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When Students Encounter PISA Questions: From the Perspective of 4C Skills

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ABSTRACT

PISA is a prestigious platform for assessing students' learning achievements globally, including 4C skills: creative thinking, critical thinking, communication, and collaboration. However, the 2022 PISA results once again showed disappointing achievements for Indonesia. Indonesian students struggle with solving complex problems (critical thinking), have difficulty conveying ideas effectively (communication), are less prepared for creative challenges (creative thinking), and lack effective collaborative learning approaches. This research aimed to analyze the 4C skills of students at SMP Negeri 31 Medan. The study involved 29 students from class IX-3. Data were collected using two selected essay questions from the 2022 PISA mathematics test, specifically designed to assess 4C skills through indicators like interpreting, formulating, and reasoning. Collaboration was assessed through semi-structured interviews with the class teacher to gain insights into students' interaction and teamwork skills, complementing the written test results. Qualitative descriptive analysis was used to interpret students' written responses, while collaboration data were analyzed based on teacher observations. Assessment criteria followed established indicators for critical thinking (Employ and Evaluate), creativity (formulate), communication (interpret), and collaboration (effective teamwork). The results indicate that 69.56% of students correctly answered interpretation questions (communication, level 3), 39.13% and 43.47% answered employability questions correctly (critical thinking, levels 2 and 1a), and 30.43% correctly answered formulation questions (creativity, level 2). However, teacher observations revealed that students still struggle with effective collaboration, reflecting a broader challenge in fostering teamwork and peer learning. Overall, although communication skills are relatively strong, significant improvements are needed in critical thinking, creativity, and collaboration.

Keywords: PISA, 4C, Mathematics

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Introduction

In the era of globalization and digitalization, the world of education is undergoing significant transformation that demands the development of 21st-century skills (Amrianto et al., 2024). The skills that students must possess to face these developments are the 4C skills (Asrizal et al., 2024). Students need to be instilled with four competencies that can support them in facing the challenges of the 21st century, as directly stated by the Directorate General of Teachers and Educational Personnel (GTK, 2019). The 4C skills are: Critical Thinking, Creativity, Communication, and Collaboration (Azmi et al., 2024; Sipayung et al., 2018).

The 4C skills (creativity, communication, critical thinking, and collaboration) are essential for equipping students with the competencies required to thrive in the 21st century. These skills are widely recognized as critical for addressing the complex challenges of the modern world and for fostering innovation, adaptability, and effective teamwork in various contexts (NEA, 2019; Trilling & Fadel, 2009). These 4C skills are interconnected with one another. Critical thinking skills help students to view situations and conditions critically, creativity helps students face various challenges that have not yet been encountered, collaboration allows students to engage in collaboration and networking, and communication helps students convey their ideas effectively both orally and in writing (National Council of Teachers of Mathematics, 2015; Partnership for 21 st Century Skills, 2015; Sugiman et al., 2023). The ability of Critical Thinking is a fundamental skill inproblem-solving (Fitriani et al., 2022). This ability is very important for students to possess in order to solve problems and address issues appropriately. Critical thinking skills are very important in mathematics learning (Nahdi, 2019). This ability requires students to think rationally, reflectively, and systematically. In critical thinking, students are required to evaluate, interpret, and analyze, assess information, arguments, observations, and be able to draw conclusions as well as recheck every answer or solution.

Creativity defined as the ability to generate novel ideas, concepts, or innovative solutions by creating, altering, combining, or utilizing existing elements to solve problems (Harahap & Nurlaelah, 2023; Mariati Purnama Simanjuntak, Nurdin Bukit, Yenni Dwi Aprilita Sagala, 2019; E. Y. Putri & Suripah, 2022), plays a crucial role in the development of higher-order thinking and adaptive problem-solving skills (Sawyer & Henriksen, 2016). Effective communication, encompassing the ability to express mathematical ideas clearly both orally and in writing, is essential for constructing logical arguments and engaging in meaningful academic discourse (Faizah & Sugandi, 2022; Lubis et al., 2023; Hanipah & Sumartini, 2021). This skill not only facilitates knowledge exchange but also enhances critical thinking by encouraging precise articulation and structured reasoning (Zwiers & Crawford, 2011). Collaboration, the capacity to work flexibly, fairly, and effectively with others to achieve shared goals, is increasingly important in both academic and professional contexts, where teamwork and collective problem-solving are highly valued (Manurung, 2023; Putri et al., 2024; NEA, 2019). As global economies become more interconnected, the ability to collaborate effectively has emerged as a critical component of student success (Rahayu et al., 2024).

Given the importance of these skills, understanding how well students perform in these areas, as reflected in international assessments like PISA, is essential for guiding educational improvements and aligning national educational outcomes with global standards. This study aims to assess Indonesian

students' performance in the 4C skills, particularly within the context of mathematical problem-solving, as a basis for enhancing educational practices in Indonesian schools.

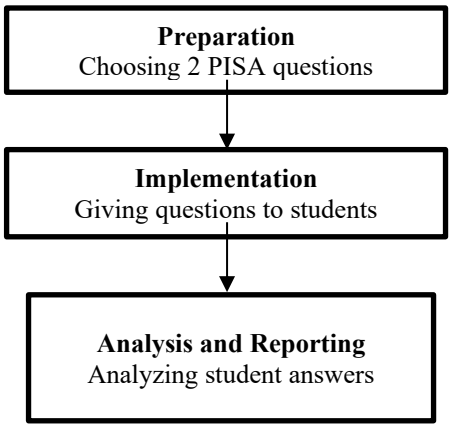
The gap in this research is a research gap where previous studies focused on the national PISA results for Indonesia, not specifically on a particular school. Previous research results show that Indonesian students consistently perform at a lower level compared to their peers in countries like Singapore or Finland in areas assessed by PISA, particularly in problem-solving, creativity, and collaboration (OECD, 2024). Subsequent research by Jatmiko found that Indonesian students' critical thinking skills often fall below the expected level, particularly in secondary education (Rizki Nur Fadillah et al., 2023). The next study is by Amaliah and Indriyani, which shows that although communication skills have developed, critical thinking and creativity skills require significant improvement at various levels of education in Indonesia (Mulyani, 2022). These three results provide an overview of the low 4C skills of Indonesian students. The novelty of this research lies in the specific context being studied, which focuses on SMP Negeri 31 Medan with a targeted population of class IX-3. The next novelty is that the questions used are based on the actual PISA framework from the OECD website (OECD, 2023). Thus, this research has a direct correlation with international standards that allow for relevant and representative comparisons. This research also breaks down the 4C skills into specific indicators based on actual test answers, providing a more detailed understanding of where students excel and where they struggle. This research also breaks down the 4C skills into specific indicators based on actual test answers, providing a more detailed understanding of where students excel and where they struggle.

Given the critical role of 4C skills in daily learning and problem-solving, understanding the current level of these skills is essential for guiding further training and development (Nurhayati et al., 2025; Zakaria et al., 2025). However, current observations and preliminary findings indicate that these skills are still at a low level, as evidenced by the 2022 PISA results, which showed a significant decline in Indonesia's mathematics proficiency. This study, therefore, aims to analyze the 4C skills of junior high school students in solving problems related to number patterns, as a first step toward understanding the areas where further development is needed.

Methods

The approach used in this research is a qualitative approach with a descriptive research type. The design of this research is a case study with the research subjects being 29 students from class IX–3. A case study was chosen in this research with the aim of obtaining factual information based on the issue

of low student achievement in Mathematics according to the 2022 PISA results. The research procedure carried out consists of a preparation stage, which involves searching for PISA 2022 questions. From the 80 PISA 2022 Mathematics questions, 2 questions were selected that are considered representative in measuring 4C skills. The procedure for conducting the research can be explained through the following image:



The selected questions are question number 1a with the ability to interpret or evaluate, question number 1b and 2a with the ability to employ, question number 2b with the ability to formulate, and question number 2c with the ability to reason. Interpret is one of the indicators of communication skills. Employ and evaluate are indicators of critical thinking. Formulate is one of the indicators of creativity (OECD, 2023). The implementation stage is carried out by providing 2 selected essay questions from the PISA questions to measure these three skills. However, to assess students' collaboration skills, this study also conducted interviews with the classroom teachers. The interviews focused on understanding how students interact, cooperate, and contribute to group problem-solving tasks during daily learning activities. This approach ensures that all 4C skills are covered, aligning the research instruments with the study objectives (Griffin et al., 2006; Rahayu et al., 2024). The data analysis and reporting stage involves evaluating students' written responses for critical thinking, communication, and creativity, while the interview data is used to assess collaboration skills. The data analysis technique used is qualitative analysis to provide a narrative description of students' work results and their collaborative behaviors as observed by their teachers.

Table 1. *Test Question Indicators*

Unit Name	Content Area	Proses	Proficiency Level
Solar System	Quantity	Interpret or evaluate	3
Solar System	Quantity	Employ	2
Triangular Pattern	Quantity	Employ	1a
Triangular Pattern	Change and Relationships	Formulate	2
Triangular Pattern	Change and Relationships	Reason	5

Results and Discussion

The subjects of this research represent 3 categories of 4C abilities, namely High Ability (HA), Medium Ability (MA), and Low Ability (LA). The data from written tests and interviews were analyzed by considering the 4C indicators. The 4C skills of Fachmi measured by the researcher are as follows (Fachmi et al., 2022).

Table 2. *4C Skills Indicators*

	4C Skills Indicators
Mathematical Critical Thinking	Using inductive and deductive reasoning. Analyzing the interconnections of each part of the whole to produce a comprehensive output in a complex system. Analyzing and evaluating facts. Drawing conclusions based on the analysis results. Solving unusual problems in both conventional and innovative ways
Creative Mathematical Thinking	Creating new ideas Analyzing the interconnections of each part of the whole to produce a comprehensive output in a complex system. Analyzing and evaluating facts
Mathematical communication	Expressing ideas/thoughts through speech and writing Using communication to share goals Analyzing and evaluating facts
Mathematical collaboration	Demonstrating the ability to work effectively in a group. Accepting the division of responsibilities and contributing to completing group tasks. Providing feedback and suggestions while showing mutual respect among friends.

The indicators presented in the table above cover the full spectrum of 4C skills: critical thinking, creativity, communication, and collaboration. However, it should be noted that, unlike the other three skills, mathematical collaboration is not directly measured through written tests or problem-solving questions in this study. Instead, it is assessed through interviews with classroom teachers. This approach was chosen to capture a more comprehensive understanding of students' collaboration skills, which often involve complex interpersonal dynamics, shared responsibilities, and group interactions that are difficult to measure through standardized tests alone (Griffin et al., 2006; Kum Yoke et al., 2024). The interview questions focused on how students interact, cooperate, and contribute to group problem-solving tasks

during daily learning activities, providing a richer, context-specific assessment of their collaborative abilities.

Question 1a, students are given a question to determine the three planets that have the average distance from the sun in astronomical units (au) according to the displayed model. From the seven planets, namely Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune Which planet is included in the model? The results of Subject HA's work can be seen in Figure 1.

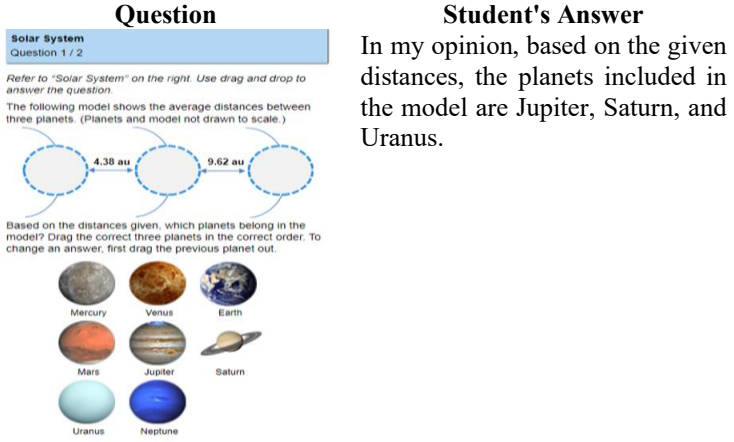


Figure 2. *Students' outcomes in Interpret (Communication).*

The result of Subject HA's completion, the student was able to solve the problem with the correct and precise answer. The three planets included in the model are Jupiter, Saturn, and Uranus. In solving this problem, the students have been able to analyze well and plan the solution accurately, as well as draw conclusions and solve the problem in an innovative way.

Question 1b, students are asked to determine how many million kilometers the distance from the planet Neptune to the Sun. The student's work below demonstrates their ability to solve problems correctly and accurately. In the solution, the student expressed their opinion without deviating from the existing facts. The students are already able to reason, analyze each part, and use the existing facts to solve problems. In this question, the student has been able to apply their 4C skills to analyze, create ideas, evaluate existing facts, and use their communication skills to solve problems. The results of the HA subject's work can be seen in Figure 2.

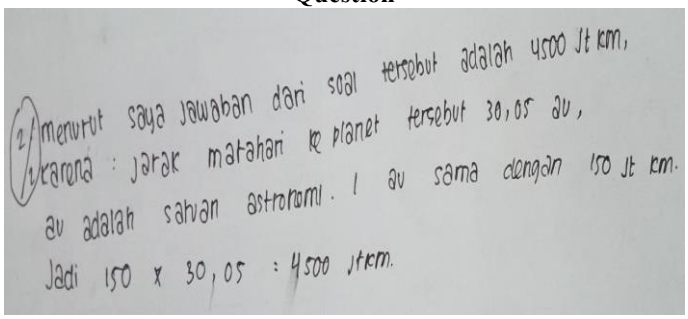
Question	Student's Answer
	In my opinion, the answer to that question is 4500 million kilometers because the distance from the sun to that planet is 30.05 AU. AU is an astronomical unit.1 au is equal to 150 million kilometers.So, 150 x 30.05 = 4500 million kilometers.

Figure 3. *Students' outcomes in Employ (Critical Thinking).*

Question 2a, in this question, students are given the task of determining what percentage of the blue triangles are in Alex's pattern? The work results of Subject HA can be seen in Figure 3.

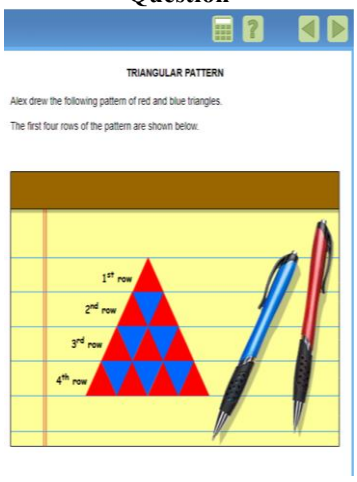
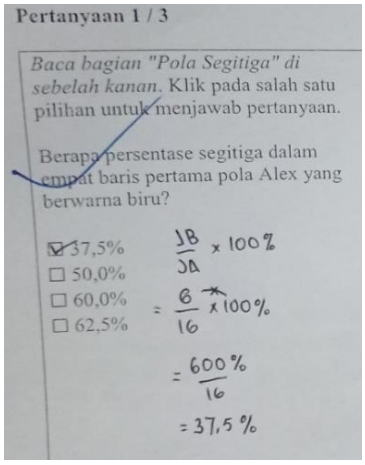
Question	Student's Answer
	

Figure 4. *Students' outcomes in Employ (Critical Thinking).*

The results of the student's work above were completed correctly and accurately. The student completed it with reasoning, planning, and precise analysis. This can be seen from the way the students solve the problem, namely from the pattern where, if observed, there are 6 blue triangles and the total number of triangles is 16. Therefore, to determine the percentage, the students multiply using the formula: the number of blue triangles divided by the total number of triangles in the pattern multiplied by 100%, resulting in a percentage of blue triangles of 37.5%. In this question, the students have applied the 4C skills very well.

Question 2b, students are given the task of determining the percentage of blue triangles in the pattern in the fifth row? The work results of the student subject HA can be seen in Figure 4.

Question **Student's Answer**

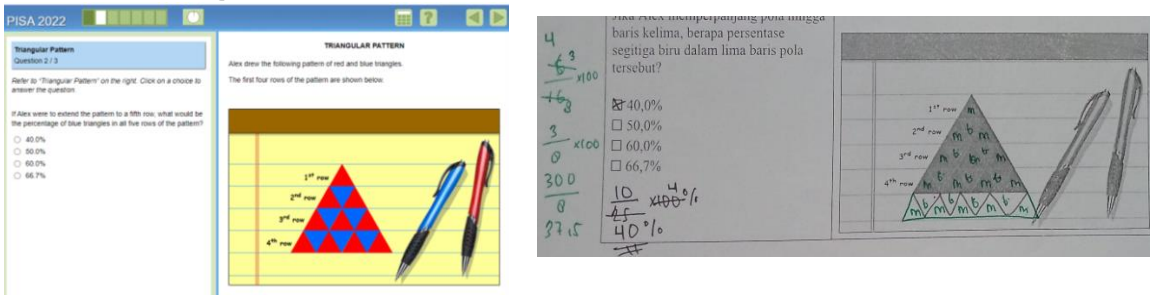
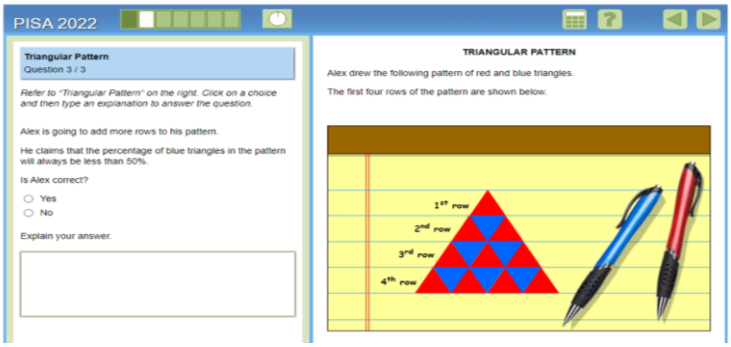


Figure 5. *Students' Outcomes in Formulate (Creativity).*

The student's answers above were done correctly and accurately. In their solution, the student was able to think critically and creatively, where if we look at the provided pattern, it only goes up to the fourth row, whereas the question asks for the percentage of blue triangles in the fifth row. In this question, the students were able to describe and extend the pattern, utilize the existing facts, and create new ideas to solve the problem. Therefore, if observed, the students added one more row as the fifth row, resulting in a total of 10 blue triangles in the pattern, and a total of 25 triangles overall. Thus, the percentage of blue triangles in the fifth row is 40.0%, which can be calculated using the formula: the number of blue triangles divided by the total number of triangles in the pattern multiplied by 100%.

Question 2c, Alex added more rows to the pattern. Alex claims that the percentage of blue triangles in the pattern will always be less than 50%. Is Alex correct? In this question, students are directed to analyze and evaluate a pattern and provide their opinion on whether Alex's statement is wrong or correct. The work results of student Subject HA can be seen in Figure 5.

Question **Student's Answer**



Yes. Because the blue column appears a bit.

Figure 6. *Students' outcomes in Reason (Critical Thinking).*

The student's solution results in stating that Alex's statement is correct. The student stated that yes, with the reason that the blue column will always appear a little. The student's answer is correct and accurate. The student answered by analyzing and evaluating, as well as reasoning from previous patterns, so that if observed, the blue triangle will appear slightly in each row compared to the red triangle. This happens because the pattern used is extended downward.

Subject MA on 4C Ability from the 5 questions given, shows that students do not demonstrate moderate 4C ability. In the average analysis results, students have answered correctly, but the common mistake is that students check the correct answer option without providing the solution. Therefore, based on the students' work results, they are classified or categorized under Subject LA, not Subject MA. The reason is that the students do not demonstrate the 4C skills, namely critical thinking, creative thinking, communication, and collaboration.

Subject LA on 4C skills from the 5 questions given, shows that 1) the student chose the correct answer option but did not provide a solution; 2) provided an answer and solution but was incorrect; and 3) did not answer at all. Question 1a and 1b some students did not answer at all. Question 1b and 2c, The student answered the question by choosing an option but was incorrect and provided an incorrect solution. From the solution, the student still does not understand how to determine the percentage from the given pattern. Students are still unable to reason, analyze, evaluate, relate to facts, and find solutions, as well as their written communication skills, which are still very lacking.

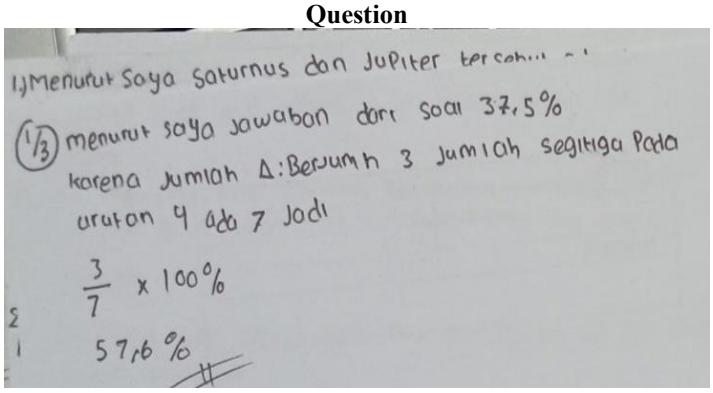
Question	Student's Answer
	In my opinion, the answer to question 37.5% is because the number of Δ is 3. The number of triangles in the 4th sequence is 7. So $\frac{3}{7}x100\% = 57{,}6\%$".

Figure 7. *Example of an Incorrect Answer*

Based on the above description, it is known that high-ability students can solve problems accurately and correctly. The ability to solve problems accurately and correctly can be achieved by reading the questions, paying attention to the images, and understanding the problems in detail. In addition, they possess good thinking skills, a strong understanding of concepts, and high motivation. Students with high abilities can reason, analyze the interconnections of each part of the whole to produce comprehensive outputs in a complex system, use appropriate communication, good cooperation, and are able to draw accurate and correct conclusions. Students with moderate abilities, based on observations, understand the problem but are lacking in writing or explaining their ideas or concepts. However, in this study, such a thing was not found. Low-ability students cannot understand the problem correctly, so the answers they provide are wrong and inaccurate. This often happens because students do not read the questions thoroughly, do not analyze the problems, and cannot plan the problems. Other

contributing factors include experiencing learning difficulties, attitudes (like/dislike), attention, laziness, and lack of motivation, which significantly affect students' low ability to solve math problems (Saputri, 2019).

The findings of this study indicate that students with moderate and low abilities are more prevalent than high-ability students in class IX-3 at SMP Negeri 31 Medan. This observation is significant as it suggests that a considerable number of students struggle with understanding problems correctly and reading questions carefully. These challenges are compounded by low motivation and interest in learning, which are critical factors influencing student performance (D. A. H. Putri & Usmeldi, 2023). This result aligns with the broader context of the PISA 2022 achievement data, which emphasizes that many students worldwide face similar difficulties in demonstrating high-level skills. The OECD has consistently highlighted the importance of developing critical thinking, communication, collaboration, and creativity (4C skills) as essential competencies for students in the 21st century (OECD, 2023). However, studies have shown that factors such as motivation, learning interest, and effective teaching strategies significantly impact the development of 4C skills. For example, research by (Amrianto et al., 2024) found that students' motivation and engagement in learning activities positively correlated with their critical thinking and communication skills. Similarly, (Asrizal et al., 2024) emphasized the importance of contextual and interactive learning approaches in enhancing students' 4C competencies. Moreover, collaborative learning strategies have been found to be particularly effective in improving these skills, as demonstrated by (Nahar et al., 2022), who reported significant improvements in collaboration and communication abilities through group-based projects. These findings underscore the importance of integrating 4C skills into regular classroom instruction and creating learning environments that actively engage students. This approach not only supports the development of critical and creative thinking but also fosters communication and collaboration, which are essential for students' future success (Azmi et al., 2024; Ponnusamy & Raman, 2024).

In interpreting these results, it is important to consider the implications of the medium and low 4C abilities of the students. The lack of understanding and careful reading of questions may indicate gaps in foundational knowledge or ineffective teaching strategies that fail to engage students meaningfully. Previous studies have shown that motivation and interest are closely linked to academic achievement (Dunn & Zimmer, 2020). Therefore, enhancing these aspects could lead to improved performance and a better grasp of 4C skills, as suggested by the OECD's recommendations for Indonesian students.

Moreover, this research contributes to the existing literature by highlighting the specific context of SMP Negeri 31 Medan, revealing that while students' collaboration skills are in the developing stage, the emphasis on individual problem-solving may hinder the full realization of collaborative learning.

This finding is consistent with other studies that suggest collaborative learning environments foster deeper understanding and engagement (Johnson & Johnson, 2014; Nahar et al., 2022). However, the current reliance on individual assessments may not adequately reflect students' collaborative competencies, which warrants further investigation.

This research focuses on evaluating students' 4C skills based on the PISA questions, which are designed to assess critical thinking, creativity, and communication abilities. However, the assessment of students' collaboration skills was not directly measured through the PISA questions, as they were administered individually. Instead, teachers' perspectives were used to assess students' collaboration skills during the problem-solving process. The interviews with teachers were conducted specifically in the context of their observations as students worked on the PISA tasks, allowing for a deeper understanding of the collaborative behaviors that occurred during these activities. While this approach offers valuable insights into how students interact and collaborate in a classroom setting, future research should consider incorporating more direct methods for assessing collaboration alongside individual problem-solving tasks to provide a more holistic view of 4C skills in student competence.

Students with moderate and low abilities are still found in this study with a larger proportion compared to high-ability students. In this analysis, students with low and moderate abilities still do not understand the problems correctly, do not read the questions carefully, and several other factors such as motivation and interest in learning are still lacking. This result, taking the case of class IX-3 at SMP Negeri 31 Medan, shows a consistent outcome with the PISA 2022 achievement. This ability must be nurtured and fully directed by educators to achieve high-level skills in accordance with OECD recommendations for Indonesian students. This ability can be improved over time through the learning process, by extensively discussing 4C skills and enhancing motivation and interest in learning, which can help improve this ability (Ye & Xu, 2023).

The PISA questions used are questions to assess students' critical thinking, creativity, communication, and collaboration skills. Because PISA questions are given individually, collaboration skills are not directly evaluated through the provided questions. Instead, teacher observations are used to assess how students collaborate during the group discussion process in solving a PISA problem. This approach aligns with the study's objective to review 4C skills, where collaboration abilities use different assessment methods to obtain information related to group dynamics and interpersonal interactions. This method provides a comprehensive perspective on the 4C skills of students at SMP 31 Medan. The aspects of this study can be further strengthened by using more direct collaboration steps in future research. However, the current approach shows results related to students' collaborative behavior in the classroom.

Conclusion

This study aimed to assess the 4C skills (critical thinking, creativity, communication, and collaboration) of students in class IX-3 at SMP Negeri 31 Medan through PISA-based questions. The findings reveal a significant disparity in students' abilities, with the majority demonstrating moderate to low levels of 4C competencies, while only a small portion exhibited high-level skills. Students in the high-ability category were able to interpret problems accurately, provide correct solutions, and effectively communicate their reasoning. These students demonstrated a strong understanding of mathematical concepts, critical thinking, and analytical skills, aligning well with the 4C skill framework. They could integrate multiple pieces of information and generate comprehensive outputs in complex problem situations, reflecting their higher-order thinking abilities. In contrast, students with moderate abilities often struggled to articulate their ideas clearly, despite having a basic understanding of the problems. While these students sometimes chose the correct answer, they frequently failed to provide complete or accurate explanations, indicating gaps in critical thinking and communication. Low-ability students exhibited significant challenges in understanding problems correctly, leading to incorrect and incomplete responses. This group often lacked the ability to plan, reason, and analyze mathematical relationships, resulting in frequent errors and missed solutions. Factors contributing to this include low motivation, poor reading comprehension, and minimal interest in learning, which have been identified as key barriers to academic success. While this study primarily assessed individual 4C skills through PISA questions, collaboration skills were evaluated through teacher interviews. The findings suggest that students generally struggle with collaborative learning, as evidenced by their limited participation in group tasks and reliance on individual effort. This highlights the need for more structured collaborative learning opportunities in the classroom to foster teamwork and collective problem-solving.

These findings underscore the importance of strengthening students' 4C skills through targeted interventions, including the use of more engaging instructional strategies, clearer problem explanations, and increased emphasis on collaborative learning. Future studies should consider incorporating direct assessments of collaboration alongside individual tasks to provide a more comprehensive evaluation of students' overall competencies. Overall, this research highlights the critical need for educational reforms that prioritize 4C skills, aligning with global standards such as those emphasized by the OECD, to better prepare students for the complex challenges of the 21st century.

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