



Self-Efficacy and Cognitive Bias in Students' Mathematical Literacy on the Pythagorean Theorem

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Abstract

This descriptive qualitative study examined how self-efficacy and cognitive bias related to the mathematical literacy of 29 Grade VIII students at a public junior high school in Yogyakarta on the Pythagorean theorem. Data were collected through a two-item essay literacy test, a self-efficacy questionnaire, a cognitive bias questionnaire, and semi-structured interviews with six purposively selected subjects, and were verified through technique triangulation. Four students showed high, 18 moderate, and 7 low mathematical literacy. The subject with low cognitive bias fulfilled all five literacy indicators; subjects with moderate self-efficacy and cognitive bias fulfilled four but omitted interpreting and communicating results; low-literacy subjects fulfilled two or none and reported low confidence and reliance on peers despite moderate-to-high questionnaire self-efficacy. Self-efficacy appeared related to engagement and persistence, whereas cognitive bias appeared related to verification and communication quality. Attending to students' task-level confidence and reasoning shortcuts may help strengthen mathematical literacy.

Keywords: *cognitive bias; mathematical literacy; Pythagorean theorem; qualitative study; self-efficacy*

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INTRODUCTION

Mathematical literacy is a foundational competency in twenty-first century education, enabling students to formulate, employ, and interpret mathematics across diverse real-world contexts (OECD, 2023). The Programme for International Student Assessment (PISA) defines mathematical literacy as the capacity to reason mathematically and to use mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena (OECD, 2023). Despite its recognised importance, Indonesian students continue to perform poorly on international benchmarks: in PISA 2022, Indonesia obtained an average mathematics score of 366, well below the OECD average of 472, and was widely reported as ranking 70th of 81 participating countries and economies (OECD, 2023). Nationally, the Indonesian National Assessment Programme (INAP) found that 77.13% of students demonstrated low mathematical literacy, with only 2.29% reaching the high category (Satgas Gerakan Literasi Sekolah Kemendikbud, 2018). This persistently

low performance has continued despite successive curriculum reforms and assessment initiatives aimed at strengthening higher-order thinking and PISA-aligned competencies (Damanik & Handayani, 2023), suggesting that structural and curricular interventions may need to be complemented by closer attention to the psychological processes involved in how individual students engage with mathematical tasks.

Understanding the factors associated with variation in mathematical literacy is therefore a pressing research agenda. Among individual psychological variables, self-efficacy has attracted sustained scholarly interest. Bandura (1997) defines self-efficacy as an individual's belief in their capacity to execute the behaviours required to produce specific outcomes, a belief formed through four principal sources: mastery experience, vicarious experience, verbal persuasion, and physiological and affective states. In mathematical learning, these sources are theorised to translate into concrete behaviours: students who have previously succeeded on similar problems tend to approach new tasks with greater persistence, and those who observe capable peers succeed may be more willing to attempt unfamiliar problem types, so that self-efficacy is expected to be accompanied by greater effort, more flexible strategy use, and resistance to giving up when a solution is not immediately apparent (Samsuddin & Retnawati, 2022). Empirical studies in Indonesian schools are broadly consistent with this view. In a survey of 436 Grade VIII students in Yogyakarta, Nisa and Arliani (2023) found that students with higher mathematical self-efficacy tended to show higher mathematical literacy and to sustain effort on literacy tasks, and descriptive studies have reported that students with high self-efficacy fulfil more mathematical literacy indicators than peers with moderate or low self-efficacy (Ananda & Wandini, 2022; Geraldine & Wijayanti, 2022; Yulianah et al., 2022). Self-efficacy has also been linked to mathematics learning outcomes more generally (Fariha & Rachmatika, 2024).

A less-studied but potentially consequential factor is cognitive bias, that is, systematic deviations in thinking that distort the perception, processing, and interpretation of information (Haselton et al., 2005; Kahneman et al., 2011). Cognitive biases discussed in educational and decision-making settings include the illusion of control (overestimating one's control over an outcome), overconfidence (overestimating one's own competence or accuracy), the bandwagon effect (adopting others' answers or opinions without independent reasoning), and the belief in the law of small numbers (drawing firm conclusions from limited information) (Bélanger & Blanchette, 2022; Esposito et al., 2023; Kim & Park, 2020). While research on cognitive bias in general decision-making is extensive, existing studies predominantly examine self-efficacy and cognitive characteristics separately, leaving limited understanding of how confidence beliefs and cognitive distortions co-occur during mathematical literacy processes. This gap is particularly pronounced in the Indonesian junior secondary context, where the manifestation of cognitive bias in students' mathematical literacy work remains underexplored.

Prior research on related themes illustrates this fragmentation. On one side, studies such as Usman and Kristiawati (2022), Geraldine and Wijayanti (2022), and Nisa and Arliani (2023) examined mathematical literacy primarily through the lens of prerequisite mastery or self-efficacy, without attending to the cognitive distortions that might simultaneously be present in students' reasoning. On the other side, studies grounded in the heuristics-and-biases tradition (Bélanger & Blanchette, 2022; Esposito et al., 2023; Kahneman et al., 2011) have documented cognitive bias as a general judgement phenomenon but rarely situate it within students' mathematical problem-solving. Yuliyani and Setyaningsih (2022) come closest by showing that students' cognitive style was associated with their PISA-based mathematical literacy performance, yet cognitive style is a relatively stable disposition rather than the situational, correctable distortions captured by

the cognitive bias construct. This separation matters because self-efficacy and cognitive bias are theorised to operate on different sides of the same problem-solving process, self-efficacy as a motivational basis for engagement and persistence and cognitive bias as a distortion of the reasoning process itself, such that a student may appear confident yet reason poorly, or appear uncertain yet reason soundly. Examining the two constructs in isolation therefore risks producing an incomplete account of students' success or difficulty on mathematical literacy tasks. To our knowledge, no study has examined self-efficacy and cognitive bias together, at the level of individual students, in relation to mathematical literacy on the Pythagorean theorem, a core Grade VIII content area in which students commonly make errors stemming from both procedural misconceptions and distorted reasoning (Ling & Loh, 2023).

The novelty of the present study therefore lies in the integration of two constructs, self-efficacy and cognitive bias, that prior research has treated separately, rather than in the qualitative method itself or the choice of the Pythagorean theorem as content, both of which have precedents in the literature. Specifically, the study examines, within individual students, how the two constructs co-occur with performance on the five mathematical literacy indicators: formulating, applying, reasoning, interpreting and communicating, and evaluating. By triangulating test, questionnaire, and interview data from six purposively selected subjects, the study seeks to provide a nuanced portrait of the psychological patterns that accompany mathematical literacy performance. Theoretically, the study brings Bandura's (1997) self-efficacy framework and the heuristics-and-biases perspective (Kahneman et al., 2011) into a single descriptive account of mathematical literacy; practically, its findings are intended to inform classroom interventions that address motivational and cognitive barriers together rather than in isolation. This research aimed to: (1) describe the distribution of mathematical literacy, self-efficacy, and cognitive bias levels in the study class; (2) describe the mathematical literacy performance of six selected subjects in relation to their self-efficacy and cognitive bias profiles; and (3) describe how self-efficacy and cognitive bias jointly relate to students' mathematical literacy.

METHODS

This study employed a descriptive qualitative design aimed at producing a rich, detailed description of the phenomena under investigation without experimental manipulation (Sugiyono, 2018). The research was conducted at SMP Negeri 9 Yogyakarta, a state junior secondary school in the Kotagede district of Yogyakarta City, Indonesia, during the even semester of the 2023/2024 academic year (February–April 2024). The target class was VIII-E, comprising 29 students, selected on the recommendation of the mathematics teacher as a class with balanced academic and non-academic profiles and minimal prior participation in research studies. The mathematical literacy test was administered on 29 February 2024 and the two questionnaires on 4 March 2024; interviews with the six selected subjects were conducted after the test and questionnaires had been scored.

The study used three data collection instruments and an interview guideline; representative items are presented in Table 1. First, a two-item essay mathematical literacy test on the Pythagorean theorem was adopted from Khorifah et al. (2023). Item 1 presented a ladder leaning against a building that slides 1 m away from the wall and asked whether the top of the ladder also moves down by 1 m; Item 2 presented a ship driven off course by a storm and asked how close it could return to the harbour with its remaining fuel. Both items are multi-step contextual problems, and, following the test blueprint, each item was used to assess all five mathematical literacy indicators: formulating situations mathematically; applying concepts, facts, and procedures; reasoning and argumentation;

interpreting and communicating results; and evaluating results and drawing conclusions. Responses were scored with an analytic rubric in which the five indicators received 0–2, 0–3, 0–3, 0–2, and 0–1 points respectively, giving a maximum of 11 points per item and 22 points in total, which were converted to a 0–100 scale. Students worked individually for 20 minutes without calculators, mobile phones, or collaboration. Using two rich, multi-step items rather than one item per indicator is consistent with how multi-indicator literacy instruments are commonly constructed, and it allowed each indicator to be observed twice for every student.

Second, a 30-item self-efficacy questionnaire, adapted from Pratiwi (2022), measured three dimensions aligned with Bandura's (1997) framework: magnitude (confidence in completing tasks at varying levels of difficulty), strength (firmness of self-belief and persistence), and generality (confidence across different mathematical topics and tasks). The questionnaire contained 15 positively and 15 negatively worded statements with five response options (from strongly agree to strongly disagree); negatively worded statements were reverse-scored.

Third, a 20-item cognitive bias questionnaire was developed for this study, grounded in the heuristics-and-biases framework (Kahneman et al., 2011) and in behavioural-bias evidence from educational and decision-making contexts (Bélanger & Blanchette, 2022; Esposito et al., 2023; Kim & Park, 2020). Using the same five-point response format, it operationalised four dimensions: illusion of control (five items), capturing the tendency to predict an answer before formulating a mathematical model or to proceed without the appropriate concepts and procedures; overconfidence (seven items), capturing an excessive belief in one's own ability and excessive optimism about task performance; bandwagon effect (four items), capturing limited independent reasoning and the tendency to regard an answer as correct because it matches classmates' answers, so that one's own work is rarely evaluated; and belief in the law of small numbers (four items), capturing a focus on narrow cues, for example treating a brief numerical result as sufficient without interpreting and communicating it, or relying on a small circle of classmates as reference points. These dimensions were selected because each corresponds to a distinct point of failure in the formulate–apply–reason–communicate–evaluate sequence that defines mathematical literacy: answering without modelling or procedure (illusion of control), overestimation of one's own accuracy (overconfidence), reliance on social validation rather than independent verification (bandwagon effect), and premature closure on limited evidence (law of small numbers).

Table 1. Sample Items of the Research Instruments

Instrument	Dimension/Indicator (Item No.)	Sample Item (English translation; original Indonesian in brackets)
ML test	Item 1; all five indicators	A ladder leans against a building at a height of 8 m. The foot of the ladder is 6 m from the base of the building. Someone accidentally bumps the bottom of the ladder so that it slides 1 m further away from the building. Does the top of the ladder also slide 1 m from its original position? Explain.
ML test	Item 2; all five indicators	A ship leaves the harbour heading north at 56 km/h. After 2 hours of sailing, a storm drags the ship 15 km to the west. The remaining fuel can only take the ship 110 km. If the ship returns directly to the harbour, how close to the harbour can it get? Explain your reasoning.

Instrument	Dimension/Indicator (Item No.)	Sample Item (English translation; original Indonesian in brackets)
SE questionnaire	Magnitude, positive (5)	If the teacher gives a difficult task, I will try to complete it. [<i>Jika guru memberikan tugas berupa soal yang sulit, saya akan berusaha menyelesaikan tugas tersebut.</i>]
SE questionnaire	Strength, positive (2)	With the abilities I have, I can work on problems even when they are difficult. [<i>Dengan kemampuan yang saya miliki, saya bisa mengerjakan soal meskipun itu sulit.</i>]
SE questionnaire	Generality, negative (19)	I get confused when working on tasks that involve difficult calculations. [<i>Saya kebingungan ketika mengerjakan tugas terkait perhitungan yang sulit.</i>]
CB questionnaire	Illusion of control, positive (1)	I already know the result of a problem even without formulating it into a mathematical model. [<i>Saya sudah mengetahui hasil dari soal walaupun tanpa melalui proses merumuskan masalah ke model matematika.</i>]
CB questionnaire	Overconfidence, positive (4)	I am the best at doing all mathematics tasks compared with my classmates. [<i>Saya paling bisa mengerjakan semua tugas matematika dibandingkan dengan teman-teman saya.</i>]
CB questionnaire	Bandwagon effect, positive (11)	I never re-check my answers because they are already the same as my classmates' answers. [<i>Saya tidak pernah mengecek kembali jawaban saya karena sudah sama dengan teman-teman yang lain.</i>]
CB questionnaire	Law of small numbers, positive (8)	I just answer carelessly when I encounter mathematics word problems. [<i>Saya hanya mengerjakan secara asal ketika mendapati soal cerita matematika.</i>]

Note: ML = mathematical literacy; SE = self-efficacy; CB = cognitive bias. Translations are by the authors. Negatively worded questionnaire items were reverse-scored. The test items were adopted from Khorifah et al. (2022).

Finally, a semi-structured interview guideline was used to probe each subject's written work. Core questions were organised by the five mathematical literacy indicators (e.g., "How did you write down what was known and formulate the mathematical model for this item?" and "How did you draw a conclusion from the problem?"), followed by probes on confidence ("How confident are you that you can solve this item?"), checking behaviour ("After finishing, do you always check or evaluate your answer?"), similarities with classmates' answers, alternative strategies, and task prioritisation. Each subject's written solution was kept in view during the interview so that the researcher's interpretation of the response could be checked with the student.

Content validity of the cognitive bias questionnaire was established through expert judgement by three validators (a lecturer in educational psychology, a school guidance and counselling teacher, and an educational psychology practitioner) and quantified using Aiken's V (Retnawati, 2016). Of the 25 draft items, the five items with $V < 0.40$ were discarded; the 20 retained items had V values between 0.75 and 1.00, with 18 items in the high-validity range ($V \geq 0.80$) and two items in the moderate range ($V = 0.75$). The internal consistency of the 25-item draft, estimated with Cronbach's alpha, was $\alpha = 0.923$. The self-

efficacy questionnaire was an established instrument adapted from Pratiwi (2022), and its internal consistency in the present class was $\alpha = 0.925$ (30 items, $N = 29$). The interview guideline was reviewed by three validators before use. Because the cognitive bias questionnaire was newly developed and administered to a single class, its scores were used only to profile and screen students and were always interpreted together with the test and interview evidence rather than on their own.

Subject selection proceeded in two stages. In the first stage, all 29 students completed the mathematical literacy test, the self-efficacy questionnaire, and the cognitive bias questionnaire, and their scores were categorised as high, moderate, or low using the criteria in Table 2. In the second stage, six subjects were purposively selected, three with high mathematical literacy (S-6, S-8, S-15) and three with low mathematical literacy (S-5, S-11, S-20), ensuring variation in self-efficacy and cognitive bias profiles and selecting students who showed willingness and communication fluency for interview participation. The moderate mathematical literacy category, although the largest in the class (62.1%), was deliberately excluded from subject selection: following Sugiyono's (2018) principle that purposive sampling in qualitative research should prioritise information-rich cases over statistical representativeness, the study concentrated on the high and low extremes of mathematical literacy performance to maximise contrast and to isolate the clearest cases in which self-efficacy and cognitive bias patterns co-occurred with markedly different literacy outcomes. Within each mathematical literacy category, candidates were further screened using their self-efficacy and cognitive bias scores to avoid selecting three profile-homogeneous cases per category, so that the six subjects would jointly span a range of self-efficacy–cognitive bias combinations. The six subjects were therefore not intended to be statistically representative of the class but to function as maximum-variation cases (Sugiyono, 2018) capable of illuminating the range of ways in which self-efficacy and cognitive bias co-occur with mathematical literacy.

Table 2. Categorisation Criteria for Mathematical Literacy, Self-Efficacy, and Cognitive Bias

Category	Mathematical Literacy Score	Self-Efficacy Score	Cognitive Bias Score
High	$X > 57$	$X > 81$	$X > 56$
Moderate	$7 \leq X \leq 57$	$59 \leq X \leq 81$	$46 \leq X \leq 56$
Low	$X < 7$	$X < 59$	$X < 46$

The category boundaries in Table 2 were derived from the empirical mean (M) and standard deviation (SD) of the class scores on each instrument using the conventional three-level rule: high ($X > M + SD$), moderate ($M - SD \leq X \leq M + SD$), and low ($X < M - SD$). For mathematical literacy, $M = 32$ and $SD = 25$ on the 0–100 scale; for self-efficacy, $M = 70$ and $SD = 11$ (scores converted to a 0–100 scale); and for cognitive bias, $M = 51$ and $SD = 5$ (maximum score 100). The comparatively wide moderate range for mathematical literacy ($7 \leq X \leq 57$) therefore reflects the much larger dispersion of test scores relative to questionnaire scores: because each essay item was scored analytically on five indicators, a difference of one or two indicators produced a large change in a student's score, whereas the questionnaires aggregated many Likert-type responses that clustered closer to the mean. The difference in category width thus reflects the instruments' different score distributions rather than an inconsistency in how the cut-off scores were determined. Because the categories are norm-referenced to this class, they describe students' relative standing within the class rather than absolute proficiency levels.

Data analysis followed the interactive model of Miles et al. (2014), comprising three iterative stages: data condensation (selecting and abstracting relevant information),

data display (presenting patterns in narrative and tabular form), and conclusion drawing and verification. Interview transcripts were coded using a hybrid approach: a priori codes derived from the five mathematical literacy indicators, the three self-efficacy dimensions, and the four cognitive bias dimensions were applied deductively, while inductive open coding captured patterns not anticipated by the initial framework, such as the technology-dependent confidence later identified in S-20. Codes were grouped into descriptive categories and cross-referenced against test scores and questionnaire results to identify convergence or divergence between self-reported and behaviourally expressed self-efficacy and cognitive bias. Credibility was ensured through technique triangulation, that is, by comparing evidence from the written test, the questionnaires, and the interview for the same subject.

Where questionnaire and interview evidence diverged, the analysis distinguished between *questionnaire self-efficacy*, the score obtained on the self-efficacy questionnaire, and *task-level confidence*, an interpretive category constructed by the researchers from triangulated evidence for each test item: the student's answer to the interview probe on confidence, whether the student persisted with a complete written solution, and whether the student reported guessing or relying on classmates' answers. Task-level confidence was rated as high when these sources converged on confident, independent engagement on both items; as moderate when confidence and independent engagement were evident on one item but not the other; and as low when the student reported not being confident and the written work and interview indicated guessing or reliance on peers. Task-level confidence is therefore not a directly measured construct and was not derived from the self-efficacy instrument; it is used in the Results and Discussion only to describe whether students' self-reported self-efficacy was reflected in their behaviour on the specific test items.

RESULTS AND DISCUSSION

The results and discussion are presented in three integrated sections aligned with the research objectives.

Distribution of Mathematical Literacy, Self-Efficacy, and Cognitive Bias

Table 3 presents the overall distribution of the 29 Class VIII-E students across mathematical literacy, self-efficacy, and cognitive bias categories.

Table 3. Distribution of Students by Category (N = 29)

Category	Mathematical Literacy n	%	Self-Efficacy n	%	Cognitive Bias n	%
High	4	13.8%	4	13.8%	2	6.9%
Moderate	18	62.1%	21	72.4%	24	82.8%
Low	7	24.1%	4	13.8%	3	10.3%

Table 3 shows that mathematical literacy was predominantly moderate (62.1%), with more students classified as low (24.1%) than high (13.8%). Because the categories are relative to this class, this distribution cannot be compared directly with national proficiency levels, although the low absolute scores (class mean of 32 out of 100) are in line with reports that many Indonesian students perform below proficiency on mathematical literacy assessments (Damanik & Handayani, 2023; OECD, 2023). Self-efficacy followed a similar pattern, with most students in the moderate range (72.4%). Cognitive bias was overwhelmingly moderate (82.8%), with only two students (6.9%) in the high-bias category and three (10.3%) in the low-bias category. These distributions describe the class

context from which the six maximum-variation cases were drawn; they are not intended to show that the selected subjects are statistically representative of the class.

Mathematical Literacy Profiles of Selected Subjects

Table 4 summarises the self-efficacy, cognitive bias, and mathematical literacy categories of the six selected research subjects, together with the number of mathematical literacy indicators fulfilled.

Table 4. Mathematical Literacy, Self-Efficacy, and Cognitive Bias Profiles of Selected Subjects

Subject	ML Score	ML Category	SE Score	SE Category	CB Score	CB Category & ML Indicators Met
S-6	80	High	73	Moderate	45	Low CB — All 5 indicators
S-8	85	High	69	Moderate	55	Moderate CB — 4 of 5 indicators
S-15	85	High	73	Moderate	54	Moderate CB — 4 of 5 indicators
S-5	5	Low	69	Moderate	51	Moderate CB — 2 of 5 indicators
S-11	5	Low	67	Moderate	51	Moderate CB (High in interview) — 0 indicators
S-20	5	Low	92	High	51	Moderate CB (High SE yet Low ML) — 0 indicators

Note: ML = Mathematical Literacy; SE = Self-Efficacy; CB = Cognitive Bias.

Subject S-6, representing the high-ML, moderate-SE, low-CB profile, fulfilled all five mathematical literacy indicators on both test items. In the interview, S-6 described reading the problem, visualising it, and drawing a right triangle before applying the Pythagorean theorem, and explained that the conclusion was written by restating the question followed by the computed difference. S-6 also emphasised working independently: "my answer is not exactly the same as other friends', because I really did it myself without help from friends" [*jawaban saya tidak sama persis dengan teman yang lain, karena saya benar-benar mengerjakannya sendiri tanpa dibantu teman*]. Checking behaviour, however, was not uniform. S-6 reported checking Item 1 "if there is still time" but not Item 2: "usually I don't like checking, because I'm already sure it's right" [*biasanya saya tidak suka ngecek kak karena sudah yakin benar*]. Thus, even in the strongest case, high confidence co-existed with a mild overconfidence tendency, which did not lower S-6's performance on these items but could become a risk on less familiar problems. This profile is broadly consistent with Nisa and Arliani's (2023) observation that students with higher self-efficacy tend to sustain effort across mathematical literacy processes.

Subjects S-8 and S-15, both high-ML with moderate SE and moderate CB, each fulfilled four of the five indicators. The indicator not fulfilled was interpreting and communicating results (Indicator 4): S-8 omitted it on Item 2, and S-15 omitted it on both items. Both subjects applied the Pythagorean theorem correctly and wrote a final conclusion (for example, that the ship could come no closer than 3 km to the harbour), but neither explained how the numerical result answered the real-world situation. The

interviews point to two different reasons for this omission, as illustrated in Excerpt 1 (R = researcher).

Excerpt 1. Interview extracts for S-8 (Item 2) and S-15 (Item 1)

R: How confident are you that you solved Item 2?

S-8: Not very confident, because I was in a hurry. [*Kurang yakin kak, soalnya buru-buru.*]

R: After finishing, did you check or evaluate your answer to Item 2?

S-8: No. [*Tidak kak.*]

R: Why didn't you write down the concept following its procedural steps?

S-15: No, because I prefer [answering] directly. [*Tidak kak, karena saya lebih suka secara langsung.*]

R: How can you give an appropriate reason for the answer you obtained?

S-15: Well, that's just how my answer is; I'm confused about how to explain it. [*Ya pokoknya seperti itu jawaban saya, saya bingung menjelaskannya bagaimana.*]

For S-8, the omission on Item 2 co-occurred with self-reported time pressure and the absence of checking, whereas the same subject did interpret and communicate the result on Item 1. For S-15, the interview indicated a stated preference for answering directly and difficulty in verbalising the reasoning behind a correct result, which corresponds to the tendency captured by cognitive bias item 16 (preferring short answers "as long as the result is the same and correct"). In both cases, the omission did not appear to reflect a failure to understand the problem, since both subjects reached correct conclusions; rather, it reflected an orientation in which a correct numerical answer was treated as sufficient, either under time pressure (S-8) or as a habitual answering style (S-15). A comparable association between moderate confidence, cognitive shortcuts, and the bypassing of deliberative steps has been reported in other domains (Kim & Park, 2020); in the present data, however, this interpretation remains tentative because it rests on two cases.

Among the low-ML subjects, S-5 fulfilled only two indicators, formulating and applying, and only on Item 2. S-5's moderate questionnaire self-efficacy contrasted with interview evidence of low task-level confidence. On Item 1, S-5 stated, "honestly, I answered at random because I was confused" [*jujur kak, saya jawabnya asal itu karena saya bingung*] and "I just followed my friend; I don't know whether it is right or wrong" [*saya hanya ngikut teman saja, ndak tahu benar salahnya*], and the missing conclusion on Item 2 was explained by being "in a hurry" [*terburu-buru*]. This discrepancy between questionnaire scores and interview-revealed behaviour illustrates the context sensitivity of self-efficacy, consistent with Bandura's (1997) task-specificity principle: a questionnaire may capture a generalised academic self-belief, whereas performance on a particular item appears more closely related to situation-specific appraisals under examination conditions.

Subjects S-11 and S-20 fulfilled none of the indicators on either item; their written responses contained numbers unrelated to the problem context. Their interview data, summarised in Excerpt 2, clarify how this outcome co-occurred with their self-efficacy and cognitive bias profiles.

Excerpt 2. Interview extracts for S-11 and S-20

R: How can you give an appropriate reason for the answer you obtained [Item 1]?

S-11: I just made it up. [*Saya cuma ngarang aja.*]

R: How did you arrive at the conclusion for Item 1?

S-11: I just imagined it and then thought of writing that; the important thing is to

answer. [*Dibayangkan saja terus kepikiran nulis itu, yang penting jawab kan kak.*]

R: Is there another way, according to your own understanding?

S-11: My friend said to use Pythagorean triples, but I can't do it yet. [*Itu kata temenku pakai cara tripel Pythagoras, tapi saya belum bisa.*]

R: Why is your answer the same as your classmates' answers?

S-11: It was my friend who looked at my answer. [*Temen saya yang lihat jawaban saya.*]

R: How did you arrive at the conclusion for Item 1?

S-20: I just looked at a friend's answer. [*Cuma lihat jawaban teman.*]

R: Why is your answer the same as your classmates' answers?

S-20: So that it's faster and easier. [*Biar lebih cepat dan mudah.*]

R: If you have mathematics homework and homework from other subjects due the next day, which do you do first?

S-20: I would do mathematics, because I actually like mathematics, especially if it's helped by the internet, I'm sure it'll go smoothly. [*Saya akan mengerjakan matematika kak, karena aslinya saya senang dengan matematika, apalagi kalau dibantu internet saya yakin bisa lancar jaya.*]

R: So, if there is a closed-book mathematics test or task, how do you feel?

S-20: Honestly, I find it difficult, because I'm not good at memorising formulas, and with word problems I tend to find them hard to understand, so I just answer as best I can. [*Ya, jujur kak saya merasa kesulitan, karena saya bukan penghafal rumus yang baik, apalagi kalau sudah soal cerita saya cenderung sulit memahami, jadi ya saya jawab semampunya.*]

For S-11, the questionnaire placed cognitive bias in the moderate range, but the interview revealed bias-consistent behaviour that we interpreted as high: the subject produced an answer without formulating a model or following a procedure, which corresponds to the illusion-of-control dimension as operationalised in this study, and treated answering itself as sufficient. S-11 also mentioned a strategy suggested by a classmate that the subject could not yet apply and, when asked about answers identical to classmates', described answer sharing in which a peer had looked at the subject's own work. We therefore read the bandwagon pattern for S-11 as participation in peer answer convergence rather than as one-directional copying, which the interview data do not establish. Notably, S-11 described being "not confident" [*tidak yakin*] on both items, so the pattern reflects low task-level confidence combined with unverified answering rather than a mistaken belief that the answers were correct.

S-20 reported the highest questionnaire self-efficacy score in the class (92, high category) yet fulfilled none of the indicators and described being "not confident, because I can't [do it]" [*tidak yakin, karena tidak bisa*]. The interview suggests that S-20's questionnaire confidence was tied to working with internet support, whereas under the closed-book test conditions the subject reported difficulty with formulas and word problems and openly relied on a classmate's answers "so that it's faster and easier". This divergence indicates that a high questionnaire self-efficacy score does not necessarily correspond to high mathematical literacy performance when the underlying confidence is context-dependent, a point taken up in the next section.

The Role of Self-Efficacy and Cognitive Bias in Mathematical Literacy

Considered collectively, the six subject profiles reveal a consistent pattern: high mathematical literacy co-occurred with moderate-to-high task-level confidence and low-to-moderate cognitive bias, whereas low mathematical literacy co-occurred with low task-

level confidence, irrespective of questionnaire self-efficacy, and with cognitive bias that was moderate on the questionnaire but more pronounced in interview behaviour. This pattern is summarised in Table 5.

Table 5. Pattern of Task-Level Confidence, Cognitive Bias, and Mathematical Literacy Performance

Task-Level Confidence [†]	Cognitive Bias Level	Mathematical Literacy	Indicators Typically Met
High (S-6)	Low	High	All 5 (formulate, apply, reason, communicate, evaluate)
Moderate, varying by item (S-8, S-15)	Moderate	High	4 of 5 (interpreting and communicating absent)
Low (S-5)	Moderate	Low	2 of 5 (formulating and applying, Item 2 only)
Low, despite moderate or high questionnaire SE (S-11, S-20)	Moderate on questionnaire; high in interview behaviour	Low	0 of 5

Note: [†] Task-level confidence is an interpretive category derived from triangulated interview, test, and questionnaire evidence (see Methods); it was not measured by the self-efficacy questionnaire. Questionnaire self-efficacy scores for each subject are reported in Table 4.

Within these cases, self-efficacy appeared to relate to mathematical literacy in three ways. First, the high-ML subjects, each of whom expressed confidence on at least one item, attempted and completed multi-step Pythagorean solutions with few blank spaces, whereas the low-ML subjects, all of whom said they were not confident, either guessed or relied on peers. Second, each high-ML subject reported checking their work on at least one item (S-6 and S-8 on Item 1, S-15 on Item 2), whereas none of the low-ML subjects reported checking; however, checking was inconsistent even in the high-ML group, so it is better regarded as present but fragile than as a stable characteristic. Third, the high-ML subjects described working independently, while all three low-ML subjects described following or sharing classmates' answers. These patterns are consistent with Samsuddin and Retnawati's (2022) account of self-efficacy as a basis for sustained engagement in mathematical problem-solving, but given the small number of cases they should be read as co-occurrences rather than as effects.

Cognitive bias, conversely, co-occurred with weaknesses in mathematical literacy in four recognisable forms. Illusion of control, as operationalised in this study, was evident when S-11 and S-20 wrote answers without formulating a model or following a procedure, producing responses outside the scope of what was asked; because both students said they were not confident, this pattern reflected answering without modelling rather than a belief that the answers were correct. Overconfidence appeared in a milder form among the high-ML students: S-6 skipped checking Item 2 because of being "already sure it's right" and remarked that, for multiple-choice items, the answer could be guessed by visualising it without writing the steps, a strategy that reflects procedural fluency but carries risk on complex, unfamiliar problems. The bandwagon effect was most visible among the low-ML subjects, all of whom described following or sharing classmates' answers without independent verification. The belief in the law of small numbers, in the sense of treating a brief numerical result as sufficient, corresponded to the omission of the interpreting and communicating indicator by S-8 and S-15. These patterns are consistent with theoretical

accounts of how cognitive biases can bypass systematic information processing (Esposito et al., 2023; Haselton et al., 2005).

The data suggest that self-efficacy and cognitive bias are better understood as interrelated than as two independent contributors to mathematical literacy. Where confidence appeared to be grounded in accurate self-assessment, as in S-6, it co-occurred with low cognitive bias, plausibly because a student who gauges their own competence accurately is also less prone to answering without a model or adopting peers' answers. Where confidence was inflated or context-mismatched, low task-level confidence and bias-consistent behaviour appeared together rather than as separate deficits. S-20 presented the most theoretically interesting profile: the highest questionnaire self-efficacy in the class combined with no fulfilled indicators. This apparent paradox becomes interpretable when self-efficacy is considered in context. S-20 expressed confidence when working with internet support but reported difficulty under closed-book conditions, which echoes the distinction drawn by Li et al. (2024) between confidence in technology-mediated tasks and independent engagement, although that study concerned university students' use of translation technology rather than mathematics. The gap between S-20's self-rating and performance is also consistent with evidence that lower performers tend to misjudge their own competence (Schlösser et al., 2013). Rather than prompting additional preparation, the high self-rating co-existed with copying and limited elaboration once the gap was exposed under test conditions. This case underscores the practical value of assessing self-efficacy at the task level rather than relying solely on aggregate questionnaire scores, and the conceptual point that self-efficacy and cognitive bias may need to be considered jointly rather than as additive, independent predictors of mathematical literacy.

Taken together, these findings point to a conceptual distinction rather than a restatement of the case-level results: self-efficacy and cognitive bias appeared to relate to mathematical literacy through complementary but distinct mechanisms. Self-efficacy appeared chiefly related to whether a student engaged, persisted, and attempted a complete solution, consistent with Bandura's (1997) social cognitive theory, in which perceived self-efficacy regulates effort and persistence. Cognitive bias, by contrast, appeared chiefly related to the quality and completeness of reasoning once a student had engaged, interfering with the verification and communication steps of problem-solving even when motivation was present. This distinction helps to explain why the moderate-CB, high-ML students in this study reached correct answers yet omitted the communicating indicator: their confidence was sufficient to sustain engagement through to a solution, but time pressure, skipped checking, and a preference for brief answers accompanied a tendency to treat a correct number as sufficient. From a pedagogical standpoint, these findings carry tentative implications for mathematics teachers and curriculum designers. First, teachers may complement the assessment of content knowledge with attention to students' task-level confidence and bias tendencies, for example through structured mastery-experience tasks that build accurate self-efficacy and explicit prompts that interrupt overconfidence. Second, classroom practices that require students to explain and justify their solutions, such as think-aloud protocols and peer explanation tasks, could directly target the communicating indicator by making the verification step explicit and socially accountable. Third, for students with low mathematical literacy, structured scaffolding through the full five-indicator literacy process, combined with explicit metacognitive instruction on recognising peer copying and answering without a model, may offer a pedagogically grounded pathway to improvement. These recommendations extend those of Yuliyani and Setyaningsih (2022) and Geraldine and Wijayanti (2022) by adding cognitive-bias-focused strategies to general self-efficacy enhancement, and they align with calls in the cognitive bias literature

(Kahneman et al., 2011) for interventions that target reasoning processes directly rather than relying on motivational strategies alone.

CONCLUSION AND SUGGESTIONS

This qualitative study described how self-efficacy and cognitive bias appeared to be interrelated with the mathematical literacy of six subjects at SMP Negeri 9 Yogyakarta on the topic of the Pythagorean theorem. In the study class of 29 students, moderate categories predominated for mathematical literacy (62.1%), self-efficacy (72.4%), and cognitive bias (82.8%); because these categories were defined relative to the class mean and standard deviation, they describe relative standing within this class and should not be read as representative of Indonesian junior secondary students in general. Across the six selected subjects, a consistent pattern emerged: the subject combining high task-level confidence with low cognitive bias fulfilled all five mathematical literacy indicators; the two subjects with moderate, item-dependent confidence and moderate cognitive bias fulfilled four, omitting the interpretation and communication of results; and the three subjects with low task-level confidence and bias-consistent behaviour, particularly reliance on classmates' answers and answering without a model, fulfilled two or none, regardless of their questionnaire self-efficacy. Self-efficacy appeared to relate mainly to engagement, persistence, and independent work, whereas cognitive bias appeared to relate mainly to skipped verification, peer dependency, and truncated communication. A particularly noteworthy case was the divergence between high questionnaire self-efficacy and low mathematical literacy in S-20, which highlights the importance of assessing context-specific self-efficacy. As a study of six purposively selected cases, these findings offer an in-depth description of how self-efficacy and cognitive bias co-occurred with mathematical literacy performance in one class, rather than evidence of a generalisable causal effect.

This study has several limitations that should be considered when interpreting its findings. First, the in-depth analysis was based on six purposively selected subjects drawn from a single class of 29 students at one school, which limits the extent to which the observed patterns can be generalised. Second, mathematical literacy was examined within a single content area, the Pythagorean theorem, using two items completed in 20 minutes, and the patterns may differ for other topics, task formats, or grade levels. Third, the cognitive bias questionnaire was developed specifically for this study; although its content validity and the reliability of its 25-item draft were satisfactory, its internal consistency in the final 20-item form within this small class was lower, so questionnaire categories were interpreted only alongside the test and interview evidence, and the instrument requires further validation with larger samples. Fourth, task-level confidence was an interpretive category inferred from brief interviews rather than a measured construct, and the interviews relied on students' retrospective accounts. Finally, as a descriptive qualitative study, the reported associations among self-efficacy, cognitive bias, and mathematical literacy reflect patterns of co-occurrence identified through triangulated test, questionnaire, and interview data rather than statistically tested causal relationships.

Future research should employ mixed-methods designs to complement the within-subject depth of the present study with statistical generalisability across broader samples, including a larger-scale validation of the cognitive bias questionnaire. Intervention studies examining whether metacognitive training, bias-awareness exercises, and scaffolded literacy practice are accompanied by changes in the self-efficacy–cognitive bias–mathematical literacy pattern over time would constitute a valuable extension. Researchers are also encouraged to explore these dynamics across different mathematical topics and educational levels to test the transferability of the present findings.

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