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Elementary School Students' Mathematical Literacy: A Descriptive Study Based on Cognitive Style in Central Maluku

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Abstract

This study aims to analyze the mathematical literacy skills of elementary school students in terms of reflective and impulsive cognitive styles. Mathematical literacy plays a crucial role in helping students understand and apply mathematical concepts in various life situations; however, elementary school students' achievement in this area remains low. This study employed a descriptive qualitative approach involving 120 students from four elementary schools in Central Maluku Regency, selected through purposive sampling. The research instruments included the Matching Familiar Figures Test (MFFT) to identify cognitive styles, a mathematical literacy test, and interview guide. Data were analyzed interactively through the stages of reduction, presentation, and conclusion drawing. Data reduction was performed on interview transcripts and test answer sheets to identify problem solving strategies, while the literacy test was assessed using an analytical scoring rubric referring to mathematical literacy indicators. The results showed that out of 120 students, 49 students were identified as having a reflective cognitive style and 71 students as having an impulsive cognitive style. Reflevtive students obtained an average mathematical literacy score of 73,7 (SD = 4,6), while impulsive students obtained an average score of 58,1 (SD= 8,9). Qualitatively, reflective students demonstrated better abilities in answer accuracy, systematic reasoning, and the ability to explain the problem-solving process. In contrast, impulsive students tended to answer quickly but less accurately, with weak conceptual reasoning and difficulty in representing mathematical ideas. These findings highlight the importance of mathematics teaching strategies that differentiate based on students' cognitive styles to support optimal mathematical literacy development in elementary Schools.

Keywords: Mathematical literacy; Reflective cognitive style; Impulsive cognitive style; Mathematical problem-solving; Elementary school students

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INTRODUCTION

Literacy, in the context of 21st-century education, is no longer seen simply as the ability to read and write, but rather as a fundamental competency for reasoning and decision-making in real life (Organisation for Economic Co-operation and Development et al., 2023). In mathematics education, this competency manifest as mathematical literacy, which serves as the foundation for students to face the challenges of an increasingly complex, data-driven world (Stacey & Turner, 2015). Mathematics serves as a foundation and tool widely applied in various fields of science and other disciplines (Agyei et al., 2024). In an educational perspective, mathematics is a branch of science that studies the structure, form, pattern, and relationship resulting from the calculation and measurement process, which is essential for developing logical, critical, and systematic thinking skills in students (Niess, 2006). To realize this, NCTM (Niess, 2006) defines five standard competencies in mathematics learning, namely mathematical problem solving, mathematical communication, mathematical reasoning, mathematical connections, and mathematical representation. These five competencies integratively from mathematical literacy skills (Pulungan, 2014; Zahrah, 2024), making it a primary goal in the modern mathematics curriculum to equip students with reasoning skills and make effective decisions outside the classroom context.

Mathematical literacy was introduced by the OECD through PISA, which states that mathematical literacy is the ability to formulate, use, and interpret mathematics in real-world context problems, where mathematically literate students are able to recognize the role of mathematics in decision-making or problem-solving (Fukudan & Baba, 2021). Mathematical literacy emerges as preparation for students' futures through critical thinking, information analysis, and mathematical reasoning and is an important part of achieving success in various fields (Sitopu et al., 2024). According to Harisman et al. (2023), Mathematical literacy is the ability of students to understand mathematics and connect it to the real world, where this ability enables them to use mathematical information to make intelligent decisions that have a positive impact on life, work, and society. Mathematical literacy skills are important for students to master because they are able to develop mathematical reasoning through the use of mathematical concepts, procedures, facts, and tools to describe, predict, and explain an event (Kusumawardani, 2018; Syah et al., 2024). Genc and Erbas (in Praneswari et al., 2024) state that mathematical literacy in its application involves several mathematical competencies, such as problem-solving competencies and competencies in understanding and applying existing mathematical knowledge to face problems. Students with mathematical literacy skills will be able to apply mathematical concepts, procedures, facts, and tools to explain a phenomenon (Organisation for Economic Co-operation and Development, 2019). This indicates that if students have good mathematical literacy skills, they can apply mathematical concepts to solve problems encountered in everyday life (Chen & Chiu, 2016; Stacey, 2011).

Unfortunately, the high urgency of mathematical literacy is not aligned with the achievements of Indonesia students. According to the 2022 PISA study, Indonesia ranked 70th out of 81 countries with an average mathematical literacy of 472 (Organisation for Economic Co-operation and Development et al., 2023). This achievement indicates that Indonesian students' abilities in analyzing, reasoning, communicating, solving, and interpreting mathematical problems are still very weak (Masfufah & Afriansyah, 2021; Yanto & Rahaju, 2024). The persistently low achievement of Indonesian students in mathematical literacy can be traced to several interrelated factors that are manisfested in daily classroom learning practices. First, teachers face significant challenges in implementing literacy-based learning due to limited socialization and training related to mathematical literacy, a lack of teacher competence in designing literacy-oriented learning, and the limited availability of resources, books, and references on mathematical literacy (Astuti, F., Mulyatiningsih, E., Rosnawati, R., & Retnawati, 2025). Many teachers still do not understand how to develop learning experiences that encourage students' ability to apply mathematical concepts to real-world contexts and tend to rely more on routine procedural exercises (Saputra et al., 2024). Second, students' limited basic knowledge and learning experiences contribute significantly to their difficulties. Research reveals that many students are not yet fluent readers, lack a solid understanding of basic mathematical concepts, and have limited experience working with word problems or contextual problems (Leton et al., 2024). This limited exposure results in students having difficulty understanding problems, selecting appropriate mathematical concepts, and analyzing information presented in context-based questions (Udil et al., 2025). Students also experience epistemological barriers related to conceptual knowledge, such as a limited understanding of fundamental concepts like domain, range, and variable, which hinders their ability to solve problems equivalent to PISA standards (Elisya et al., 2024). The lack of varied learning experiences with word problems and limited practice in solving contextual problems further exacerbate these difficulties. Third, the implementation of literacy and numeracy programs in schools is still suboptimal. Studies show that indicators of school culture supporting literacy have not been implemented optimally, with 67,67% of respondents assessing that school-based literacy initiatives are still below expectations (Saputra et al., 2024). Furthermore, community-based support for literacy development shows very minimal implementation, with 78,54% of respondents indicating that external support systems are still inadequate (Saputra et al., 2024). The low mathematical literacy skills of Indonesian students are due to the under-optimization of their literacy skills.

Similar problems were also found at the research site. Based on initial observations, students viewed mathematics as a difficult and uninteresting subject, resulting in low learning motivation. Students were also unfamiliar with solving open-ended mathematical literacy problems, which require reasoning, logical thinking, and critical thinking. However, open-ended problems are known to foster originality of ideas, creativity, higher-order cognitive skills, and critical thinking (Sholeha et al., 2022). Furthermore, open-ended problems can develop students' mathematical reasoning skills (Ruslan & Santoso, 2013). Therefore, in mathematics learning, teachers need to optimize students' mathematical literacy skills by training them to analyze, interpret, and convey information from presented mathematical problems.

According to Rahayu et al. (2020), one of the factors that influence mathematical literacy is cognitive style. Borich and Tombari explain that cognitive style is the way a person processes and thinks about what they learn (Udiyono & Yuwono, 2018). Cognitive style is defined as an attitude, choice, or strategy to determine a person's unique way of receiving, remembering, thinking, and solving a problem. Cognitive style is referred to as a bridge between intelligence and personality (Ginting & Nasution, 2024). Cognitive styles can be grouped into two, namely reflective and impulsive cognitive styles (Kagan, 1965; Naryaningsih et al., 2022). Reflective and impulsive cognitive styles are cognitive styles that are distinguished by the level of speed or use of student time in thinking (Naryaningsih et al., 2022).

Several previous studies have shown that a reflective cognitive style tends to produce higher performance in mathematical problem solving than an impulsive cognitive style (Rozencwajg & Corroyer, 2005). Reflective students clearly have an edge in academic context, as evidenced by the fact that score much higher in mathematics than their impulsive classmates (Umaru, 2013). Previous research on reflective and impulsive cognitive styles in mathematical problem solving has been mostly conducted at the junior high or senior high school levels. Research at the elementary school level is still very limited, particularly in the context of elementary school students in eastern Indonesia (Central Maluku Regency), even though the cognitive characteristics of elementary school students differ significantly from those of higher levels. The cognitive development period of elementary school students is at the concrete operational stages, so their methods of processing information and solving mathematical literacy problems require specific study.

This research offers analytical novelties that distinguish it from previous studies. First, it more comprehensively integrates time and accuracy indicators from the Matching Familiar Figures Test (MFFT). This study simultaneously analyzes average response time (ATSP) and average number of errors (ANRSPS) as a continuous spectrum that reflects a more nuanced cognitive profile. Second, this study combines quantitative data from the MFFT with in-dept quantitative analysis of students' written work and interviews. This analytical integration is particularly important in the context of elementary school students in Central Maluku for several reasons. First, distinctive geographic and socio-cultural characteristics shape the concrete experiences available to students. Interviews allow researchers to understand how students' local knowledge and everyday experiences, such as fishing activities, inter island trade systems, or traditional games are activated in the formulation, use, dan interpretation of mathematical problems (Leton et al., 2025). Second, students at the concrete operational stage are not yet able to write down complete problem-solving strategies, so interviews are necessary to enable students to clearly explain their work steps. The combination of MFFT response time analysis, written work analysis, and in-depth interviews allows researchers to more accurately reconstruct the cognitive processes students experience when faced with mathematical literacy tasks.

This study not only confirm the performance differences between reflective and impulsive students, but also describes in detail the cognitive strategies and processes that differentiate the two groups in the context of mathematical literacy. Based on this description, the purposes of this study are to describe the mathematical literacy abilities of elementary school students with reflective and impulsive cognitive styles and to systematically compare the approaches used by the two groups of students in solving mathematical literacy problems. This research was conducted with fifth-grade elementary school. The topic used in this study was numbers and their operations in the context of literacy problem solving. This aligns with the focus of PISA mathematical literacy, which emphasizes the ability to apply mathematics in various real-life contexts.

METHOD

Research Approach

This study employed a mixed-methods approach with a sequential explanatory design. This design was chosen because the study began with the collection and analysis of quantitative data (MFFT and mathematical literacy tests), followed by the collection and analysis of qualitative data (interview and analysis of written work) to deepen, expand, and explain the quantitative findings. Creswell and Clark (2018) stated that the sequential explanatory design is very appropriate to use when researchers want to uses qualitative data to further explain the quantitative findings obtained. The approach used is a comparative descriptive study, namely comparing mathematical literacy skills between two groups of students who have different cognitive styles (reflective and impulsive) in four different elementary schools in Central Maluku Regency. Figure 1 presents the research design.

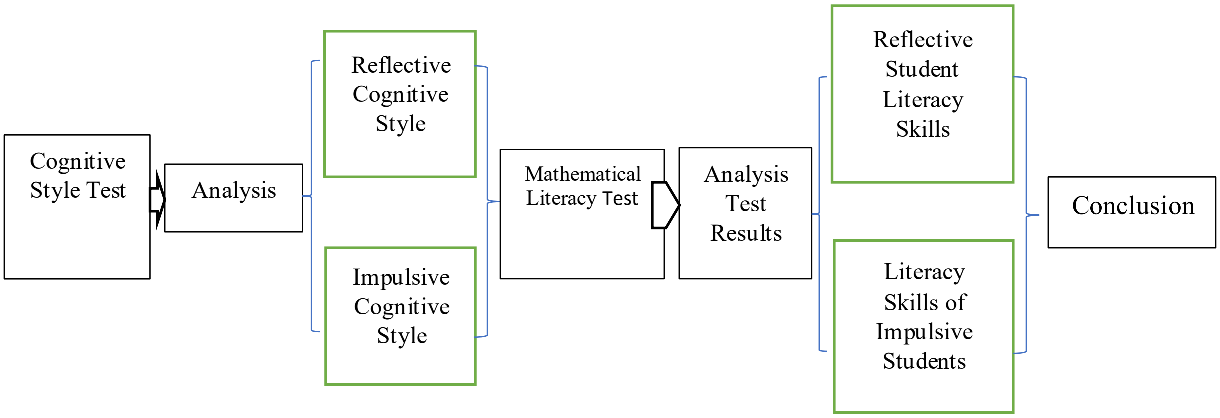


Figure 1. Research design

Research Subject

The study was conducted in four public elementary schools in Central Maluku Regency, Maluku Province: Public Elementary School 313, Public Elementary School 289, Public Elementary School, 197, and Public Elementary School 294. The selection of the four schools was based on the representation of variations in student characteristics in the Central Maluku Region. The population in this study was all elementary school students in Central Maluku Regency. A sample of 120 students was used across the four public elementary schools. The research sample consisted of 120 students spread across four schools. The sampling technique used was purposive sampling, with the criteria being that students had completed mathematics material relevan to the literacy test. For in-depth interviews, 16 representative students (2 reflective and 2 impulsive from each school) were selected based on their availability and willingness to be interviewed.

Instrument

The instruments used in this study include the Matching Familiar Test (MFFT), a mathematical literacy test, and a semi-structured interview guide. The MFFT instrument is used to indentify students' cognitive styles (reflective and impulsive). The MFFT, developed by Kagan and colleagues (Kagan et al., 1964), was used to identify students' cognitive styles into reflective and impulsive categories. The instrument consists of two practice items and twelve experimental items. In each item, students are shown a standard picture and six closely related variants. The students's task is to chooses one variant that reamians identical to the standard image. Researchers recorded two main indicators for each item, namelay response time and number of errors. Then students sere classified based on avergae student response time for all items (ATSP) and average number of errors or repetition of student attempts (ANRPS). Based on the citeria for reflective students having a response time above the median (slow) and the number of errors below the median. While for impulsive students having a response time below the median (fast) and the number of errors above the median. MFFT instructions were translated into Indonesian and simplified to be easily understood by elementary school students in Central Maluku regency. The MFFT instrument has been tested for validity and reliability through previous research (Rozencwajg, P., & Corroyer, 2005; Warli, 2013).

The mathematical literacy test consists of five open-ended essay questions developed by adapting the PISA 2022 framework. The questions were designed by considering the characteristics of elementary school students at the concrete operational stage and contextualized with the real-life situations of students in Central Maluku Regency. The context domains used include personal, job, social contexts. The test items measure three key cognitive processes of mathematical literacy according to the PISA standard: formulate, employ, and interpret (Organisation for Economic Co-operation & Development, 2013). The difficulty level of the items varies from level 1 to level 3 (Table 1), according to the PISA framework for primary school students.

Table 1. Summary of Question Difficulty Levels

Quetion Number	Context	Dominant Cognitive Process	Difficulty Level	PISA Level
1	Personal/Social	Formulation and Interpretation	Medium	Level 2
2	Job	Testing and Evaluation	Difficult	Level 3
3	Consumer	Formulation and Use	Easy	Level 1b
4	Job	Use	Easy	Level 1a
5	Personal	Formulation and use (inverse)	Medium	Level 2

The mathematical literacy test assessment rubric was developed analytically with a score range of 0 – 4 for each cognitive process (Table 2). The formulation aspect is assessed based on the ability to identify information and create mathematical models. The utilization aspect is assessed based on the accuracy of calculations and application of concepts. The interpretation aspect is assessed based on the ability to interpret results and draw conclusions. An example of a question in a mathematical literacy test is " an elevator is a type of vertical transportation, a method used to transport objects or people from the ground up or back down. Elevators move mechanically using electrical power. An elevator is designed woth a specific capacity, usually expresses as a capacity limit. The elevator's capacity limit is 550 kg. Five people, each weighing 380 kg, are already inside the elevator. Outside the elevator, Andi, rosa, and Joni are about to enter. If Andi weighs 95 kg, Rosa weighs 83 kg, and Joni weighs 45 kg. Which people can enter the elevator? (there can be more than one answer)". Instrument validation was conducted through expert judgment by two mathematics education experts and a pilot test was limited to 30 students outside the research sample.

Table 2. Mathematical Literacy Test Assessment Rubric

Cognitive Process	Score	Category	Description
Formulate	4	Excellent	Students are able to identify all relevant information in contextual problems and transform it into a mathematical model accurately and completely
	3	Good	Students are able to identify most of the relevant information and create mathematical models, but there are some minor inaccuracies or omissions
	2	Fair	Students are able to identify soma relevant information, but the mathematical model they create is imprecise or incomplete
	1	Poor	Students are unable to identify relevant information well and are unable to create mathematical models
	0	No Answer	The student did not provide any response or answer at all
Employ	4	Excellent	Students are able to apply mathematical concepts, carry out calculation procedures correctly, and use efficient strategies
	3	Good	Students are able to apply mathematical correctly but there are small errors in calculations or procedures
	2	Fair	Students are able to apply mathematical concepts but there are errors in calculations or the strategies used are not appropriate
	1	Poor	Students are unable to aplly mathematical concepts correctly and the strategies used are incorrect
	0	No Answer	The student did not provide any response or answer at all
Interpret	4	Excellent	Students are able to interpret mathematical results back into the context of real problems, draw appropriate conclusions, and evaluate the reasonableness of solutions
	3	Good	Students are able to interpret mathematical results into the context of the problem but are incomplete or do not carry aout an evaluation
	2	Fair	Students are able to interpret the results but they are not accurate or the conclusions drawn are not appropriate to the context
	1	Poor	Students are unable to interpret mathematical results into the context of the problem or the interpretation given is incorrect
	0	No Answer	The student did not provide any response or answer at all

The semi-structured interview guide serves to explore in depth the thinking processes, reasons, and strategies used by students in solving mathematical literacy problems. The interviews used a think-aloud technique, where students were asked to express their thoughts while solving the problem. The interview guide was validated through peer debriefing and a limited pilot test.

The research was conducted in three main stages in September-October 2024, namely identification of cognitive styles (MFFT), mathematical literacy test, interview. In the cognitive styles identification phase (MFFT), students were given the test in a quiet, conducive environment. Researchers explained the purposes and procedure for the MFFT in simple language. Two practice items were provided to ensure students understood the instructions. Twelve experimental items were administered sequentially. Researchers recorded first response time using a stopwatch and the number of errors for each item. The duration per student varied between 15 and 30 minutes, depending on their cognitive styles. In the mathematics literacy test phase, the test was administered as a class under the supervision of the researcher and the class teacher. Students were given a test sheet and an answer sheet. The researcher read the general instructions and ensured that all students understood them. Students were given 90 minutes to complete five description questions. During the test, students were allowed to ask questions if any instructions were unclear. In the interview phase, 16 representative students (2 reflective and 2 impulsive students per school) were selected for interview. Interview were conducted individually in a separate, quiet room. Interviews used a think-aloud technique and were recorded with the permission of the students and parents. Interviews lasted between 30 and 45 minutes per student. The atmosphere was relaxed and comfortable so students could express their thoughts freely.

Data Analysis

The research data that includes MFFT data and the mathematics literacy test was analyzed quantitatively, while the mathematics literacy test data in the form of cognitive processes, interview results and documentation of student work results were analyzed qualitatively. Qualitative analysis using the Miles and Huberman model, which is interactive through the flow of data reduction, data presentation, and conclusion drawing (Miles et al., 2014). The analysis process begins with data reduction through descriptive tests, organizing the data into tables and graphs, summarizing the interview results, and analyzing the patterns of test results in graphs. This study used a hybrid deductive-inductive coding approach. The deductive approach was applied by referring to the theoretical framework of PISA mathematical literacy, which encompasses three main cognitive processes: formulating, employing, and interpreting (Organisation for Economic Co-operation & Development, 2013). Before data analysis began, the researchers developed a codebook containing a list of codes, operational definitions, and examples of their application. This codebook was structured based on mathematical literacy indicators and cognitive styles characteristics and then refined throughtout the analysis process. Example, F-IDE code for the formulation-information identification category. Definition for this category: students identify and write down the information known and asked in the problem. Example, "given: the elevator capacity limit = 550 kg. Inside the elevator there are already 5 people with a total weight of 380 kg. Outside the elevator, Andi, Rosa and Joni will enter the elevator. Andi's weight is 95 kg, Rosa's weight is 83 kg and Joni's weight is 45 kg. Asked: people who can enter the elevator."

The coding process is carried out in several stages, including, open coding, axial coding, selective coding. Data integration was conducted using a weaving or integrating through narrative approach (Fetters et al., 2013), where data from both sources were combined in a narrative for each research subject. The integration procedure included, (1) creating an individual profil for each student interviewed that integrated quantitative data (MFFT scores, literacy test scores, work time), written work data (strategies, errors, completeness of answer), and interview data (explanations of thought processes); (2) cross-case analysis to identify consistent patterns within the reflective and impulsive student groups; (3) integration matrix to combine findings from both data sources.

The research procedure was carried out by paying attention to the ethical principles of reasearch involving humans, especially children as research subjects. The researchers obtained research permission from the principals of the four elementary schools participating in the study. All parents/guardians provided informed consent after receiving a full explanation of the research's purpose, procedures, and credential assurance. Furthermore, consent was obtained directly from the children using language and procedures appropriate to their level of understanding. Participation was voluntary, and students could withdraw at any time without consequence. To ensure the credibility of the research findings, several qualitative triangulation and validation techniques were used (Lincoln & Guba, 1985), including source triangulation, technique triangulation, member checking, peer debriefing.

RESULTS AND DISCUSSION

Descriptive of Students' Cognitive Styles

Mathematical literacy is a crucial skill that can help students understand and use mathematics in various life contexts. Mathematical literacy needs to be supported by students' cognitive styles in mathematics learning. Cognitive styles refer to how students process information, understand problems, and solve them accurately. The aim of this study is to analyze elementary school students' mathematical literacy skills in terms of their cognitive styles.

This study involved four elementary schools in Central Maluku Regency, Maluku Province. The study began with the Matching Familiar Figure Test (MFFT) to identify students' cognitive styles, including reflective and impulsive cognitive styles. Students were then given a literacy test to determine their mathematical literacy skills based on their cognitive styles. Table 3 presents the results of the reflective and impulsive cognitive style tests for students in four schools in Central Maluku Regency, Maluku Province.

Table 3. Results of the Matching Familiar Figure Test (MFFT)

School Name	N	Reflective	%	Impulsive	%
Public Elementary School 313	28	14	50,0	14	50,0
Public Elementary School 289	35	20	57,1	15	42,9
Public Elementary School 197	33	11	33,3	22	66,7
Public Elementary School 294	24	4	16,7	20	83,3
Total	**120**	**49**	**40,8**	**71**	**59,2**

Table 3 shows that of the 120 students, 49 (40,8%) had a reflective cognitive style and 71 (59,2%) had an impulsive cognitive style. This composition varied across schools, public elementary school 313 has 28 students, with 14 (50%) students having a reflective cognitive style and 14 (50%) impulsive. For public elementary school 289, 20 (57%) students have a reflective cognitive style, while 15 (42,9%) students have an impulsive cognitive style. In public elementary school 197, 11 (33,3%) students have a reflective cognitive style, and 22 (66,7%) students have an impulsive cognitive style. In public elementary school 294, the impulsive cognitive style is more dominant than the reflective style; 4 (16,7%) students have a reflective style, while 20 (83,3%) students have an impulsive cognitive style.

Mathematical Literacy Test Performance Based on Cognitive Style

After identifiying cognitive styles, students were given a mathematical literacy test consisting of 5 decriptive questions. Table 4 presents descriptive statistics of mathematical literacy test performance based on cognitive styles per school.

Table 4. Results of the Mathematical Literacy Test Based on Cognitive Style per School

School Name	Cognitive Style	N	Mean	SD	Min	Max
Public Elementary School 313	reflective	14	70,0	4,2	62	78
	impulsive	14	67,5	5,1	58	75
Public Elementary School 289	reflective	20	75,5	3,8	68	82
	impulsive	15	55,0	6,3	45	65
Public Elementary School 197	reflective	11	72,5	4,5	65	80
	impulsive	22	60,0	5,9	50	70
Public Elementary School 294	reflective	4	80,0	2,9	77	84
	impulsive	20	50,0	7,2	38	62

Table 4 shows that consistently across all schools, students with a reflective cognitive style achieved higher avarege math literacy scores than impulsive students. The variability in scores (SD) in the impulsive group tended to be greater, indicating a wider distribution of abilities than in the relatively homogeneous reflective group.

Table 5. Summary of Mathematical Literacy Test Based on Cognitive Style

Cognitive Style	N	Mean	SD	Min	Max
Reflective	49	73,7	4,6	62	84
Impulsive	71	58,1	8,9	38	75
Total	120	64,5	10,5	38	84

Table 5 shows that, overall, reflective students achieved an average of 73,7, SD = 4,6 while impulsive students achieved an average of 58,1, SD = 8,9 with a difference of 15,6 points.

ANRPS and ATSP Students' Cognitive Styles

Figure 2 presents the results of the student test, analyzed from the average number of repetitions of problem solving (ANRPS) of students completing the problem until they get a solution to the correct answer and the average time/speed of solving the problem (ATSP).

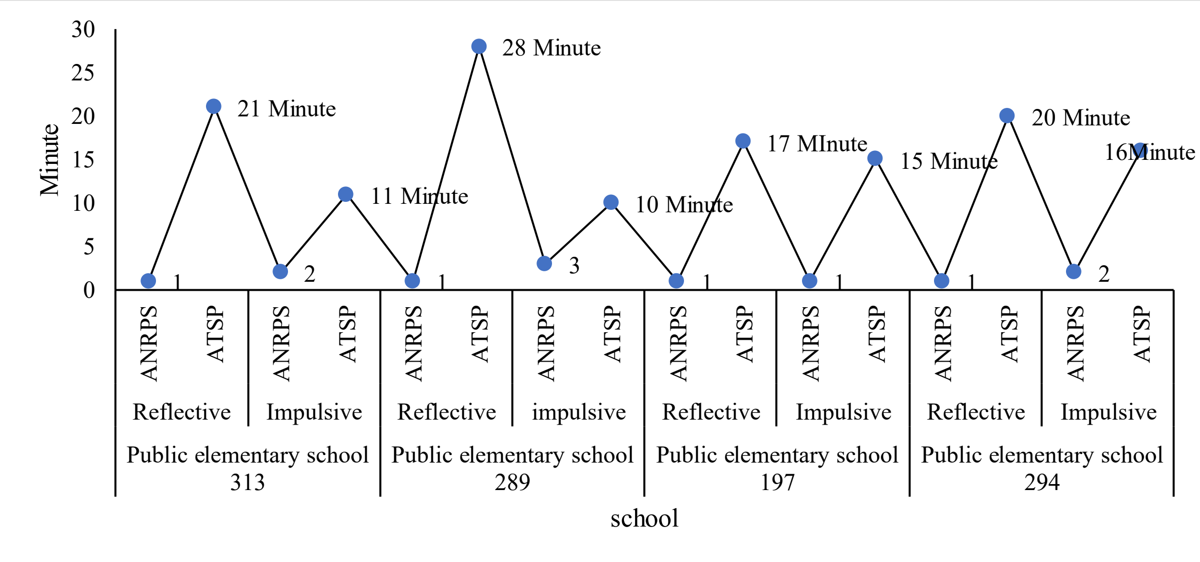


Figure 2. ANRPS and ATSP students' cognitive styles

Based on the results in Figure 2, it can be seen that in Public Elementary Schools, 313 students with reflective learning styles had ANRPS once with ATSP for 21 minutes and impulsive students had ANRPS twice with ATSP for 11 minutes. For reflective cognitive styles in Public Elementary Schools, 289 ANRPS were conducted once with ATSP for 28 minutes, while impulsive style students had ANRPS three times with ATSP for 10 minutes. It was also identified that in Public Elementary Schools, 197 reflective students had ANRPS once with ATPS for 17 minutes and impulsive students had ANRPS once with ATPS for 15 minutes. Furthermore, in Public Elementary Schools, 294 reflective students had ANRPS once with ATPS for 20 minutes while impulsive students had ANRPS twice with ATPS for 16 minutes. Repetitions are calculated based on indicators such as, crossing out, rechecking signs such as circles, ticks, or small notes.

These results indicate that students with a reflective cognitive style have better mathematical literacy skills than impulsive students. However, impulsive students are faster in solving problems than reflective students. Although impulsive students have faster ANRPS than reflective students, the results achieved are not optimal. Students with a reflective learning style tend to think more deeply and carefully before providing answers. Reflective students spend more time analyzing information from questions, considering various options, and analyzing the accuracy of what is done. In contrast, students with an impulsive learning style tend to use time quickly and provide answers without much consideration. Impulsive students prioritize speed in solving problems given and often act based on what they think, in this case being less thorough in solving mathematical literacy problems.

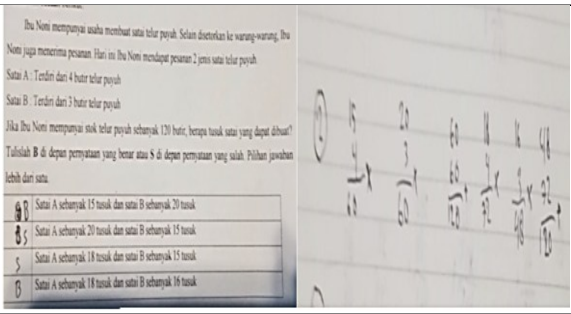
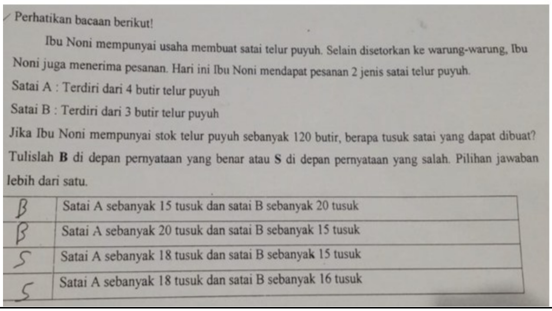
Analysis of The Results of Mathematical Literacy Skills Reviewed from The Perspective of Cognitive Style

The results and analysis of the results of mathematical literacy skills work reviewed from the perspective of reflective and impulsive cognitive styles are presented in the following Tables 6-8. In the tables, RS_1, IS_1, RS_2, IS_2, RS_3, IS_3 were selected using the typical case sampling technique, namely students who have the most representative characteristics of their cognitive style group with ATSP/ANRPS criteria according to the group median, scores close to the average, and completeness of answer that show typical reflective/impulsive characteristics.

Question:
Mrs. Noni runs a business making quail egg satay. Besides selling to food stalls, Mrs. Noni also accepts orders. Today, Mrs. Noni received an order for two types of equail egg satay.
Satay A: consists of 4 quail eggs
Satay B: consists of 3 quail eggs
If Mrs. Noni has 120 quail eggs in stock, how many skewers of satay can she make? write "T" in front of the true statement or "F" in front of the false statement. There is more than one answer choice.

	Satay A has 15 skewers and satay B has 20 skewers
	Satay A has 20 skewers and satay B has 15 skewers
	Satay A has 18 skewers and satay B has 15 skewers
	Satay A has 18 skewers and satay B has 16 skewers

Table 6. Answers Of Reflective And Impulsive Cognitive Style Students At Public Elementary School 294

Reflective students	Impulsive students
 Ibu Noni mempunyai usaha membuat satai telur puyuh. Selain disetorkan ke warung-warung, Ibu Noni juga menerima pesanan. Hari ini Ibu Noni mendapat pesanan 2 jenis satai telur puyuh Satai A : Terdiri dari 4 butir telur puyuh Satai B : Terdiri dari 3 butir telur puyuh Jika Ibu Noni mempunyai stok telur puyuh sebanyak 120 butir, berapa tusuk satai yang dapat dibuat? Tulislah **B** di depan pernyataan yang benar atau **S** di depan pernyataan yang salah. Pilihan jawaban lebih dari satu. B – Satai A sebanyak 15 tusuk dan satai B sebanyak 20 tusuk S – Satai A sebanyak 20 tusuk dan satai B sebanyak 15 tusuk S – Satai A sebanyak 18 tusuk dan satai B sebanyak 15 tusuk B – Satai A sebanyak 18 tusuk dan satai B sebanyak 16 tusuk	 Perhatikan bacaan berikut! Ibu Noni mempunyai usaha membuat satai telur puyuh. Selain disetorkan ke warung-warung, Ibu Noni juga menerima pesanan. Hari ini Ibu Noni mendapat pesanan 2 jenis satai telur puyuh. Satai A : Terdiri dari 4 butir telur puyuh Satai B : Terdiri dari 3 butir telur puyuh Jika Ibu Noni mempunyai stok telur puyuh sebanyak 120 butir, berapa tusuk satai yang dapat dibuat? Tulislah **B** di depan pernyataan yang benar atau **S** di depan pernyataan yang salah. Pilihan jawaban lebih dari satu. B – Satai A sebanyak 15 tusuk dan satai B sebanyak 20 tusuk B – Satai A sebanyak 20 tusuk dan satai B sebanyak 15 tusuk S – Satai A sebanyak 18 tusuk dan satai B sebanyak 15 tusuk S – Satai A sebanyak 18 tusuk dan satai B sebanyak 16 tusuk
Based on the interview results from RS_1's answers, it can be seen that initially he gave a different answer to the first statement. However, after the student did a careful calculation and realized that the initial answer given was wrong, the student changed his answer. RS_1 calculated the number of quail eggs in the first statement by multiplying 15 by 4 on Satay A. Then multiplying 20 by 3 on Satay B, then adding them up so that the result was 120 eggs. Furthermore, in the fourth statement, the student multiplied 18 by 4 on satay A and 16 by 3 on Satay B, then adding the two multiplication results to get 120. This shows that the answer given by the student is very correct.	Based on the interview results and IS_1's answers, it can be seen that students immediately wrote down the answers by guessing without further explanation regarding the reasons or how to obtain the answers.

Based on Table 6, RS_1's thinking process reflects the characteristics of a reflective student, namely being thorough, doeble-checking, and not hesitating to correct any errors found. This student was also able to explain the calculation steps coherently and clearly, demonstrating a good conceptual undersatnding of the given mathematical literacy problem. Meanwhile, IS_1 tends to respond quickly based on the first number seen in the problem, without conducting in-depth analysis or double-checking the accuracy of the answer. When asked to explain their thought process, these students struggle to provide logical reasoning and rely solely on intuition. This indicates that IS_1 has impulsive characteristics, namely rushing into decisions, lacking thoroughness, and not evaluating or reflecting on the answer given. As a result,the answers produced are often inaccurate or incomplete, as students prioritize speed over accuracy in solving problems.

Table 7. Answers Of Reflective And Impulsive Cognitive Style Students At Public Elementary School 313

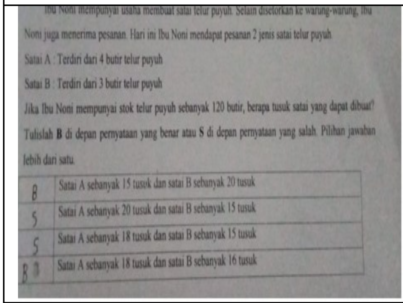
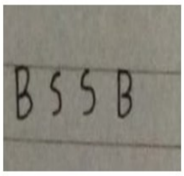
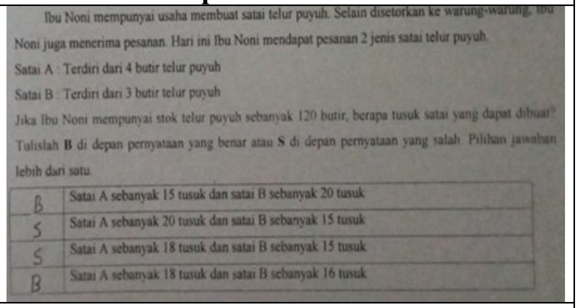
<table>
<tr><th>Reflective students</th><th>Impulsive students</th></tr>
<tr><td>
Ibu Noni mempunyai usaha membuat satai telur puyuh. Selain disetorkan ke warung-warung, Ibu Noni juga menerima pesanan. Hari ini Ibu Noni mendapat pesanan 2 jenis satai telur puyuh.
Satai A : Terdiri dari 4 butir telur puyuh
Satai B : Terdiri dari 3 butir telur puyuh
Jika Ibu Noni mempunyai stok telur puyuh sebanyak 120 butir, berapa tusuk satai yang dapat dibuat?
Tulislah B di depan pernyataan yang benar atau S di depan pernyataan yang salah. Pilihan jawaban lebih dari satu.
B | Satai A sebanyak 15 tusuk dan satai B sebanyak 20 tusuk
S | Satai A sebanyak 20 tusuk dan satai B sebanyak 15 tusuk
S | Satai A sebanyak 18 tusuk dan satai B sebanyak 15 tusuk
B | Satai A sebanyak 18 tusuk dan satai B sebanyak 16 tusuk

</td><td>
Ibu Noni mempunyai usaha membuat satai telur puyuh. Selain disetorkan ke warung-warung, Ibu Noni juga menerima pesanan. Hari ini Ibu Noni mendapat pesanan 2 jenis satai telur puyuh.
Satai A : Terdiri dari 4 butir telur puyuh
Satai B : Terdiri dari 3 butir telur puyuh
Jika Ibu Noni mempunyai stok telur puyuh sebanyak 120 butir, berapa tusuk satai yang dapat dibuat?
Tulislah B di depan pernyataan yang benar atau S di depan pernyataan yang salah. Pilihan jawaban lebih dari satu.
B | Satai A sebanyak 15 tusuk dan satai B sebanyak 20 tusuk
S | Satai A sebanyak 20 tusuk dan satai B sebanyak 15 tusuk
S | Satai A sebanyak 18 tusuk dan satai B sebanyak 15 tusuk
B | Satai A sebanyak 18 tusuk dan satai B sebanyak 16 tusuk</td></tr>
<tr><td>Based on the interview results and student answers, RS_2 wrote B for the first and fourth statements. According to RS_2, statements one and four based on the calculation results by multiplying the number of eggs by the number of satay skewers is 120 eggs, so the answer given by RS_2 is correct.</td><td>Based on the interview results and IS_2's answers, the student wrote B for statements one and four without providing a reason. The interview with IS_2 revealed that IS_2 initially wrote a different answer but, after recalculating, changed her answer again.</td></tr>
</table>

Table 7 shows that RS_2 was able to clearly explain each step of the calculation and demonstrated a good understanding of the relationship between the number of satay skewers and the total number of eggs used. This reflects the characteristics of a reflective student who is thorough, systematic, and able to provide rational justification for each answer. RS_2 not only provided the correct answer but was also able to explain his thinking process coherently and had a stable belief in his answer. In contrast, IS_2, although ultimately answering correctly, demonstrated an unstable thinking process and was unable to provide a rational justification. This finding reinforces the importance of assesing not only the product (final answer) but also students'thinking processes in mathematical literacy.

Table 8. Answers Of Reflective And Impulsive Cognitive Style Students At Public Elementary School 197

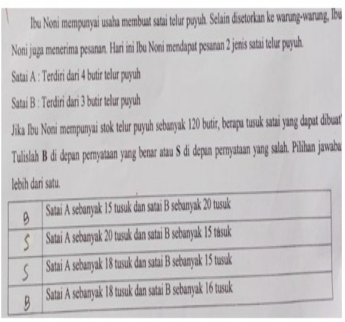
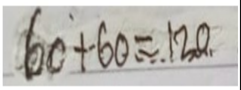
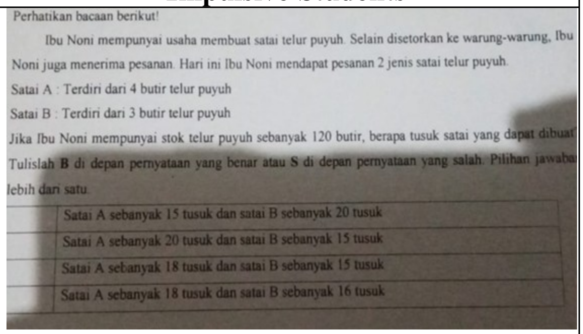
<table>
<tr><th>Reflective Students</th><th>Impulsive Students</th></tr>
<tr><td>
Ibu Noni mempunyai usaha membuat satai telur puyuh. Selain disetorkan ke warung-warung, Ibu Noni juga menerima pesanan. Hari ini Ibu Noni mendapat pesanan 2 jenis satai telur puyuh.
Satai A : Terdiri dari 4 butir telur puyuh
Satai B : Terdiri dari 3 butir telur puyuh
Jika Ibu Noni mempunyai stok telur puyuh sebanyak 120 butir, berapa tusuk satai yang dapat dibuat?
Tulislah B di depan pernyataan yang benar atau S di depan pernyataan yang salah. Pilihan jawaban lebih dari satu.
B | Satai A sebanyak 15 tusuk dan satai B sebanyak 20 tusuk
S | Satai A sebanyak 20 tusuk dan satai B sebanyak 15 tusuk
S | Satai A sebanyak 18 tusuk dan satai B sebanyak 15 tusuk
B | Satai A sebanyak 18 tusuk dan satai B sebanyak 16 tusuk

</td><td>
Perhatikan bacaan berikut!
Ibu Noni mempunyai usaha membuat satai telur puyuh. Selain disetorkan ke warung-warung, Ibu Noni juga menerima pesanan. Hari ini Ibu Noni mendapat pesanan 2 jenis satai telur puyuh.
Satai A : Terdiri dari 4 butir telur puyuh
Satai B : Terdiri dari 3 butir telur puyuh
Jika Ibu Noni mempunyai stok telur puyuh sebanyak 120 butir, berapa tusuk satai yang dapat dibuat?
Tulislah B di depan pernyataan yang benar atau S di depan pernyataan yang salah. Pilihan jawaban lebih dari satu.
Satai A sebanyak 15 tusuk dan satai B sebanyak 20 tusuk
Satai A sebanyak 20 tusuk dan satai B sebanyak 15 tusuk
Satai A sebanyak 18 tusuk dan satai B sebanyak 15 tusuk
Satai A sebanyak 18 tusuk dan satai B sebanyak 16 tusuk</td></tr>
<tr><td>Based on the interview and answers, RS_3 wrote B in the first and fourth statements. RS_3 believes that the first and fourth statements are true because the calculation results fulfill the stock of quail eggs as much as 120. In the first statement, 15 x 4 = 60, and 20 x 3 = 60, so that 60 + 60 = 120.</td><td>Based on the interview and answers, IS_3 did not write any answers because IS_3 did not understand and comprehend how to work on the questions to find a solution.</td></tr>
</table>

Table 8 shows that RS_3's ability to clearly explain the calculation process and provide reasons why a statement is true or false demonstrates the characteristics of a reflective student who is thorough, systematic, and has good conceptual understanding. RS_3 not only focuses on the correct answer, but is also able to identify why other options are incorrect. Meanwhile, IS_3 is not only impulsive in the sense of rushing, but also tends to avoid challenges when faced with problems that are considered difficult. This characteristic is different from reflective students who will try various strategies even though they are not necessarily successful. IS_3's inabilityto initiate the problem-solving process indicates a lack of understanding of basic concepts and systemtic thinking strategies, which are typical of students with an impulsive cognitive style at an extreme level.

Discussion

Finding 1: differences in formulation ability between reflective and impulsive students

Empirical evidence

The result of the study indicate that reflective students excel in the formulation stage of mathematical literacy. RS_1, RS_2, and RS_3 were able to identify relevant information from theproblem, write down what was known and what was asked, and transform the contextual problem into a mathematical model. For example, RS_3 explained coherently:" 15 x 4 = 60 for satay A, 20 x 3 = 60 for satay B, totaling 120 items". This student was also able to identify why other statements did not meet the criteria. In contrast, impulsive students demonstrated significant weaknesses in formulation. IS_1 immediately guessed the answer without writing down known information. IS_2 demonstrated instability by changing answer without clear reason. IS_3 was unable to even begin the process due to a lack of understanding of the problem. These findings are consistent with quantitative data showing that the average literacy score of reflective students (73,7) was significantly higher than that of impulsive students (58,1).

Interpretation with literature

Reflective students' excellence in formulating aligns with the PISA framework, which places the formulating process as the foundation of mathematical literacy (Organisation for Economic Co-operation & Development, 2013). The ability to identify mathematical structures in real-world situations requires in-depth information processing, a key characteristic of the reflective cognitive style (Rozencwajg & Corroyer, 2005). Warli (2013) assert that reflective students tend to analyze all information before making a decision, while impulsive students respond based on the first stimulus they see.

Impulsive student errors revealed two specific patterns: first, context modeling errors. IS_2, in the quail egg satay problem, wrote"15 x 4 =60, 20 x 3 = 60, so 120" for the statement, but inconsistently applied the same model to the other statements. IS_3 did not realize that the same mathematical model must apply to all possible combinations. Second, implicit reading errors. IS_3 completely failed to understand that the problem asked for the evaluation of four statements, not finding a single answer. IS_3 was unable to formulate that his task was to check the truth of each combination.

Finding 2: Differences in employability and their relationship to processing time

Empirical evidence

ANRPS and ATSP data show a consistent pattern. Reflective students spent more time (average ATSP 21,5 minutes) with fewer repetitions (average ANRPS 1,2 minutes). Impulsive students worked faster (average ANRPS 2,3 minutes). RS1 carefully calculated 15 x 4 = 60 and 20 x 3 = 60, then double-checked by adding 60 + 60 = 120. RS_2 even used two different strategies to verify his answer. In contrast, IS1 made a calculation error and did not realize it until the interview.

Interpretation with literature

Impulsive students' speed is actually counterproductive because it encourages more repetition. Rozencwajg and Corroyer (2005) explained that impulsive students implement different information processing strategies, they tend to use a holistic approach without detailed analysis, while reflective students use a step by step analytical approach. Wulandari and Lu'luilmaknun (2022), emphasized that although reflective students take longer, their results are more optimal because they focus on accuracy. The finding of higher ANRPS in the impulsive group demonstrates that the speed, accuracy trade off in mathematical literacy favors students who prioritize accuracy.

Despite their overall superiority, the reflective students in this study also made errors. RS_1 initially gave a different answer before eventually correcting it. The analysis revealed two types of errors that consistently occured among reflective students: first, errors due to problem complexity. On problem with multiple steps and multiple possible answers (problem number 1, about elevators), reflective students sometimes missed one or two combinations due to limited working memory. This aligns with cognitive load theory (Sweller, 1988), which states that even systematic processing has limits. Second, errors due to unfamiliarity with the problem format. Some reflective students were accustomed to problems with a single, definitive answer, so when faced with problems with multiple possibilities, they had difficulty adjusting their stategies. This findings is important because it demonstrates that thoroughness alone is not enough. Reflective students also need to be trained in cognitive flexibility and cognitive load managemet.

Finding 3: Differences in interpretive ability and implications for answer quality

Empirical evidence

Interviews revealed that IS_1 and IS_2 did not understand the importance of returning mathematical results to their original context. For them, finding the number 120 was the ultimate goal, whereas in mathematical literacy, interpreting results is an integral part of the process

Interpretation with literature

Interpretive ability within the PISA framework requires students to reinterpret mathematical results in real world situations and evaluate the reasonableness of solutions (Organisation for Economic Co-operation & Development, 2013). Reflective students in this study demonstrated these abilities, while impulsiv students stopped at the employ stage. Research by Masfingatin and Suprapto (2020) found that reflective students were able to provide rational explanations for their answers because they focused not only on the product but also on the process. In contrast, impulsive students viewed mathematics as an activity of finding numbers, rather than solving contextual problems. Happy et al. (2019) added that the inability to interpret in impulsive students was related to a lack of reflection and self evaluation habits.

This study has several limitations. First, the sample size was limited (120 students), requiring caution in generalizing. Second, the identification of cognitive styles only used the MFFT, which measure one dimension, whereas cognitive styles are multidimensional. Third, the study did not control for external variables such as motivation, family support, or the quality of instruction that may influence mathematical literacy. Nevertheless, these findings have significant practical implications. Teachers need to design lessons that explicitly train all three literacy processes, formulation, use, and interpretation, rather than just calculation. For impulsive students, interventions in the form of metacognitive scaffolding, such as rechecking checklists and think aloud exercises, can help develop reflective habits. For reflective students, challenges in the form of open-ended questions with multiple possible answers can train cognitive flexibility.

CONCLUSION

The results of the analysis of elementary school students' mathematical literacy abilities in terms of reflective and impulsive cognitive styles referring to the empirical evidence presented in Table 3 on the distribution of cognitive styles, Tables 4-5 on literacy test performance, Figure 2 on ATSP and ANRPS patterns, and Tables 6-8 related to the qualitative analysis of mathematical literacy test results, it was found that: first, reflective and impulsive cognitive styles were identified in elementary school students in Central Maluku, with a higher proportion of impulsive students, but this varied across schools. Second, reflective students significantly outperformed impulsive students in mathematical literacy across all aspects (formulation, use, interpretation), as evidenced by average scores of 73,7 and 58,1. Third, reflective students' problem solving processes were characterized by thoroughness, systematic planning, and continuous evaluation, while impulsive students were characterized by inefficient speed, lack of planning, and absence of evaluation. Fourth, the errors that occured in the two groups had different characteristics, with impulsive students making more conceptual and procedural errors, while reflective students made more errors due to complexity and cognitive bias. These findings highlight the importance of differentiated teaching strategies based on students' cognitive styles to support optimal mathematical literacy development in elementary schools.

RECOMMENDATION

This study only examined the direct relationship between cognitive style and mathematical literacy. It did not explore the psychological mechanisms that mediate this relationship, such as self-regulation or metacognitive awareness. Recommendations for further research relate to the role of self-regulation and metacognitive awareness in mediating the effect of cognitive style on elementary school students' mathematical literacy. The findings of this study indicate that the difference in mathematical literacy abilities between reflective and impulsive students is not solely due to speed or accuracy, but is closely related to self regulation processes and metacognitive awareness. Some specific evidence from this study that points to this mechanism include: weak self-monitoring of students' errors, the absence of double-checking of written work, weak planning aspects of self-regulation, and the absence of activation of cognitive strategies.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Nessy Pattimukay	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Johannis Takaria	✓	✓	✓	✓	✓			✓	✓	✓	✓			
La Suha Ishabu	✓	✓	✓	✓		✓	✓			✓	✓		✓	
Chyntia Pasalbessy				✓	✓	✓				✓				
Musa Marsel Maipauw						✓	✓					✓		
Sherly Latuihamallo											✓			

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The data that support the findings of this study are available on request from the corresponding author.

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