ISSN 2303-0992
ISSN online 2621-3176
Matematika dan Pembelajaran
Volume 14 No. 1, June 2026, p. 52-86
Submitted: April 5, 2026; **Revised**: June 16, 2026; **Accepted**: June 28, 2026

ENACTING MATHEMATICAL DISPOSITION: EXPLORING HOW STUDENTS WITH HIGH MATHEMATICAL LITERACY ENGAGE IN MATHEMATICAL LITERACY TASKS

***)Rustam Effendy Simamora[1], Ayu Ningsih[2], Alfian Mucti[3], Shinta Wulandari[4]**
**)Corresponding author*
[1,2,3,4] *Mathematics Education Department, Universitas Borneo Tarakan, Indonesia*
erustam@borneo.ac.id

Abstrak

Disposisi matematis (DM) secara luas diakui sebagai faktor kunci yang memengaruhi kinerja siswa, khususnya dalam literasi matematis (LM), yang ditekankan dalam pendidikan menengah di Indonesia melalui Asesmen Kompetensi Minimum. Akan tetapi, sebagian besar penelitian masih mengandalkan pendekatan kuantitatif, sehingga memberikan wawasan yang terbatas tentang bagaimana DM teraktualisasi selama proses pemecahan masalah dalam konteks pembelajaran di kelas. Penelitian ini bertujuan untuk mengeksplorasi bagaimana DM teraktualisasi pada siswa dengan LM tinggi ketika mengerjakan tugas LM. Dengan menggunakan desain studi kasus multipel kualitatif, lima siswa sekolah menengah atas dipilih secara purposif. Data dikumpulkan melalui hasil pekerjaan tertulis, observasi selama penyelesaian tugas secara individu dan kelompok, penilaian diri, serta dua tahap wawancara, kemudian dianalisis menggunakan analisis tematik. Temuan penelitian menunjukkan bahwa DM, yang mencakup rasa ingin tahu, kepercayaan diri, ketekunan, fleksibilitas, dan refleksi, muncul sebagai suatu sistem yang dinamis dan sensitif terhadap konteks. Meskipun semua siswa menghasilkan jawaban yang benar, kedalaman keterlibatan bervariasi tergantung pada bagaimana disposisi tersebut diaktifkan dan diatur. Dalam situasi kolaboratif, DM mengalami perubahan dengan memperkuat kepercayaan diri dan meningkatkan partisipasi, tetapi juga menghadirkan tantangan, seperti berkurangnya verifikasi jawaban akibat ketergantungan berlebih pada kesepakatan kelompok. Temuan ini menunjukkan bahwa LM menyediakan landasan kognitif untuk pemecahan masalah, sementara DM memediasi bagaimana proses tersebut dijalankan.

Kata kunci: Disposisi Matematis; Literasi Matematis; Pembelajaran Berbasis Tugas; Pemecahan-Masalah; Penelitian Kualitatif.

Abstract

Mathematical disposition (MD) is widely recognized as a key factor influencing students' performance, particularly in mathematical literacy (ML), which is emphasized in Indonesian education through the *Asesmen Kompetensi Minimum* (AKM), a national assessment focusing on literacy and numeracy. However, most studies rely on quantitative approaches, offering limited insight into how MD is enacted during problem-solving in classroom contexts. This study explores how MD is enacted by students with high ML when engaging in mathematical literacy tasks. Using a qualitative multiple-case study design, five senior high school students were purposively selected. Data were collected through written work, self-assessments, observations in individual and group settings, and two phases of interviews, and analyzed using thematic analysis. The findings reveal that MD emerges as a dynamic, context-sensitive system involving curiosity, confidence, persistence, flexibility, and reflection. Although all students produced correct solutions, their depth of engagement varied depending on how these dispositions were activated and regulated. Collaborative settings reshaped MD by redistributing confidence and enhancing participation, but also introduced challenges, such as reduced verification due to overreliance on group agreement. These findings suggest that ML provides the cognitive foundation for problem solving, while MD mediates its enactment.

Keywords: Mathematical Disposition; Mathematical Literacy; Problem-Solving; Qualitative Study; Task-Based Learning.

Citation: Simamora, R. E., Ningsih, A., Mucti, A., & Wulandari, S. (2026). Enacting Mathematical Disposition: Exploring How Students with High Mathematical Literacy Engage in Mathematical Literacy Tasks. *Matematika dan Pembelajaran*, 14(1), 52–86. DOI: http://dx.doi.org/10.33477/mp.v14i2.14009

INTRODUCTION

Mathematical literacy (ML) has become a central focus of contemporary mathematics education, emphasizing students' ability to apply mathematical knowledge in real-world contexts, interpret problems, and make reasoned decisions. In the Indonesian secondary education context, ML is a key component of the *Asesmen Kompetensi Minimum* (AKM—Minimum Competency Assessment), a national assessment designed to measure students' fundamental competencies in literacy and numeracy as part of broader national education reform policies in Indonesia (Pusat Asesmen Pendidikan, 2024). This perspective is reflected in international frameworks developed by the Organisation for Economic Co-operation and Development (OECD), which define ML as the capacity to formulate, employ, and interpret mathematics in a variety of contexts (OECD, 2019, 2023). Recent research further highlights that ML involves not only procedural fluency but also modelling, reasoning, and decision-making in authentic situations (Kaiser & Stender, 2022; Wijaya et al., 2015). These competencies are reflected in the Indonesian educational context, particularly through AKM tasks that require students to interpret real-world problems, analyze data, and make reasoned decisions based on contextual information.

Despite the growing emphasis on ML in international and Indonesian educational contexts, many students continue to experience difficulties in solving context-based mathematical problems, particularly in interpreting situations and constructing appropriate mathematical representations (OECD, 2023; Wijaya et al., 2014). Empirical evidence from Indonesian classrooms also indicates that students' mathematical disposition (MD) remains relatively low across key indicators such as curiosity, persistence, and flexibility, with an overall average of 54%, categorized as low (Fairus et al., 2023). This suggests that challenges in mathematical learning are not only cognitive but are also closely related to students' affective engagement in learning processes.

National data further indicate that students' literacy and numeracy achievement in Indonesia remains uneven across schools, suggesting that improving mathematical performance requires attention not only to content mastery but also to the quality of learning processes and student engagement (Pusat Asesmen Pendidikan, 2024). These difficulties suggest that success in ML cannot be explained solely by cognitive ability, but is also closely related to how students engage with problems, including their confidence, persistence, and willingness to explore solution strategies (Hannula, 2020; Kilpatrick et al., 2001; Schukajlow et al., 2021). In line with findings from Indonesian educational reports, students' learning outcomes are influenced by multiple factors, including classroom environment, learning processes, and student characteristics, which collectively shape how they participate in and respond to mathematical tasks (Pusat Asesmen Pendidikan, 2024). In this sense, affective factors—particularly those associated with mathematical disposition (MD)—play an important role in shaping students' problem-solving processes (Hannula, 2020; NCTM, 2000).

MD is commonly understood as students' tendency to think and act positively toward mathematics, including aspects or dimensiona such as curiosity, confidence, persistence, flexibility, and reflection. Those dimensions have been widely recognized as essential components of productive mathematical engagement (Fairus et al., 2023; Hannula, 2022; Kilpatrick et al., 2001; NCTM, 2000). These dimensions are closely aligned with current national priorities that emphasize not only cognitive achievement but also the development of students' character and active engagement in learning as part of holistic educational outcomes (Pusat Asesmen Pendidikan, 2024). Curiosity refers to students' inclination to explore ideas, seek additional information, and engage with mathematical tasks beyond surface-level understanding. Confidence relates to students' beliefs in their ability to engage with and solve mathematical problems, enabling them to act on their reasoning. Persistence reflects sustained effort when encountering difficulties, allowing students to continue working through challenging problems. Flexibility involves the ability to adapt strategies, consider alternative approaches, and utilize various resources effectively. Finally, reflection supports the evaluation and regulation of mathematical thinking, enabling students to verify solutions and refine their reasoning. Such an understanding is important for advancing both theoretical and practical perspectives in mathematics education.

MD has long been recognized as an essential component of mathematical proficiency, as emphasized by Kilpatrick et al. (2001) and the NCTM (2000). Beyond mathematics education, broader perspectives on ML also identify dispositions as integral to meaningful mathematical activity, alongside knowledge, skills, and the purposeful use of mathematics in authentic contexts (Dole & Geiger, 2018). Such perspectives highlight dispositions including confidence, flexibility, initiative, and risk-taking as important contributors to successful engagement with mathematical tasks. More recent studies also highlight the role of affective variables in shaping students' engagement and achievement in mathematics, particularly in problem-solving contexts (Hannula, 2020; Schukajlow et al., 2021). Students with positive MDs tend to demonstrate productive behaviors such as exploring multiple strategies, justifying their reasoning, and sustaining effort when facing challenging tasks. The present study aims to explore how MD is enacted by students with high ML when solving mathematical literacy tasks (MLTs).

Despite its recognized importance, much of the existing research has examined MD using quantitative approaches, often treating it as a relatively stable trait and positioning it as a predictor of mathematical performance (Schukajlow et al., 2021; OECD, 2023). Similarly, prior studies in the Indonesian context have predominantly employed descriptive or quantitative approaches to measure students' levels of disposition, providing limited insight into how these dispositions are enacted during real-time problem-solving processes (Fairus et al., 2023). As a result, these approaches offer limited understanding of how MD operates within the process of problem solving, particularly in terms of how dispositions emerge, evolve, and interact with cognitive processes during engagement with mathematical tasks. In Indonesian classroom settings, where students' learning is shaped by contextual problem characteristics and challenges in interpreting real-world situations (Wijaya et al., 2014), a qualitative approach is particularly valuable to capture how MD is enacted dynamically during problem-solving processes, as it enables an in-depth exploration of students' actions, interactions, and meaning-making in context (Cobb, 2007; Hannula, 2020). Such an approach allows for a more comprehensive understanding of MD as a dynamic and situated construct, rather than a fixed attribute measured through isolated variables.

Recent developments in mathematics education research have begun to emphasize the dynamic and situated nature of affect (Hannula, 2020; Schukajlow et al., 2021). In Indonesian classrooms, this can be observed when students show hesitation in interpreting contextual problems, rely on familiar procedures instead of exploring alternative strategies, or demonstrate increased confidence and engagement when supported through collaborative discussion (Wijaya et al., 2014). MD is increasingly viewed as a construct that is enacted through interaction with tasks, tools, and social contexts, rather than as a fixed internal attribute (Hannula, 2020; Pepin et al., 2021). This perspective is consistent with evidence from

Indonesian educational settings, which shows that learning outcomes are closely linked to the quality of classroom interaction and the extent to which students are actively involved in the learning process (Pusat Asesmen Pendidikan, 2024). This perspective aligns with socio-constructivist views of learning, which highlight that both cognitive and affective processes are co-constructed through meaningful activity. However, empirical studies that investigate this perspective—particularly in the context of ML—remain limited.

Although recent studies have examined mathematical literacy and affective aspects of mathematics learning, the enactment of MD during MLTs remains underexplored. Existing research has investigated students' engagement in MLTs (e.g., Bolstad, 2023) and the influence of affective factors such as self-efficacy and learning environments on mathematical literacy (e.g., Alali & Wardat, 2024). Similarly, studies on MD have predominantly conceptualized disposition as a relatively stable characteristic or as a predictor of mathematical performance (Schukajlow et al., 2021; Fairus et al., 2023). While these studies provide valuable insights into the relationships among affective and cognitive variables, they offer limited understanding of how MD is enacted and negotiated during the process of solving MLTs. In particular, little is known about how students with high mathematical literacy express and sustain key dimensions of MD, such as curiosity, confidence, persistence, flexibility, and reflection, in authentic problem-solving contexts. This gap highlights the need for qualitative investigations that examine MD as a dynamic and situated process of engagement.

By adopting a qualitative case study approach, this study seeks to contribute to a deeper understanding of MD as a dynamic, situational, and process-oriented construct that emerges through interaction with tasks and contexts (Hannula, 2020; Schukajlow et al., 2021). The findings are expected to enrich current discussions on the integration of cognitive and affective dimensions in mathematics education (Fredricks et al., 2004; Sinatra et al., 2015) and to inform the design of learning environments that promote meaningful mathematical engagement. Accordingly, the research questions guiding this study are as follows: How is MD enacted by students with high ML when solving MLTs, and what characteristics of MD emerge during the problem-solving process? How do task context and social interactions influence the enactment of MD?

METHOD

This study adopted a qualitative approach using a multiple-case study design to explore how MD is enacted by students with high ML when solving MLTs (Creswell & Poth, 2018). A case study design was selected to enable an in-depth investigation of students' cognitive and affective processes within authentic learning contexts, particularly when these processes are dynamic, intertwined, and shaped by situational factors (Yin, 2018; Creswell & Creswell, 2023). Each participant was treated as an individual case, allowing both within-case and cross-case analysis. The study was grounded in an interpretive paradigm, which focuses on understanding how participants construct meaning through their interaction with tasks and learning environments.

The study was conducted at SMA Negeri 1 Tarakan, Indonesia, during the 2023/2024 academic year. Participants were selected using purposive sampling based on their ML levels, informed by their performance in the AKM, classroom achievement, and teacher recommendations. Following a purposive sampling strategy (Creswell & Creswell, 2023), participants were intentionally selected from Grade XI students who were considered communicative and able to provide rich information relevant to the research objectives. The selection of Grade XI students was aligned with the implementation of AKM in Indonesia, which is administered at this grade level, thereby providing a valid and relevant basis for identifying students' ML levels.

The classification of students' ML levels (high, medium, and low) was based on their prior AKM results and their observed mathematical performance during classroom learning. Students were categorized into high, medium, and low

ML groups based on a combination of their AKM performance, classroom assessment results, and teacher evaluations. Students classified as having high ML consistently demonstrated strong performance in AKM-type tasks, particularly in interpreting contextual problems, constructing appropriate mathematical representations, and providing justified solutions. From five different academic tracks (Social, Science, Entrepreneur, Engineering, and Health), three students representing each ML level were selected, resulting in a total of 15 participants.

To examine how MD is enacted in both individual and collaborative contexts, each focal participant worked with two peers with lower ML levels during group tasks. Although the primary analysis centers on the five high-ML students, the inclusion of students with varying ML levels enabled the study to capture how MD is shaped and negotiated through social interaction (Cobb, 2007; Vygotsky, 1978). In particular, this design allowed for the exploration of how key dimensions of MD are influenced by group dynamics, task demands, and peer contributions (Hannula, 2020; Schukajlow et al., 2021). Therefore, the inclusion of participants with diverse ML levels was not intended for comparative purposes, but to provide a richer interactional context for examining how MD is enacted by high-ML students in both individual and collaborative problem-solving situations, in line with the research questions of this study. All participants were assigned pseudonyms to ensure confidentiality.

In qualitative research, the researcher acts as the primary instrument (Creswell & Creswell, 2023). To support this role, multiple complementary instruments were employed to capture the enactment of MD from different perspectives, including students' actions, written work, and reflections across both individual and collaborative contexts. The MLTs were designed based on AKM-type problems and aligned with contemporary ML frameworks. The tasks focused on statistical concepts, particularly mean, median, and mode, and were situated in personal and social contexts with varying levels of cognitive demand, including understanding, application, and reasoning. For example, one task required students to interpret a frequency distribution table and determine the appropriate histogram representation, which involved analyzing data, comparing alternative visualizations, and justifying their choices (see Figure 1).

Students completed the tasks in two settings, namely individually and collaboratively in small groups. This dual implementation enabled the study to examine how MD is enacted across different social contexts. Importantly, each task session—both individual and group—was accompanied by a self-assessment sheet designed to capture students' immediate affective responses and reflections. Students' written work was collected to examine how MD is reflected in their mathematical reasoning. Particular attention was given to how students interpret problems, select strategies, structure their solutions, and justify their answers.

The self-assessment consisted of two components. First, students were asked to evaluate their own feelings while working on the task by selecting or adding descriptive expressions such as *interested*, *challenged*, *confident*, *confused*, *bored*, or *curious*. Second, students were asked to evaluate the task itself by indicating whether it was, for example, *challenging*, *enjoyable*, *difficult*, *confusing*, or *meaningful*. This instrument was adapted from Susanto et al. (2021) and allowed students to articulate their experiences using their own language. The integration of self-assessment within the task environment enabled the researcher to capture students' MD as it was experienced in situ, rather than retrospectively. In this sense, the self-assessment functioned not merely as a reflective tool but as a means of accessing students' lived affective experiences during problem solving.

Problem 3. Stick Length Data
Context: Personal (Level: Reasoning and Application)

a) Consider the following table!

Stick Length	Frequency
44 - 46	5
47 - 49	12
50 - 52	18
53 - 55	20
56 - 58	10
59 - 61	3

The table above is a frequency distribution table of stick lengths (in cm). If a researcher presents histograms like the following figures. Determine which histogram corresponds to the frequency table. Explain!

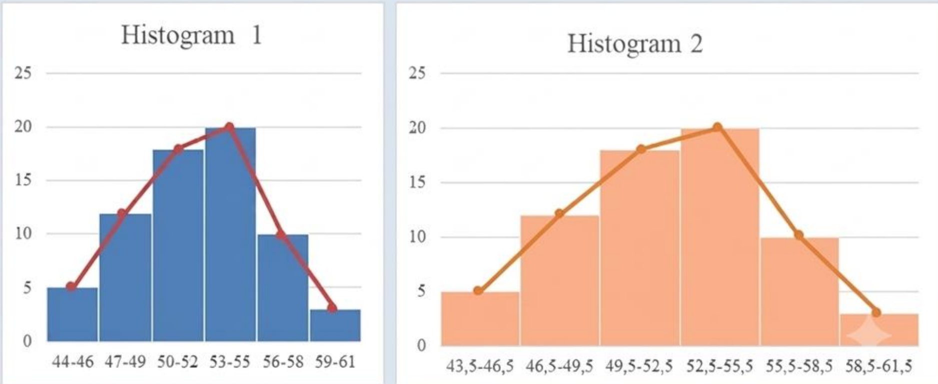


Figure 1. Example of a Mathematical Literacy Task Requiring Students to Interpret a Frequency Distribution Table and Select the Appropriate Histogram Representation in a Contextual Setting

Observation protocols were developed to capture the real-time enactment of MD during task engagement. Observations focused on key dimensions such as curiosity, confidence, persistence, flexibility, and reflection. In individual settings, attention was directed toward students' initiative and independence, while in group settings, observations emphasized collaboration, interaction, and collective problem solving. Semi-structured interviews were conducted to explore students' internal perspectives on their problem-solving experiences. The interview protocol was designed to capture key dimensions of MD, including curiosity, confidence, persistence flexibility, and reflection. Prior to the interview, the researcher established rapport with participants to encourage open and reflective responses regarding their experiences in completing MLTs.

The interviews focused on how students explain their reasoning, respond to challenges, evaluate their solutions, and express their affective experiences. All interviews were conducted individually using a one-on-one format, allowing for an in-depth exploration of each participant's thinking and personal engagement with the MLTs. To enhance the credibility of the findings, member-checking interviews were conducted as a follow-up process. These interviews were also carried out individually with each participant, enabling them to review and reflect on the researcher's initial interpretations. Participants were asked to confirm, clarify, or challenge these interpretations, particularly in relation to how they approached tasks and expressed their MD.

The member-checking protocol was structured around the same dimensions of MD explored in the initial interviews, including curiosity, confidence, persistence, interest, flexibility, and reflection. Participants were invited to revisit their prior experiences in solving MLTs and to respond to both their earlier statements and the researcher's preliminary interpretations. For example, they were asked to reflect on their level of curiosity (e.g., initiative and use of resources), confidence (e.g., trust in their own solutions), persistence (e.g., effort when facing difficulty), flexibility (e.g., use of alternative strategies and tools), and reflection (e.g., reviewing and evaluating their answers). In addition, participants were encouraged to comment on contextual factors influencing their engagement, such as task difficulty, learning conditions, and prior understanding. Feedback from this process led to the refinement of the analysis, including the clarification of ambiguous statements, the adjustment of initial interpretations that did not fully represent participants' intentions, and the strengthening of emerging themes by ensuring their consistency with participants' explanations. These interviews also provided deeper insight into how students' MD was enacted across different task situations.

The research was conducted in several stages. Participants were first selected based on predefined criteria of high ML. Each participant then engaged in MLTs in both individual and group settings, accompanied by self-assessment activities. During task implementation, observations were conducted to document students' behaviors and interactions. Students' written work and self-assessment responses were collected immediately after task completion. Semi-structured interviews were then conducted to explore students' reasoning processes and affective experiences in greater depth. Finally, member-checking interviews were conducted to validate and refine interpretations. Data collection and analysis were carried out iteratively, allowing emerging themes to be continuously compared and refined across participants. Thematic saturation was considered achieved when no new codes or themes emerged from successive data sources, when patterns of MD were consistently observed across the five focal participants in both individual and collaborative contexts, and when additional data no longer contributed to meaningful refinement of the analytical categories (Creswell & Creswell, 2023).

The rigor of this study was ensured through several strategies aligned with established qualitative research standards. Credibility was achieved through triangulation of multiple data sources, including observations, interviews, written work, and self-assessment, as well as through member checking. Dependability was supported by maintaining a detailed audit trail documenting the research process. Confirmability was ensured through reflexive practices and ongoing discussions with supervisors to minimize researcher bias. Transferability was addressed by providing rich descriptions of each case and the research context (Lincoln & Guba, 1985; Creswell & Creswell, 2023).

RESULT AND DISCUSSION

The findings of this study reveal that students with high ML do not demonstrate a uniform pattern of MD; instead, their engagement emerges as a dynamic and context-sensitive process. Across individual and collaborative settings, MD is enacted through interconnected dimensions—curiosity, confidence, persistence, flexibility, and reflection—that function as a coordinated system rather than isolated traits. While students generally exhibited strong ML in producing correct and structured solutions, the depth and quality of their engagement varied depending on how these dispositional dimensions were activated and regulated. The integration of observational data, students' written work, self-assessment, and both phases of interviews shows that MD operates across multiple layers: it is enacted in observable actions, experienced through subjective perceptions, and reconstructed through reflection. Notably, collaborative contexts played a significant role in reshaping students' engagement, particularly by redistributing confidence and enhancing participation. These findings suggest that MD is not a fixed attribute associated with high performance, but a relational and evolving system that mediates how ML is enacted in practice.

Curiosity was operationalized not only as information-seeking behavior, but also as observable engagement indicators such as enthusiasm and active participation, which reflect students' willingness to engage with and explore the task. In this study, curiosity is conceptualized as an enacted and multidimensional process, reflected not only in information-seeking behaviors but also in students' engagement, interaction, and exploratory participation during problem solving. Curiosity emerged as a central dimension in the enactment of MD, reflected in students' active engagement with tasks and their efforts to seek additional information. This pattern was consistently observed across participants and supported by multiple data sources.

Table 1. Quantification of Curiosity-Related Codes

Setting	Code	Positive (+)	Negative (–)
Individual Task	Initiative	5	0
	Shared curiosity engagement	5	0
	Information seeking	5	0
Group Task	Asking peers	5	0
	Information seeking	5	0

Setting	Code	Positive (+)	Negative (–)
	Enthusiasm	4	1
	Exploratory idea sharing	3	2
	Curiosity-driven participation	3	2

Note:
The numerical values in this table represent the number of participants (T01–T05) who demonstrated each coded indicator of mathematical disposition. These values were derived through triangulation of multiple data sources, including (1) observations during task implementation, (2) students' self-assessments, and (3) confirmation through semi-structured interviews.

Observational data showed that all five focal participants demonstrated initiative, enthusiasm, and information-seeking behaviors during individual tasks. This trend remained evident in group settings, although variations appeared in collaborative participation (see Table 1). Initiative and information seeking were consistently positive across all participants (5/5), while behaviors such as exploratory idea sharing and curiosity-driven participation were less uniformly distributed. These variations suggest that while curiosity is strongly enacted at the individual level, its expression in collaborative contexts depends on interaction dynamics. While some codes such as enthusiasm and participation may not represent curiosity in a strict epistemic sense, they were included as observable indicators of engagement that reflect students' willingness to explore and interact with the task, thereby supporting the enactment of curiosity.

Interview data further revealed that curiosity was enacted as a deliberate strategy to expand understanding beyond the given information. As Participant T01 explained in Interview 1 (Int._1): "*By looking for alternative ways, I can answer the task more accurately. I also used my notes and the internet as references.*" (T01, Int._1). This indicates that curiosity functioned as a purposeful effort to deepen understanding rather than a passive reaction to the task. This pattern was sustained during reflection, as the same participant noted: "*I felt more enthusiastic when working on the tasks because I could explore the material further using internet resources.*" (T01, Int._2).

Self-assessment data reinforced these findings, with students frequently selecting descriptors such as *interested*, *enthusiastic*, and *curious*, suggesting that curiosity was experienced as an integral part of their engagement. However, the enactment of curiosity was not uniform. While most participants demonstrated strategic exploration, some showed more limited engagement. For instance, one participant stated: "*I mainly relied on the notes provided by the teacher*." (T03, Int._1), reflecting a more procedural approach with less exploratory depth. This pattern was also evident in written work, where some correct solutions relied primarily on routine procedures without evidence of alternative strategies.

Importantly, curiosity was influenced by task context. In collaborative settings, several participants demonstrated increased enthusiasm and engagement, indicating that peer interaction can amplify curiosity through shared exploration. Overall, these findings suggest that curiosity is enacted as an active, strategic, and context-sensitive process, ranging from deep exploration to more constrained procedural engagement. Rather than being a fixed trait, curiosity emerges dynamically through the interaction between individual initiative, task characteristics, and social context.

Confidence was operationalized as both individual and socially mediated forms of perceived control, reflected not only in students' belief in their own ability, but also in their willingness to act independently, express ideas, and engage with peers during problem-solving. Confidence emerged as a critical dimension in the enactment of MD, not as a stable personal attribute, but as a form of situated control over problem-solving processes. Across data sources, confidence was reflected in students' willingness to act on their reasoning, commit to solutions, and regulate decisions under uncertainty. Quantitative patterns (Table 2) indicate that while all participants demonstrated the ability to work independently in individual tasks (5/5), self-confidence was less consistently observed (3/5), suggesting a distinction between performing tasks and feeling confident in doing so. The codes included in this table represent both individual and socially mediated forms of confidence. While some codes such as collaboration do not directly indicate confidence, they were included to capture the context in which confidence is enacted and redistributed during group interaction.

Table 2. Quantification of Confidence-Related Codes

Setting	Code	Positive (+)	Negative (–)
Individual Task	Working independently	5	0
	Self-confidence	3	2
	Confidence in own ability	2	3
Group Task	Trust in peers' ability	5	0
	Collaborative confidence	5	0
	Expressing opinions	3	2

In individual settings, confidence was primarily grounded in prior knowledge and familiarity with mathematical content. Some participants demonstrated decisiveness and independence, supported by statements such as: "*I am confident in my answer because I have learned this material before and still remember it*." (T02, Int._1). This indicates that confidence functioned as a cognitive–affective bridge, enabling students to mobilize prior knowledge into action. However, this pattern was not uniform. Other participants expressed uncertainty despite adequate performance, as reflected in the statement: "*I am not very confident because I feel that my calculation skills are still lacking*." (T03, Int._1). This suggests that confidence is not a direct function of competence, but is mediated by self-evaluation and perceived limitations.

In collaborative contexts, confidence became more dynamic and socially distributed. While confidence in one's own ability decreased (2/5), trust in peers and collaborative engagement were consistently high (5/5), indicating a redistribution of confidence through interaction (Table 2). This shift was reflected in participants' accounts: "*I feel more confident when working in a group because we can support each other*." (T03, Int._2). Here, confidence is co-constructed through shared responsibility and peer support, enabling participation even among previously hesitant students. However, this social amplification of confidence also introduced tensions. In some cases, high confidence reduced critical evaluation, as illustrated by: "*Because we were already confident, we did not check the answer again*." (T01, Int._1). This indicates that confidence, when unregulated, may lead to overconfidence and weaken reflective processes. Importantly, this tendency was later reconsidered during reflection: "*Even though I trust my group, I still check the answer again to make sure it is correct*." (T01, Int._2), suggesting that confidence can be recalibrated through reflective awareness.

Self-assessment data supports these findings, showing that students reported higher confidence in group settings, often accompanied by increased comfort. However, this perceived confidence did not always correspond to deeper engagement, indicating that confidence may mask underlying uncertainties if not critically regulated. Overall, confidence is best understood as a situated, distributed, and regulated form of control—emerging dynamically through the interaction between prior knowledge, task demands, and social context.

Persistence emerged as a key dimension in the enactment of MD, reflected not merely in sustained effort but in how students regulate their engagement when encountering difficulty. Across data sources, persistence appeared as an adaptive process involving effort, strategy adjustment, and reflective continuation rather than simple task endurance. Persistence was conceptualized as sustained, goal-directed effort over time, including the ability to maintain engagement, endure cognitive demands, and adapt strategies in response to challenges. Codes such as task endurance and sustained engagement reflect the temporal dimension of persistence, while adaptive persistence captures students' ability to sustain effort through feedback and revision.

Quantitative patterns (Table 3) show that while all participants demonstrated sustained energy and serious effort in individual tasks (5/5), indicators such as "task endurance" were less consistent (3/5), suggesting that persistence involves maintaining engagement despite fluctuating affective states. In group settings, persistence remained relatively strong but showed slight variation across indicators (4/5), indicating sensitivity to interaction dynamics. The persistence-related codes were refined to capture sustained and adaptive forms of effort. Rather than focusing solely on observable behaviors such as enthusiasm or lack of boredom, persistence was interpreted as a combination of endurance, sustained engagement, and the ability to adapt effort through feedback during problem-solving.

Table 3. Quantification of Persistence-Related Codes

Setting	Code	Positive (+)	Negative (–)
Individual Task	Serious effort	5	0
	Sustained engagement	5	0
	Task endurance	3	2
Group Task	Adaptive persistence	5	0
	Task endurance	4	1
	Sustained engagement	4	1
	Serious effort	4	1

Observational and written data revealed that students maintained engagement even when tasks became challenging, as reflected in multi-step solutions, revisions, and organized reasoning. Interview data further indicated that persistence was enacted strategically. For example, one participant explained: "*I found it difficult at first, but I looked for similar problems so that I could understand how to solve it*." (T01, Int._2), while another described an iterative process: "*I tried to understand it by reviewing the material and practicing again until I finally understood*." (T02, Int._2). These responses suggest that persistence operates as a cyclical process of attempting, revising, and understanding, closely linked to self-regulation and learning strategies. Notably, even participants with lower confidence demonstrated persistence, as reflected in: "*I tried my best to complete the task seriously*." (T03, Int._1), indicating that persistence can function independently of confidence.

Self-assessment data reinforced this pattern, with students frequently selecting descriptors such as challenged, motivated, and trying hard, suggesting that difficulty often triggered continued effort rather than disengagement. However, persistence was not uniformly sustained. Some participants reported fatigue, boredom, or time pressure, which reduced the depth of engagement: "*The time given was limited, so I felt rushed when completing the task*." (T01, Int._2). These findings indicate that persistence is sensitive to external constraints, where regulated effort may shift toward task completion under pressure.

In collaborative contexts, persistence became socially influenced. While some students maintained active engagement, others relied more on peers, indicating that persistence, like confidence, can be redistributed depending on group roles and participation. Overall, persistence is best understood as an adaptive and regulated form of effort—emerging dynamically through students' responses to difficulty, shaped by self-regulation, and influenced by both internal motivation and contextual conditions.

Flexibility was conceptualized as the ability to shift strategies, consider alternative approaches, and adapt thinking in response to task demands. Codes such as flexible use of resources and strategy adjustment reflect cognitive flexibility, while considering alternative perspectives captures the social dimension of flexibility in collaborative settings. Flexibility emerged as a critical dimension in the enactment of MD, reflected in students' ability to adapt strategies, utilize multiple resources, and respond to varying task demands. However, this flexibility was not uniformly distributed, but ranged from strategic adaptation to more constrained engagement. The flexibility-related codes were refined to capture students' ability to shift strategies, utilize resources adaptively, and consider alternative perspectives. Rather than focusing on surface-level behaviors, flexibility was interpreted as a dynamic and context-dependent process involving both cognitive and social adaptation. Quantitative patterns (Table 4) show that all participants used multiple resources (flexible use of resources) in individual tasks (5/5), while flexibility in collaborative contexts was less consistent, particularly in adapting to peer interaction (3/5), indicating that flexibility is more stable at the individual level than in group settings.

Table 4. Quantification of Flexibility-Related Codes

Setting	Code	Positive (+)	Negative (–)
Individual Task	Flexible use of resources	5	0
	Flexible strategy use	4	1
Group Task	Flexible strategy use	4	1
	Considering alternative perspectives	4	1
	Adaptive strategy use in collaboration	3	2

Observational and interview data indicate that some participants enacted flexibility as a strategic process of selecting and integrating resources. For example, one student explained: "*We used Google, AI* (=Artificial Intelligence), *and textbooks, then chose the approach that was easiest to understand*." (T02, Int._1), suggesting that flexibility involves evaluative decision-making rather than mere access to tools. This pattern was sustained in reflection: "*I used different tools such as Google, my notes, and sometimes AI to make the process faster and more efficient*." (T02, Int._2). These responses indicate that flexibility is both enacted and consciously recognized as part of an efficient problem-solving strategy. Written work further supported this, showing variation in approaches, organization of data, and verification of results. However, not all participants demonstrated this level of flexibility. Some showed more constrained engagement, relying on a single familiar method: "*I mainly relied on the notes provided by the teacher*." (T03, Int._1). In such cases, flexibility was limited to procedural execution rather than adaptive problem solving. Self-assessment data further reflected this variation, with some students reporting exploratory engagement, while others expressed confusion that limited their willingness to try alternative strategies.

In collaborative contexts, flexibility became socially mediated. Active participants demonstrated the ability to negotiate ideas and integrate multiple perspectives, whereas others tended to follow dominant approaches without significant contribution. This suggests that flexibility is influenced not only by cognitive capacity but also by social positioning within the group. Overall, flexibility is best understood as a strategic and context-sensitive form of adaptation, emerging dynamically through interaction with resources, tasks, and peers rather than as a fixed individual skill.

Reflection was conceptualized as students' ability to evaluate, monitor, and revise their thinking during and after problem solving. Codes such as self-evaluation and verification capture metacognitive processes that go beyond task completion and indicate deeper engagement with mathematical reasoning. Reflection emerged as a higher-order dimension in the enactment of MD, functioning as a form of metacognitive monitoring through which students evaluate, verify, and regulate their problem-solving processes. However, its enactment was uneven across participants. Quantitative patterns (Table 5) show that while Evaluating solution process in problem solving was generally strong (4/5), self-checking and verification was less consistently observed, particularly in individual tasks (2/5), indicating that reflection is not automatically activated during problem solving. The reflection-related codes were refined to capture students' metacognitive engagement, particularly their ability to evaluate, monitor, and verify their thinking processes. Reflection was not interpreted as general attitudes toward mathematics but as active regulation of understanding during problem solving.

Table 5. Quantification of Reflection-Related Codes

Setting	Code	Positive (+)	Negative (–)
Individual Task	Evaluating solution process	4	1
	Self-evaluation of understanding	3	2
	Self-checking and verification	2	3
Group Task	Shared evaluation of understanding	4	1
	Evaluating group solution	3	2
	Collective verification	3	2

Observational and interview data indicate that some students engaged in basic forms of reflection, primarily through verification of answers. For example, participants stated: "*I checked my answer briefly before submitting it*." (T01, Int._1), suggesting that reflection was enacted as procedural checking. This pattern was also evident in written work through revisions and improved organization. Reflection was not consistently sustained. In some cases, confidence reduced the perceived need for verification: "*Because we were already confident, we did not check the answer again*." (T01, Int._1). This indicates that confidence, when unregulated, can suppress reflection and weaken evaluative control. Importantly, this tendency was reconsidered during reflective interviews: "*Even though I trust my group, I still check the answer again to make sure it is correct*." (T01, Int._2), suggesting that reflection can be reconstructed through metacognitive awareness.

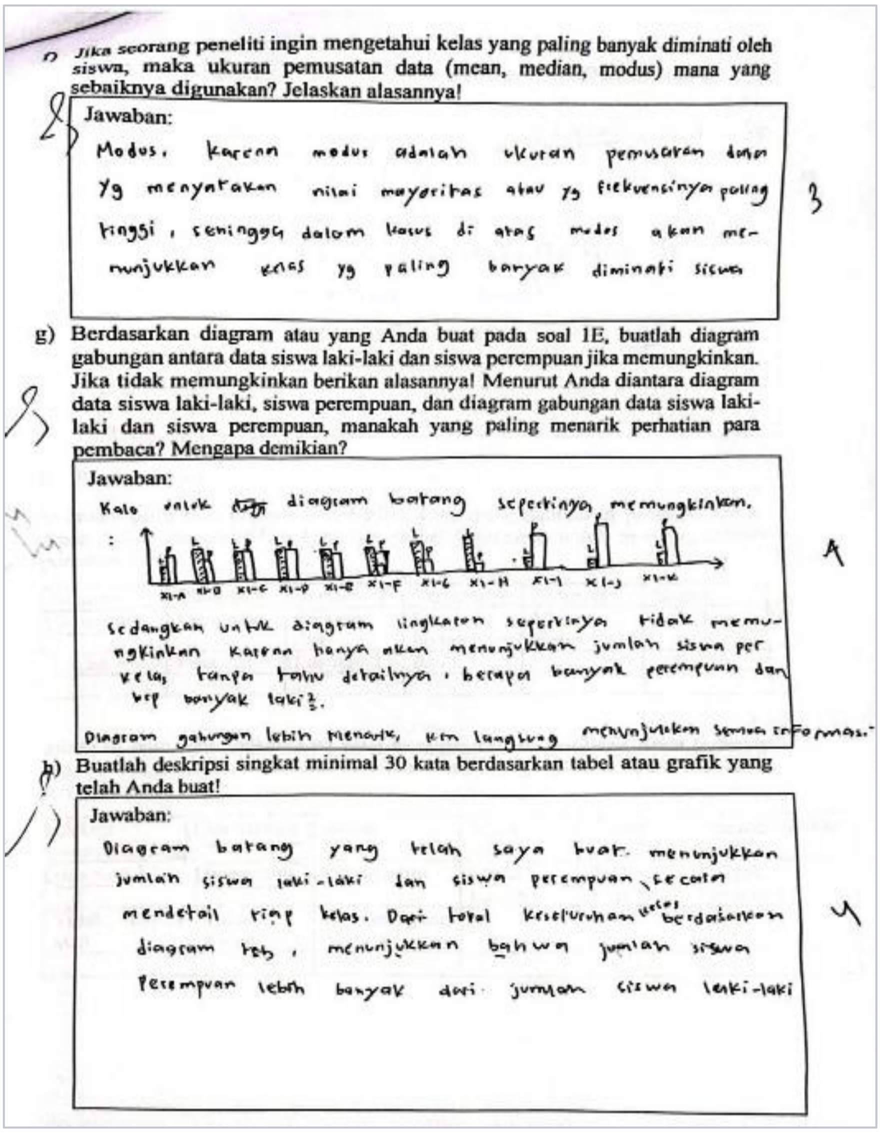
Self-assessment and observational data further indicate that reflection is sensitive to contextual constraints. Factors such as time pressure and task conditions influenced whether students engaged in reflective processes, with some prioritizing task completion over verification. In collaborative contexts, reflection also became socially distributed. While some students actively evaluated group solutions, others relied on peers without independently verifying answers, indicating that reflection may be unevenly enacted within groups. Overall, reflection functions as a conditional and regulated form of metacognitive control. It is not automatically triggered by competence or confidence, but emerges through the interaction of self-regulation, contextual constraints, and social dynamics. As such, reflection differentiates deeper mathematical engagement from superficial task completion.

The findings across the five dimensions—curiosity, confidence, persistence, flexibility, and reflection—suggest that MD is best understood as an interconnected and dynamically enacted system rather than a set of independent traits. Each dimension contributes to different phases of problem solving: curiosity initiates engagement, confidence enables commitment, persistence sustains effort, flexibility supports adaptation, and reflection regulates and refines the process. These dimensions operate relationally rather than linearly, where the absence or imbalance of one dimension can constrain the effectiveness of others (e.g., confidence without reflection leading to overconfidence, or persistence without flexibility resulting in unproductive effort). Taken together, these findings position

MD as an integrated system of engagement—comprising curiosity, confidence, persistence, flexibility, and reflection—that operates dynamically across individual and social contexts. Importantly, this system is highly sensitive to context. In individual settings, MD is primarily internally regulated, while in collaborative contexts, it becomes socially mediated and distributed across group members. The integration of observational data, written work, self-assessment, and interview data demonstrates that MD operates across multiple layers—as observable behavior, subjective experience, and reflective reconstruction. These findings support a reconceptualization of MD as a dynamic, context-sensitive, and multi-layered system of engagement that emerges through interaction with tasks, tools, and social environments.

The findings indicate that all selected participants demonstrated high levels of ML, particularly in their ability to interpret contextual problems, apply appropriate mathematical concepts, and produce correct solutions. However, beyond correctness, the analysis reveals that ML is not merely a cognitive outcome but an enacted competence that varies in depth and quality across participants. Students' written work provides the most direct evidence of their ML. Across tasks involving statistical concepts such as mean, median, and mode, participants were able to identify relevant information, perform accurate calculations, and present appropriate conclusions. Their solutions often showed structured reasoning, including step-by-step procedures and clear organization of data. This indicates that students were not only capable of executing procedures but also of connecting mathematical concepts to contextual situations.

This is exemplified in students' responses to contextual questions, where they were required to justify the use of a particular measure of central tendency. As shown in Figure 2, one participant correctly identified the mode as the most appropriate measure to determine the most preferred class, and supported the answer with a contextual explanation by linking the concept of mode to the highest frequency. In addition, students demonstrated the ability to interpret and compare graphical representations, such as deciding between bar charts and line graphs for presenting combined data, and providing reasoning based on clarity and completeness of information. Furthermore, students were able to produce descriptive interpretations of data, explaining trends and comparisons (e.g., differences between male and female students) in a coherent manner.



f) Jika seorang peneliti ingin mengetahui kelas yang paling banyak diminati oleh siswa, maka ukuran pemusatan data (mean, median, modus) mana yang sebaiknya digunakan? Jelaskan alasannya!

Jawaban:
Modus. karena modus adalah ukuran pemusatan data yg menyatakan nilai mayoritas atau yg frekuensinya paling tinggi, sehingga dalam kasus di atas modus akan menunjukkan kelas yg paling banyak diminati siswa

g) Berdasarkan diagram atau yang Anda buat pada soal 1E, buatlah diagram gabungan antara data siswa laki-laki dan siswa perempuan jika memungkinkan. Jika tidak memungkinkan berikan alasannya! Menurut Anda diantara diagram data siswa laki-laki, siswa perempuan, dan diagram gabungan data siswa laki-laki dan siswa perempuan, manakah yang paling menarik perhatian para pembaca? Mengapa demikian?

Jawaban:
Kalo untuk diagram batang sepertinya memungkinkan.

sedangkan untuk diagram lingkaran sepertinya tidak memungkinkan karena hanya akan menunjukkan jumlah siswa per kelas, tanpa tahu detailnya. berapa banyak perempuan dan brp banyak laki².

Diagram gabungan lebih menarik, krn langsung menunjukkan semua informasi.

h) Buatlah deskripsi singkat minimal 30 kata berdasarkan tabel atau grafik yang telah Anda buat!

Jawaban:
Diagram batang yang telah saya buat. menunjukkan jumlah siswa laki-laki dan siswa perempuan secara mendetail tiap kelas. Dari total keseluruhan kelas berdasarkan diagram tsb, menunjukkan bahwa jumlah siswa perempuan lebih banyak dari jumlah siswa laki-laki

Figure 2. Example of a Student’s Written Response Demonstrating Mathematical Literacy through Selecting an Appropriate Measure of Central Tendency (Mode), Interpreting Graphical Representations, and Providing Contextual Justification and Data Description

These responses indicate that students' ML extends beyond procedural accuracy to include interpretation, justification, and communication of results in context. This level of competence corresponds to what can be characterized as proficient ML, where students are able to interpret, formulate, and solve problems in meaningful contexts. However, closer examination reveals variations in how this literacy was enacted. While some students provided well-justified and contextually grounded explanations, others produced correct answers with limited elaboration, suggesting differences in the depth of their mathematical reasoning.

Some students demonstrated deeper forms of literacy, characterized by explicit justification, interpretation of results, and connection to context. Their written responses included explanations that went beyond calculation, indicating an understanding of the meaning of mathematical results within the given situation. This suggests that their literacy is not only procedural but also interpretive. In contrast, other students, while producing correct answers, demonstrated more procedural forms of literacy. Their solutions were accurate but minimally explained, with limited evidence of interpretation or reflection. This indicates that correctness alone does not fully capture the depth of ML.

Interview data further supports this distinction. Some students articulated clear reasoning and understanding of the concepts used, while others focused primarily on procedural execution. For instance, one participant explained: "*I found it difficult at first, but I looked for similar problems so that I could understand how to solve it.*" (T01, Int._2) This response indicates that the student engaged not only in procedural work but also in understanding the underlying concepts through strategic effort. In contrast, other students tended to focus on applying known procedures without deeper exploration. This suggests that ML is experienced and expressed differently, even among students classified within the same performance level. Importantly, the enactment of ML was closely related to students' MD. Students who demonstrated strong dispositions—such as curiosity, persistence, and reflection—tended to produce more structured, justified, and meaningful solutions. In contrast, students with less consistent dispositions often produced correct but less elaborated responses, indicating a more procedural form of engagement.

Collaborative contexts also influenced how ML was enacted. In group settings, some students were able to articulate their reasoning more clearly through discussion, while others relied on peers without fully engaging in the reasoning process. This indicates that ML, like DM, can be socially mediated and redistributed across group members. Self-assessment data further highlights this variation. While students generally perceived the tasks as manageable or moderately challenging, their reported experiences ranged from confident understanding to confusion, suggesting that literacy is not only demonstrated through performance but also experienced subjectively. Overall, the findings suggest that ML should be understood as a contextualized and enacted competence. It involves not only the ability to produce correct answers but also the capacity to interpret, justify, and communicate mathematical reasoning in relation to context. Moreover, its enactment is closely intertwined with MD, indicating that cognitive and affective dimensions of learning are inseparable in practice.

This study set out to explore how MD is manifested among students with high ML during engagement with MLTs. The findings extend existing research by demonstrating that MD is not a stable affective trait but an enacted, dynamic, and context-sensitive system of engagement. This perspective builds on Hannula's (2020) view of affect in mathematics education as a dynamic and multidimensional phenomenon involving the interaction of beliefs, emotions, and motivations. While Hannula primarily provides a conceptual account of how these affective dimensions interact, the present study contributes by demonstrating how they are enacted, coordinated, and reshaped during mathematical literacy problem-solving through students' engagement with tasks, peers, and learning contexts. While previous studies have emphasized the components of affect, the present study contributes by illustrating how these components emerge and interact during problem-solving processes. This interpretation is also consistent with contemporary perspectives on educational phenomena that emphasize understanding processes through the coordinated actions and interactions that occur in practice, rather than through isolated individual attributes (Schoenfeld, 2023). In this sense, MD is not something students possess, but something they do. Importantly, this study addresses a gap in the literature by providing a qualitative, process-oriented account of how MD is enacted in real classroom contexts, particularly within the Indonesian secondary education system where ML is emphasized through the AKM.

This finding has important implications for teacher practices in Indonesian classrooms, particularly in designing learning environments that go beyond content delivery to actively engage students in meaningful problem-solving (OECD, 2023; NCTM, 2000). Teachers may need to provide opportunities for students to explore, discuss, and reflect on their thinking, for example through AKM-type contextual tasks and collaborative activities that promote reasoning and interaction (Wijaya et al., 2015), as well as through guided reflection to support metacognitive awareness (Schukajlow et al., 2021). In this way, ML can be intentionally developed as part of the learning process rather than assumed as a fixed characteristic. This is particularly relevant in the Indonesian context, where numeracy-based learning emphasizes not only cognitive outcomes but also students' engagement in meaningful, context-based problem solving (Pusat Asesmen Pendidikan, 2024).

The findings reveal that confidence functions as a form of perceived control, closely related to students' ability to act on their reasoning. This supports the control-value framework proposed by Reinhard Pekrun, which highlights the role of perceived control in shaping achievement emotions and engagement (Pekrun et al., 2017; Schukajlow et al., 2021). However, the present study extends this framework by demonstrating that control is not solely internal but can be socially distributed. In collaborative contexts, students' confidence was reconfigured through interaction, enabling participation even among those who initially lacked self-confidence. At the same time, excessive confidence led to reduced reflection, suggesting that control must be balanced by metacognitive regulation. These findings resonate with research on social interaction in learning, which emphasizes that cognition and affect are co-constructed in social settings (Cobb, 2007), but they further highlight that confidence can shift from productive engagement to overconfidence, a nuance that has received limited attention in prior studies. In the Indonesian classroom context, these findings suggest that teachers can actively support the development of students' confidence by designing learning environments that provide both individual accountability and collaborative support. For example, teachers may use structured group work with clearly defined roles, encourage students to explain and justify their reasoning, and incorporate questioning strategies that prompt students to reflect on the validity of their answers (NCTM, 2000; OECD, 2023). In addition, providing formative feedback and opportunities for success in AKM-type contextual tasks can help strengthen students' perceived control while preventing overconfidence by maintaining a focus on reasoning and verification.

The study also reveals that persistence and flexibility function as complementary processes in regulating engagement. Persistence enables students to sustain effort in the face of difficulty, while flexibility allows them to adapt strategies and explore alternative approaches. This finding is consistent with research on adaptive expertise and mathematical modelling (Kaiser & Stender, 2022; Ferri, 2018), which emphasizes the importance of flexible thinking in complex problem solving. However, the present study adds nuance by showing that persistence without flexibility may lead to unproductive repetition, whereas flexibility without persistence may result in fragmented engagement. Furthermore, these processes align with broader frameworks of student engagement (Fredricks et al., 2004), which conceptualize engagement as a multidimensional construct involving behavioral, cognitive, and emotional components. The findings reinforce that persistence and flexibility are not purely cognitive skills but are deeply intertwined with affective and motivational factors.

In practical terms, this interplay can be supported in Indonesian classrooms through task-based learning, particularly using AKM-type contextual problems that require students to interpret data, test alternative strategies, and revise their solutions. Teachers can scaffold persistence by encouraging students to remain engaged when encountering difficulty, while simultaneously promoting flexibility through prompts such as comparing multiple solution methods, justifying different approaches, or using various resources (e.g., tables, diagrams, or digital tools) to solve the same problem (OECD, 2023; Wijaya et al., 2015).

Reflection emerged as a key mechanism that regulates the enactment of MD. Students who engaged in reflective practices were more likely to verify their solutions, identify errors, and refine their reasoning. This supports prior research on metacognition (Sinatra et al., 2015), which emphasizes the role of reflective thinking in conceptual understanding. However, the present study extends this perspective by demonstrating that reflection is not automatically activated by competence. Instead, it is contingent upon factors such as confidence, time constraints, and social dynamics. In particular, the finding that overconfidence can suppress reflection highlights an important gap in the literature, where confidence is often treated as uniformly positive. This study shows that without regulation, confidence may reduce critical evaluation, thereby affecting the quality of mathematical reasoning. Therefore, teachers need to intentionally scaffold reflection in classroom practice. This can be done by incorporating structured reflection prompts (e.g., "How do you know your answer is correct?" or "Is there another way to verify this solution?"), allocating specific time for checking and revising answers, and embedding reflective discussion in both individual and group activities (NCTM, 2000; Schukajlow et al., 2021). In addition, teachers can model reflective thinking and encourage students to justify and evaluate their reasoning, ensuring that reflection becomes an integral part of problem solving rather than an optional final step.

Consistent with the framework of the OECD (2019, 2023), ML involves the ability to formulate, employ, and interpret mathematics in real-world contexts. The findings confirm that all participants demonstrated this competence at a high level. However, this study extends the OECD framework by showing that ML is not only a cognitive outcome but an enacted competence. Although the participants demonstrated high levels of ML, the depth of interpretation, justification, and reasoning varied considerably across problem-solving situations. These variations were closely linked to differences in MD and have important implications for differentiated instruction in Indonesian classrooms, where students with similar levels of cognitive achievement may require different forms of instructional support depending on how their dispositions are enacted. In this context, differentiated instruction refers to instructional practices that adapt content, process, and learning support based on students' readiness, interests, and learning profiles, allowing each student to engage meaningfully according to their needs (Tomlinson, 2000; Cahyanti et al., 2024; Rohmah, 2024). Teachers may need to differentiate not only in terms of task difficulty but also in the type of scaffolding provided, such as offering additional prompts for students who need support in reflection, encouraging exploration for those with limited curiosity, or providing structured guidance for students who demonstrate lower confidence.

The findings of the present study resonate with recent developments in Indonesian mathematics education, which position ML not merely as a set of computational skills but as a meaningful learning context that requires students to understand problems, plan strategies, apply mathematical reasoning, and interpret solutions in authentic situations (Simamora et al., 2025). From this perspective, success in mathematical learning depends not only on mastering mathematical content but also on students' ability to engage productively with contextual tasks. This view complements earlier studies on context-based problem solving, which show that Indonesian students may experience difficulties in interpreting and mathematizing real-world situations despite possessing procedural knowledge

(Wijaya et al., 2014, 2015). It also aligns with current educational priorities in Indonesia, where differentiated instruction has been promoted through the Kurikulum Merdeka to accommodate students' diverse characteristics and learning needs. Taken together, these perspectives support the findings of the present study by suggesting that ML and MD.

The present study adds that even when students succeed cognitively, the quality of their engagement depends on how their disposition is enacted. Taken together, the findings support an integrated view of mathematical learning in which disposition and literacy are mutually constitutive. MD operates as a system of engagement that activates, sustains, and regulates the use of mathematical knowledge, while ML provides the cognitive foundation for meaningful problem solving. This integrated perspective challenges the traditional separation between cognitive and affective domains in mathematics education (Kilpatrick et al., 2001; NCTM, 2000). Instead, it positions learning as a holistic process in which thinking, feeling, and acting are intertwined.

From a theoretical perspective, this study contributes to the reconceptualization of MD as an enacted and relational construct. It highlights the need for future research to move beyond measuring disposition as a static variable and instead examine how it unfolds in real-time activity (Hannula, 2020). From a practical perspective, the findings suggest that mathematics instruction should be designed to support not only cognitive development but also the enactment of productive dispositions. This includes designing contextual and open-ended tasks (OECD, 2019; Pepin et al., 2021), fostering collaborative learning environments, and promoting reflective practices that support metacognitive regulation. In line with differentiated instruction practices, teachers can systematically adjust learning processes—for example by varying the level of guidance, structuring peer interaction, and providing targeted feedback—to respond to differences in students' disposition profiles and optimize both engagement and learning outcomes (Agustin, 2023; Pitaloka, 2025).

CONCLUSION

This study demonstrates that MD among students with high ML is not a stable attribute, but a dynamic, context-sensitive system enacted during engagement with MLTs. The findings show that curiosity, confidence, persistence, flexibility, and reflection function as interconnected dimensions that shape how students engage with problems and regulate their reasoning. While all participants produced correct solutions, variations in the depth of engagement indicate that ML provides the cognitive foundation, whereas MD determines how that knowledge is enacted in practice. MD operates across multiple layers—observable actions, subjective experiences, and reflective processes—and is influenced by both individual and social contexts.

From a theoretical perspective, this study contributes to the reconceptualization of MD as an enacted and process-oriented construct, emphasizing the integration of cognitive and affective dimensions in mathematical activity. From a practical perspective, the findings highlight the importance of designing learning environments that support the development of productive dispositions. This includes the use of contextual and open-ended tasks, collaborative learning opportunities, and structured reflection to support students' engagement and metacognitive regulation. Attention to task design and classroom conditions, such as time allocation and interaction patterns, is also essential in supporting how MD is enacted.

This study is limited by its focus on a small number of participants with high ML, which may limit generalizability. Future research is recommended to examine how MD is enacted across different levels of ML and to explore instructional interventions that support the development of disposition over time. Longitudinal and classroom-based studies may further enhance understanding of how MD evolves in authentic learning environments. Overall, this study highlights that MD is not something students possess, but something they actively enact and regulate, offering new directions for research and practice in mathematics education.

REFERENCE

Alali, R., & Wardat, Y. (2024). Exploring students' mathematical literacy: The role of self-efficacy and learning environment. *Environment and Social Psychology, 9*(8), Article 2838. https://doi.org/10.59429/esp.v9i8.2838

Alan H. Schoenfeld. (2023). A theory of teaching. In A. K. Praetorius & C. Y. Charalambous (Eds.), *Theorizing teaching: Current status and open issues* (pp. 159–187). Springer. https://doi.org/10.1007/978-3-031-25613-4_6

Bolstad, O. H. (2023). Lower secondary students' encounters with mathematical literacy. *Mathematics Education Research Journal, 35*, 237–253. https://doi.org/10.1007/s13394-021-00386-7

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE Publications.

Ferri, R. (2018). Learning how to teach mathematical modelling. *ZDM Mathematics Education, 50*(1–2), 7–17. https://doi.org/10.1007/s11858-017-0933-8

Cobb, P. (2007). Putting philosophy to work: Coping with multiple theoretical perspectives. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 3–38). Information Age Publishing.

Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). Sage.

Dole, S., & Geiger, V. (2018). *Numeracy across the curriculum: Research-based strategies for enhancing teaching and learning*. Routledge. https://doi.org/10.4324/9781003116585

Fairus, Fauzi, A., & Sitompul, P. (2023). Analisis kemampuan disposisi matematis pada pembelajaran matematika siswa SMKN 2 Langsa. *Jurnal Cendekia: Jurnal Pendidikan Matematika, 7*(3), 2382–2390. https://doi.org/10.31004/cendekia.v7i3.2549

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059

Hannula, M. S. (2020). Affect in mathematics education. In S. Lerman (Ed.), *Encyclopedia of mathematics education*. Springer. https://doi.org/10.1007/978-3-030-15789-0_174

Kaiser, G., & Stender, P. (2022). Mathematical modelling in mathematics education: Recent developments and future directions. *ZDM Mathematics Education, 54*, 1–15. https://doi.org/10.1007/s11858-022-01357-0

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding it up: Helping children learn mathematics*. National Academy Press.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. National Council of Teachers of Mathematics.

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods, 16*(1), 1–13. https://doi.org/10.1177/1609406917733847

Organisation for Economic Co-operation and Development. (2019). *PISA 2018 assessment and analytical framework*. OECD Publishing. https://doi.org/10.1787/b25efab8-en

Organisation for Economic Co-operation and Development. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Pepin, B., Xu, B., Trouche, L., & Wang, C. (2021). Developing mathematical thinking in digital environments: Theoretical perspectives and design principles. *ZDM Mathematics Education, 53*, 1–13. https://doi.org/10.1007/s11858-021-01263-7

Pusat Asesmen Pendidikan. (2024). *Profil satuan pendidikan dengan capaian AKM tinggi pada jenjang SMA/SMK/MA/sederajat*. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Schukajlow, S., Rakoczy, K., & Pekrun, R. (2021). Emotions and motivation in mathematics education: Theoretical considerations and empirical findings. *Educational Psychology Review, 33*, 1–28. https://doi.org/10.1007/s10648-020-09534-9

Simamora, R. E., Maulana, R. D., & Rahayu, S. W. (2025). STAD cooperative learning with worksheets for mathematical problem solving in a numeracy context. *Mathematics Education and Application Journal (META), 7*(2), 107–117.

Sinatra, G. M., Heddy, B. C., & Lombardi, D. (2015). The challenges of conceptual change in science and mathematics education. *Educational Psychologist*, *50*(1), 1–13. https://doi.org/10.1080/00461520.2014.1002924

Stillman, G. (2019). Modelling in mathematics education. *ZDM Mathematics Education*, *51*, 1–12. https://doi.org/10.1007/s11858-019-01013-2

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

von Glasersfeld, E. (1995). *Radical constructivism: A way of knowing and learning*. Falmer Press.

Wijaya, A., van den Heuvel-Panhuizen, M., & Doorman, M. (2014). Difficulties in solving context-based mathematics problems: An analysis of students' errors. *Educational Studies in Mathematics, 86*(1), 43–65. https://doi.org/10.1007/s10649-013-9515-8

Wijaya, A., van den Heuvel-Panhuizen, M., & Doorman, M. (2015). Opportunity-to-learn context-based tasks provided by mathematics textbooks. *ZDM Mathematics Education*, *47*(2), 273–285. https://doi.org/10.1007/s11858-014-0645-6

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Sage.