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Critical Thinking Abilities of Prospective Mathematics Teachers Based on Learning Styles

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Abstract

This research attempts to describe the critical thinking abilities of prospective fifth-semester mathematics education teachers at PGRI University Semarang through a qualitative approach. The researcher, as the primary instrument, employed a learning style questionnaire, a Group Theory critical thinking test, and an interview guide with purposively selected subjects. Data were analyzed through flow diagrams which included data reduction, data presentation, and drawing conclusions. Data credibility is obtained through triangulation of sources and time. The research result show that the average critical thinking ability test for visual and audotory styles is relatively higher than for kinsestetic learners. At the stages of focus, reasoning, and inference, all three stylesthe stages of saturation, clarity, and overview, a clear distinction emerges, with the visual style demonstrating greater effectiveness by producing answer that are both accurate and complete, unlike the auditory and kinesthetic counterparts. The ability of the three learning styles to express valid arguments to clarify the truth of the answers they make is still very low. Providing training with open-ended problem-based questions and problem-based learning as well as honing the arguments of prospective mathematics teachers are the alternative solutions chosen to improve critical thinking skills.

Keywords: learning style, critical thinking, prospective mathematic teacher

INTRODUCTION

In the industrial era 4.0, countries can thrive only if they respond quickly to adaptation demands and seek new alternatives in problem-solving to anticipate technological developments. The ability to solve problems and reason logically is one of the essential competencies that human resources must possess to remain competitive (Carlgren, 2013). Several studies confirm that this competence determines a person's resilience and competitiveness in achieving success in learning, work, and everyday life during the industrial era 4.0 (Bermingham, 2015; Kivunja, 2015; Zare & Othman, 2015). Individuals with strong critical thinking and communication skills adapt more easily to changing conditions and are valued in both academic and professional contexts (Carlgren, 2013; Mason, 2007; Rudd et al., 2000).

Critical thinking is a higher-order cognitive competence that enables individuals to analyze and evaluate information, differentiate facts from opinions, construct logical arguments, make sound judgments, and reflect on decisions to solve problems effectively and adapt to life's challenges (Alwehaibi et al., 2017; Chukwuyenum, 2013; Setyawati, 2022; Kurniasih, 2012; Rachmantika & Wardono, 2019; Nur'Azizah et al., 2021; Duron et al., 2006; Ghazivakili et al., 2014; Nold, 2017; Sternberg et al., 2007; Sternberg & Sternberg, 2015; Cahyono et al., 2019; Fisher, 2000; Logeswar et al., 2016; Norris, S, 1989). In the field of education, this competence is recognized as a vital skill for students to solve problems both in school and in their future lives (Hidayati & Sinaga, 2019; Johnson & Johnson, 2009; Toheri et al., 2020). Zainudin and Istiyono (Zainudin & Istiyono, 2019) also highlight critical thinking, creativity, innovation, communication, and problem-solving as essential competencies for students. These skills are consistently listed as key components for college and career readiness (Costa & Kallick, 2014; Costa, Arthur L., 2015; Kraisuth & Panjakajornsak, 2018; Zainudin & Istiyono, 2019).

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Several studies have shown that Indonesian students' critical thinking abilities in mathematics remain relatively low (Hidayati & Sinaga, 2019; Syahrial et al., 2019; Tanudjaya & Doorman, 2020). Researchers have examined various factors that may influence this condition, such as learning independence, gender, personality type, mathematical ability, and instructional media (Arifah et al., 2020; Fitriana et al., 2018; Shubina & Kulakli, 2019; Susilo, et al., 2022; Anjariyah et al., 2018; Fitriana et al., 2018; Rosidin et al., 2019; Thadea et al., 2018; Isrokatun et al., 2023; Gofur, et al., 2022).

However, studies that specifically investigate critical thinking in relation to students' learning styles are still limited, even though learning style is a key element that can guide teachers in designing differentiated and more effective instructional strategies (Coffield et al., 2004). Therefore, this study aims to fill that gap by examining students' critical thinking skills from the perspective of their learning styles.

Several studies have attempted to describe the characteristics of students' or prospective teachers' higher-order thinking and produced different findings that contribute to learning design. For example, Rasiman (2008), using Facione's indicators of critical thinking (Facione, 2011) and Polya's problem-solving framework (Cahyono, 2016; Polya, 1981) found differences in mathematical reasoning among students at IKIP PGRI Semarang, categorized into four levels based on initial ability. Afifah & Agoestanto (2020) revealed variations in students' reasoning processes when solving open-ended mathematics problems depending on their curiosity. Other studies highlight gender differences. Rodzalan & Saat (2015), reported that male students demonstrate stronger reasoning and problem-solving, while Cahyono (2017) argued that female students perform better in terms of thinking processes.

Learning style itself shows a consistent positive influence on students' reasoning abilities (Mulyawati & Supardi, 2023; Myers & Dyer, 2006). Although gender differences do not significantly affect preferred learning styles, these styles provide meaningful support for higher-order thinking (Dilekli, 2017). Some studies suggest that visual learners perform better than auditory and kinesthetic learners (Safitri & Miatun, 2021). Others claim that kinesthetic learners demonstrate higher abilities (Amir, 2015; Oktaviani et al., 2023), while Amir (2015) also reported visual learners outperform auditory learners. These contradictory results highlight a clear research gap: while learning style appears to be a strong predictor of reasoning skills, its precise role remains uncertain and requires further investigation.

Teaching higher-order thinking demands more time and effort, but knowing students' learning styles can significantly facilitate the process (Cahyono et al., 2019; Rayneri et al., 2006). Encouraging students to solve non-routine problems has also been shown to enhance reasoning skills more effectively than traditional approache (Aini et al., 2019; Kardoyo et al., 2020; Yusuf et al., 2019). To achieve this, problems must foster innovation, problem comprehension, mathematical reasoning, and the ability to construct valid arguments, often in the form of open-ended tasks (Cahyono, Kartono, et al., 2021; Cahyono, Rohman, et al., 2021). Group Theory, in particular, requires such reasoning skills and the ability to present sound arguments (Setyawati, 2024; Cahyono et al., 2019). Thus, prospective mathematics teachers must master this competence to understand Group Theory effectively (Setyawati, 2024)

Previous studies have primarily examined students' critical thinking in relation to problem solving, reasoning, or the use of instructional media, whereas this research specifically investigates critical thinking from the perspective of students' learning styles. This dimension remains underexplored in mathematics education research, which makes the study particularly significant. The novelty of this research lies in two main contributions. First, it develops and applies new indicators of critical thinking based on

Ennis's FRISCO framework (Fisher, 2000; Logeswar et al., 2016), allowing for a more detailed analysis of students' reasoning processes. Second, it integrates these indicators with Dewey's stages of problem solving (Carson, 2007; Roskaputri & Fitriana, 2021) within the context of abstract algebra, particularly group theory, which has rarely been the focus of prior investigations. This combination provides a fresh perspective and practical insights for educators to design differentiated learning strategies tailored to students' learning styles.

METHODS

This research was carried out at Universitas PGRI Semarang with fifth-semester students of the 2024/2025 academic year who were enrolled in a group theory course. The study followed a systematic procedure that encompassed the research design, participants and sampling, instruments, data collection techniques, data analysis, and indicators of critical thinking skills.

Research Design

This study employed a qualitative descriptive approach to explore students' critical thinking skills based on their learning styles in a group theory course. Conducted in natural settings, the researcher served as the primary instrument, collecting data from interviews, observations, documents, and audiovisual materials. The process was dynamic, with continuous reflection on the researcher's role in interpreting meanings. This approach also adopts a holistic perspective, examining the situation as an integrated whole rather than in isolated parts (Creswell, 2019).

Participants and Sampling

The participants of this study were 28 prospective mathematics teachers. They completed a learning style test adapted from Bobbi DePorter and engaged in solving open-ended problems designed to assess critical thinking skills. Using a purposive sampling technique, participants with high critical thinking scores were selected, ensuring representation from each dominant learning style (Visual, Auditory, and Kinesthetic). Their critical thinking abilities were then evaluated using the Critical Thinking Evaluation Scale (CTES) to provide a comprehensive qualitative analysis.

Instruments

This study employed three main instruments: a learning style questionnaire, the Critical Thinking Evaluation Scale (CTES), and interview guidelines. The learning style questionnaire was adapted from Bobbi DePorter's model, which classifies students into Visual, Auditory, and Kinesthetic categories. It consisted of 30 items on a three-point Likert scale and was validated through expert judgment by a psychology specialist to ensure its clarity and suitability for mathematics education. Students' critical thinking skills were assessed using the CTES, which consisted of one open-ended problem rated with an eight-point Likert scale. The CTES was reviewed by two experts, namely a mathematics expert and a mathematics education lecturer, to confirm the clarity and relevance of its items. The validation criteria covered several aspects: (1) the availability of sufficient information to solve the problem, (2) the use of interrogative or directive statements that require elaborative answers, (3) the inclusion of reasoning in the solution steps, (4) the measurement of critical thinking ability, (5) the use of non-routine problems, (6) the suitability of the time allocation for problem-solving, (7) the use of simple, communicative, and unambiguous language, and (8) adherence to correct grammar in accordance with Indonesian language conventions. The categorization of critical thinking ability levels in this study was based on the percentage of the maximum possible score. Scores up to 50% of the maximum were classified as low (0–36), scores between 51% and 75% as medium (37–54), and scores above 75% as high (55–72). This classification system refers to Azwar (2012), who emphasized that interpretation of test scores can be conducted by dividing the range of possible scores into categories according to their proportion of the maximum score. The detailed score ranges are presented in Table 1.

Table 1. Critical thinking ability score range

Critical thinking ability score range	Critical thinking ability criteria
$0 \leq CT \leq 36$	Low
$37 \leq CT \leq 54$	Medium
$55 \leq CT \leq 72$	High

The selection of research subjects was carried out using a purposive sampling method. From each dominant learning style group (Visual, Auditory, and Kinesthetic), the participants with the highest critical thinking scores were chosen. To gain deeper insights into their reasoning in solving group theory problems, in-depth interviews were then conducted with these selected subjects. The main instrument in this research is the researcher himself who acts as a planner, data collector, data analyzer, data interpreter, and reporter of research results. In the research process, researchers were assisted by a learning style questionnaire instrument, assignment sheets in the form of critical thinking test questions, and interview guidelines. The following is an example of a critical thinking test question for prospective mathematics teachers on group theory problems, and is shown in Figure 1 below:

Create 2 different Latin square shapes (Cayley tables) from G = (p,q,r,s) with the * operation, so that (G , *) is a commutative group? and show that the Cayley table you created is a commutative group!

Figure 1. Critical Thinking Skills Test questions used

The qualitative data analyzed in this research are the results of the work of prospective mathematics teachers in completing an open-ended critical thinking ability test on group theory material and the results of direct interviews with prospective mathematics teachers after taking the test. The questions used in qualitative interviews are semi-structured and open which are deliberately created to obtain the respondent's opinions or views (Cresswell, 2012). Validity is analyzed using an interactive model which includes activities (1) data reduction, (2) data presentation, and (3) drawing conclusions Credible data requires triangulation of methods and triangulation of analysis sources (Wiersma & Jurs, 2009).

Data Collection Procedures

Data were collected in four stages. First, students completed a learning style questionnaire and the Critical Thinking Evaluation Scale (CTES). Based on these results, participants were purposively selected to represent different learning styles and critical thinking levels. Semi-structured interviews were then conducted to explore their reasoning processes, followed by documentation to support and complement the findings.

Data Analysis

The data were analyzed using Miles and Huberman's interactive model, which includes three concurrent activities: data reduction, data display, and conclusion drawing/verification (Miles, Huberman, & Saldaña, 2014). Data reduction was carried out by selecting and simplifying relevant information, while data display involved organizing the results into matrices and narrative descriptions to facilitate interpretation. Conclusions were drawn and verified continuously throughout the research process. To enhance the credibility of the findings, triangulation across instruments and data sources was applied (Creswell, 2019).

Indicators

The critical thinking ability indicators in this research were analyzed using the stages presented by Ennis, namely Focus, Reason, Inference, Saturation, Clarity and Overview (FRISCO) (Fisher, 2000) and the problem solving cycle presented by John Dewey (Carson, 2007). Indicators of critical thinking skills in this research are presented in Table 2.

Table 2. Indicators of Critical Thinking Ability in Solving Problems

Main Elements of Critical Thinking (Ennis)	Problem Solving Steps According to John Dewey	Indicators of Critical Thinking Ability
Focus	Confront Problem Diagnose or Define Problem	Explore information to support the preparation of arguments; 1. State that there is a problem with the information provided 2. Interpret information through the activity of mentioning/writing/selecting all important information provided and supporting the problem solving process clearly and completely
Reason Inference	Inventory Several Solution	Develop valid arguments through activities: 1. Organizing/revealing previously learned definitions, axioms, or formulas related to the problem (finding patterns (sketches)). formulate problems in variable form, model problems in algebraic equations) 2. Use definitions, axioms or formulas that have been studied previously to develop several alternative problem solving strategies
Situation	Predict consequences of solutions of Solutions	Testing the validity of arguments through activities: 1. Determine one assumption/hypothesis from several hypotheses/assumptions as an appropriate alternative problem solution so as to be able to predict the allocation of time needed to solve the problem. 2. Carry out plans to solve mathematical problems correctly 3. Able to determine problem solving assumptions based on the availability of facts that have been studied to predict the time needed
Clarity Overview	Test Consequences	Evaluate arguments through activities: 1. Draw conclusions from the process to determine the most appropriate solution. 2. Ensure the correctness of the answers written through valid logic 3. Carry out a thorough re-examination to prepare arguments based on valid logic to argue that the conclusions reached are correct.

RESULT & DISCUSSION

The results of the learning style test using a questionnaire instrument adapted from Bobbi De Porter and an open-ended critical thinking ability test on group theory material classified 28 prospective mathematics teachers as in Table 2 below:

Table 3. Results of the learning style questionnaire test and open-ended critical thinking ability test `

Learning Style	Sum of Prospective Teachers	Prospective teachers with high scores	Prospective teachers with moderate scores	Prospective teachers with low scores	Average score of critical thinking abilities
Visual	13	2	8	3	49
Auditori	9	2	4	3	45
Kinestetik	6	1	3	2	39
Sum	28	5	15	8	

Table 3 summarizes the distribution of prospective mathematics teachers' learning styles and critical thinking skills. This table does not serve as a basis for statistical generalizations or quantitative comparisons. Rather, it is used solely to facilitate the purposive sampling process in selecting research participants. Specifically, this information helps identify students with high critical thinking skills in each dominant learning style (Visual, Auditory, and Kinesthetic), who were then selected as subjects for the qualitative phase of the study. The findings indicate that differences in learning styles may relate to variations in the critical thinking processes and abilities of prospective mathematics teachers. According to the research results of several researchers (Azmi & Andriyani, 2022; Cahyono et al., 2022; Ghazivakili et al., 2014; Ghofur et al., 2016; Nurbaeti et al., 2015; Yildirim & Özkahraman, 2011) which revealed that learning style is one of the important driving factors when trying to improve students' critical thinking abilities. Dilekli (Dilekli, 2017) revealed that learning styles have a significant impact on 'evaluation', 'inductive reasoning', and 'critical thinking' skills. This is different from the research results of (Purwanto et al., 2020) which states that there are differences in learning outcomes when viewed from learning styles, but students' learning styles do not affect students' mathematical critical thinking abilities. This is different from research by (Oktaviani et al., 2023) which revealed that the average critical thinking ability of the kinesthetic learning style is higher than the auditory learning style and the visual learning style and the inquiry learning model can improve students' critical thinking abilities.

Five prospective mathematics teachers who achieved high scores on the critical thinking ability test were selected for in-depth interviews to explore and profile their critical thinking skills. Based on the information summarized in Table 3, which presents the distribution of learning styles and critical thinking scores, participants with high critical thinking ability within each dominant learning style (Visual, Auditory, and Kinesthetic) were identified and chosen for the qualitative phase. Table 3 was used solely to facilitate the purposive sampling process and was not intended for statistical generalization or quantitative comparison. The description of the selected subjects is presented in Table 4.

Table 4. Subject selection results

No	Prospective Mathematics Teachers Code	Learning Style
1	VSA, VBG	Visual
2	ADY, AMR	Auditori
3	KMF	Kinestetik

Table 4 shows that each learning style is represented by two research subjects, except for the Kinesthetic group, as only one prospective mathematics teacher met the criteria. All selected subjects satisfied the study’s criteria for the focus of the qualitative analysis. The following is an example of a prospective teacher's work:

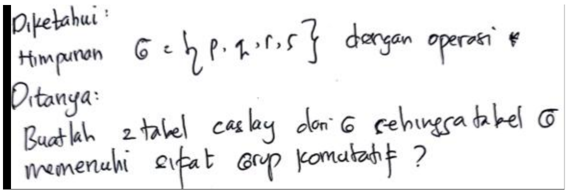

Figure 2. Image of VSA Job results

Figure 2 reveals that the subjects were able to identify problems that had to be solved in the information provided and were able to reveal the important elements contained in the information provided by writing the elements that were known and asked about in the questions correctly and completely. This indicates that the subject fulfilled the focus indicator with the problem-solving step, namely confronting the problem and diagnosing the problem.The research results are in line with the research of several researchers who revealed that visual, auditory, and kinesthetic learning styles are able to reveal the meaning of questions by notating known and asked elements correctly and completely (Cahyono et al., 2022; Fatma et al., 2019; Huda et al., 2017; Murtiyasa & Wulandari, 2022; Newton, 2015; Pradika et al., 2019; Sulisawati et al., 2019). Several studies reveal that kinesthetic and auditory learning style subjects do not write down important elements in the information provided, but correctly reveal elements that are known and asked about during the interview process (Hesse et al., 2015; Yanti et al., 2021).

The reason and inference stages of the three learning styles are able to go through the stages smoothly, but the kinesthetic learning style requires stimulus questions from the researcher to go through it correctly and completely. This is revealed in the results of interviews with the following KMS subjects in table 5. From the interview transcripts, it is evident that, with structured guidance from the researcher, the KMS subjects were able to recall relevant definitions, axioms, and formulas and apply them to develop multiple problem-solving strategies. While some students expressed uncertainty during evaluation, they demonstrated the ability to identify key information, test assumptions, and reflect on solution validity, aligning with the FRISCO indicators (Clarity, Focus, Inference) and Dewey’s critical thinking steps (Explore Information, Test Consequences). In line with the research results of several researchers who stated that the three learning styles have relatively the same ability to analyze problems and determine the relationship between the material that has been studied to develop strategies for solving problems (Huda et al., 2017; Setiawani et al., 2017; Sulisawati et al., 2019).

Table 5. Interviews with the following KMS

<table>
<thead>
<tr><th>Interview</th><th>Analysis</th></tr>
</thead>
<tbody>
<tr><td>Researcher: Based on the information obtained from the problem, do you have an idea to solve the problem?
KMS: “After remembering what I have learned before, finally I have an idea.”</td><td>The student identifies key information and activates prior knowledge, showing focus. This aligns with Dewey’s step of exploring information. Compared to Smith (2005) who reported that students often struggle to initiate problem-solving, this student demonstrates a clear starting point.</td></tr>
<tr><td>Researcher: What ideas did you come up with?
KMS: “Create two ceslay tables from four elements G with the operation *,
<table>
<tr><td>*</td><td>p</td><td>q</td><td>r</td><td>s</td></tr>
<tr><td>p</td><td></td><td></td><td></td><td></td></tr>
<tr><td>q</td><td></td><td></td><td></td><td></td></tr>
<tr><td>r</td><td></td><td></td><td></td><td></td></tr>
<tr><td>s</td><td></td><td></td><td></td><td></td></tr>
</table>
(KMS subject while describing on paper), then through trial and error fill in the empty table.”</td><td>The student demonstrates advanced reasoning by organizing known procedures and planning alternative strategies. Actively experimenting with multiple solution approaches, the student shows flexibility and reflective thinking. Previous studies indicate that students who explore various strategies perform better in problem-solving and exhibit deeper conceptual understanding (Andal & Andrade, 2022; Hacatrjana, 2022).</td></tr>
<tr><td>Researcher: Are there certain requirements to fill it out?
KMS: “Filled with G elements, namely p, q, r or s, identity elements so that (G,*) fulfills closed, associative properties, has identity, and inverses. But I'm still a bit confused about these traits.”</td><td>The student demonstrates Reason by attempting to apply definitions and axioms while planning a solution, showing active engagement in organizing prior knowledge. At the same time, the student exhibits Situation by recognizing the necessary conditions and constraints that the problem requires (closure, associativity, identity, and inverses). Partial confusion reflects developing reasoning skills and engagement with the problem context, aligning with the FRISCO indicators of Reason and Situation.</td></tr>
<tr><td>Researcher: How many possible ceslay tables can be created that are commutative groups?
KMS: “What is clear is that there is [a solution], I'm not sure of the number, but what is requested is two different ones.”</td><td>The student evaluates possible solutions and predicts outcomes, consistent with inference. The uncertainty highlights the challenge in anticipating all valid group structures.</td></tr>
<tr><td>Researcher: How many possible ceslay tables can be created that are commutative groups?
KMS: “I don’t think it’s possible to create more than 2 commutative group tables, I’m just confused.”</td><td>"The student evaluates the constraints and tests assumptions, demonstrating the clarity indicator and aligning with Dewey’s ‘test consequences’ step, despite expressing uncertainty</td></tr>
</tbody>
</table>

At the saturation stage, learning style becomes a clear differentiator of prospective teachers' critical thinking abilities in solving problems. In research, it is revealed that only the visual learning style is able to write answers to problems perfectly. There were several errors in the answers written by auditory and kinesthetic learning style subjects, but the auditory learning style was better than the kinesthetic learning style. This is revealed in the answers of KMF and VSA subjects in Figure 3 and 4.

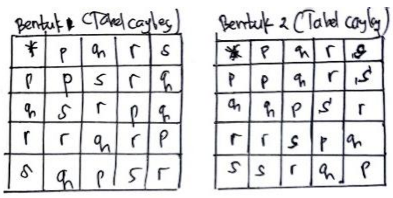

Figure 3 answers of VSA

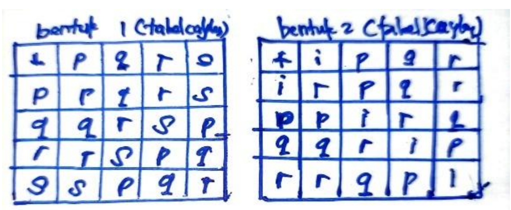

Figure 4 answers of KMF

Based on Figures 3 and 4, information can be seen that the VSA subject can write answers to questions correctly and precisely, namely two caslay tables that fulfill the commutative property. Figure 4 shows that the KMF subject was able to create two caslay tables, However, there were still errors in identifying the identity element (adding element i which is not a member of set G, so the closed property is not fulfilled), and the commutative property of the table formed. Visual and auditory learning styles are also better than kinesthetic learning styles when determining correct answer assumptions from available data to predict the time needed to solve problems. This is revealed in the following interview transcript with subjects ADY and VBG;

Table 6. Interviews with the following ADY

Interview	Analysis
Researcher: Are the facts you learned previously enough to solve the problem? ADY: “Enough, sir!”	The student confirms that previously learned facts are sufficient to understand the problem, showing the ability to identify key information. This aligns with Dewey’s *explore information* step.
Researcher: Based on your understanding of the problem you have formulated and the facts you have learned, how long will it take to solve the problem? ADY: “30–35 minutes, sir!”	The student predicts the time needed to complete problem-solving based on prior knowledge, demonstrating *inference*.
Researcher: Are you sure 30-35 minutes is enough? ADY: “Yes, I’m sure, sir. That’s enough time to solve the problem.”	At the Clarity and Overview stages, the students attempted to evaluate their solutions, aligning with Dewey’s Test Consequences step and the Clarity indicator. However, their evaluation was limited: although they could write correct answers, they struggled to provide valid, data-based arguments to justify them

So it can be concluded that at this stage learning styles play an important role in achieving critical thinking skills. In accordance with the results of research by Arifah (Arifah et al., 2020) which revealed that visual learning styles tend to have better critical thinking abilities than kinesthetic and auditory learning styles. The results of research by several researchers reveal that students' learning styles are one of the determinants of students' levels of critical thinking abilities(Arifah et al., 2020; Cahyono et al., 2022; Ghazivakili et al., 2014). Leasa, Corebima, and Batlolona (Leasa et al., 2020) states that learning style is a driving factor that must be a top priority in efforts to achieve critical thinking skills

At the Clarity and Overview stages, the three learning styles experienced difficulties when asked to provide valid arguments based on data and facts to state that the answers written were correct even though they were able to write the answers correctly. The three learning styles have not been able to re-check answers through valid argumentation because they only carry out re-reading activities from beginning to end of answers written when re-checking or evaluating, and solve them according to the example questions given during learning, this is revealed in the transcript (see Table 7).

Table 7. Interviews with the following CMS

Interview	Analysis
Reseaecher: After completing the questions, are you sure the answer you wrote is correct? CMS: “Seems pretty sure, sir!, because that’s my best answer, sir!”	The student expresses confidence in their answers; however, this confidence is not based on valid data- or fact-based argumentation.
Researcher: What is your reason for stating that you are confident? CMS: “Because I worked according to the examples of questions I learned about commutative groups.”	The student justifies their solution using prior knowledge and examples, demonstrating reasoning based on previously learned materials. This shows planning and application of prior knowledge, but does not yet involve data-based arguments, indicating a developing stage in critical thinking.
Researcher: After doing the work and finding the results, is there an effort to check the correctness of the answers? CMS: “Yes, it’s clear there is, sir, I reread it from beginning to end of the answer I wrote!”	The student actively reviews the solution for correctness, aligning with Dewey’s *Test Consequences* step. Evaluation is limited to re-reading, lacking argument-based verification, reflecting underdeveloped Clarity and Overview skills.
Researcher: You just reread it from start to finish when you double check, is that all? When reading what do you do? CMS: “Yes, just read, sir, while making sure the answers are in accordance with the steps in discussing the questions during the lesson.”	The student cross-checks answers with prior learning steps, demonstrating procedural verification. The lack of alternative solutions or data-based justification shows that the ability to construct valid arguments, an important critical thinking skill, is still limited
Researcher: Have you found any alternative answers?? CMS: “I tried filling it in another form, but I couldn’t find it, sir, the only answer I found was two ceslay tables, and even then I wasn’t sure it was correct.”	Students attempted to explore alternative solutions and predict outcomes, reflecting developing but still lacking skills in inference and reasoning. This uncertainty highlights the difficulty in systematically exploring all solution paths.

In the interview transcript above, it is revealed that the subject believes that the answer written is correct even though it is not based on a valid argument (data or facts), re-checked the answer by re-reading it from start to finish and has not been able to find a different alternative answer and it can be concluded that the third ability The learning style in stating arguments based on valid information is still relatively low. The results of this research are in line with Behrooznia, Hashemi, and Mahjoobi (Hashemi et al., 2014) revealed that there is a positive correlation between critical thinking skills and argumentation skills, and involving students with tasks that require argumentation skills can improve critical thinking skills significantly. Cahyono, dkk (Cahyono, Kartono, et al., 2021) states that personality type has a significant impact on critical thinking skills and the ability of prospective mathematics teachers to express valid arguments for the answers to the description questions given is still classified as low criteria.

Skill in expressing arguments for statements expressed by prospective teachers through reasons based on data or facts is one indicator that needs to be considered in efforts to improve critical thinking skills. Based on the research results, there is a need for learning innovation that is based on problems and is able to improve critical thinking skills by taking into account the development of prospective teachers' skills in expressing valid arguments. According to the opinion of several experts, one of the important indicators that can be used to assess critical thinking skills is a person's skills in making valid arguments (Cahyono, Kartono, et al., 2021; Ennis, 2011; Facione, 2011; Perkins, C., & Murphy, 2006). Several educators agree with the opinion that the ability to compose and convey arguments makes a major contribution to the development of students' critical thinking abilities (Lazarou et al., 2017; Rayner & Papakonstantinou, 2018). Another view explains that the purpose of critical thinking is to provide reasons through valid arguments that are directed at solving problems, making decisions, formulating conclusions, and identifying problems. (Evens et al., 2014).

CONCLUSIONS

The study indicates that learning style is a key factor differentiating the critical thinking abilities of UPGRIS Semarang prospective mathematics teachers in solving group theory problems. Visual learners showed relatively higher performance, particularly in the Focus, Reason, and Inference indicators, corresponding to Dewey's Explore Information and Diagnose/Define Problem steps. Across all learning styles, students struggled in the Clarity and Overview indicators, as they were unable to justify answers with valid data or arguments and relied primarily on re-reading, reflecting limited engagement in Dewey's Test Consequences step. These findings highlight the need for problem-based learning innovations that explicitly develop argumentation skills to enhance overall critical thinking and effective problem-solving.

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