future studies may involve larger samples and different mathematical topics to further explore students' mathematical critical thinking across various learning contexts.

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