

Unveiling the Link Between Numeracy Skills and Self-Efficacy: A Study on Physics Learning Through AKM Assessments

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Abstract. This study explores the relationship between numeracy skills and self-efficacy among grade 10 students within the context of the Minimum Competency Assessment (AKM) in physics, focusing on linear and parabolic motion. Employing a quantitative descriptive design, the research involved 140 students from a public high school in Bekasi, Indonesia. Instruments included a numeracy test comprising 17 AKM-based physics questions and a self-efficacy questionnaire adapted from Bandura's framework, covering the dimensions of level, generality, and strength. Results indicated that most students (53%) were at the "Basic" level of numeracy performance, while 67% exhibited moderate self-efficacy. A significant positive correlation was found between self-efficacy and numeracy performance ($r = 0.743$), with the "Strength" dimension showing the strongest correlation ($r = 0.716$). These findings suggest enhancing self-efficacy, particularly the strength dimension, can improve numeracy skills and AKM readiness. The study underscores the importance of tailored interventions to strengthen self-efficacy and recommends further research into additional factors affecting numeracy performance and interdisciplinary approaches to teaching numeracy across subjects.

Keywords: *numeracy skills, self-efficacy, physics, assessment*

1. Introduction

The Minimum Competency Assessment (AKM) was introduced in Indonesia in 2021 as a replacement for the National Examination (UN), shifting the focus towards evaluating students' literacy and numeracy skills essential for societal participation and further learning [1,2]. The AKM emphasizes contextual assessments requiring higher-order thinking skills, utilizing various question types such as multiple-choice, matching, and essays to evaluate competencies comprehensively [3,4]. This shift aligns with global educational trends aiming to prepare students for real-world problem-solving and critical thinking challenges.

Numeracy, in particular, plays a crucial role in daily life and interdisciplinary learning, especially in physics. It enhances individuals' ability to manage daily tasks, optimize health, and function effectively in technology-rich environments [5–7]. In physics education, strong numeracy skills facilitate understanding complex concepts like linear and parabolic motion, which rely heavily on mathematical reasoning and problem-solving abilities. Interdisciplinary approaches, such as STEAM, further highlight the importance of numeracy in fostering a comprehensive educational experience [8,9].

Despite the implementation of AKM, Indonesian high school students continue to exhibit significant gaps in numeracy skills, with the majority performing at basic or below-basic levels [10,11]. From 2000 to 2014, there was a noticeable decline in numeracy skills, with the average grade 7 student in 2014

performing at the same level as a grade 4 student in 2000 [11]. This decline affects all student subgroups, indicating systemic issues in teaching methods and curriculum alignment [12]. Traditional teaching methods may not be effective; innovative approaches like Realistic Mathematics Education (RME) have shown promise in improving numeracy skills, suggesting that teaching methods play a crucial role in addressing these gaps [3,13].

Additionally, students often exhibit moderate self-efficacy when solving physics problems, lacking confidence and readiness, which adversely affects their academic performance and persistence [14]. Factors contributing to low self-efficacy include prior mathematical attainment, gender differences, and inadequate educational interventions [15–17]. Female students, in particular, generally exhibit lower self-efficacy in physics compared to their male counterparts, even when performance levels are similar [16]. Specific educational interventions, such as the IMPULSE approach, have been shown to improve students' understanding of engineering concepts and their confidence in solving open-ended problems [18]. Addressing these issues requires investigating the relationship between numeracy skills and self-efficacy to develop effective educational interventions that enhance both competencies [9]. Understanding this relationship is crucial for designing strategies that improve numeracy skills and bolster students' confidence and persistence in learning physics [10,19].

Research highlights self-efficacy as a key psychological factor influencing student performance and persistence in learning [20–24]. In physics education, students with higher self-efficacy demonstrate better problem-solving abilities and are more resilient in the face of challenges [16]. Educational interventions focusing on improving self-efficacy, such as mastery experiences and positive feedback, have been effective in enhancing students' confidence and academic outcomes [25].

Moreover, innovative teaching methods like Realistic Mathematics Education (RME) have shown promise in improving numeracy skills by contextualizing mathematical concepts in real-life situations [12]. Integrating numeracy-rich tasks within physics education encourages the application of mathematical reasoning, thereby simultaneously enhancing numeracy skills and self-efficacy [16,19,26]. These approaches underscore the potential of combined interventions to address the gaps in numeracy and self-efficacy among high school students.

Existing studies have explored the impact of self-efficacy on academic performance and the effectiveness of methods like RME in improving numeracy [6,12]. However, there is a lack of research examining the direct relationship between numeracy skills and self-efficacy within the AKM framework, specifically in the context of physics education [27,28]. Most research tends to focus on these variables independently. For instance, studies highlight the importance of numeracy in daily life and its role in interdisciplinary learning, especially in physics, but do not delve into how numeracy skills influence self-efficacy in this context [9,29–31].

This challenge is particularly evident in topics such as linear and parabolic motion, where mathematical proficiency and confidence are critical for student success. Prior studies indicate that students' confidence in physics is significantly influenced by their prior mathematical attainment and overall mathematics confidence [19,32]. However, the interdependence of numeracy skills and self-efficacy remains underexplored. Furthermore, while interventions like the IMPULSE approach have improved students' understanding and confidence in engineering concepts, similar studies focusing on physics education and numeracy skills are limited [18]. Understanding how numeracy skills influence self-efficacy and vice versa could provide valuable insights for educators aiming to enhance learning outcomes in physics. Therefore, a comprehensive study addressing this interrelationship is necessary to inform the development of targeted educational strategies that enhance both numeracy skills and self-efficacy, ultimately improving students' performance and persistence in physics education [24,33,34].

The objective of this study is to investigate the relationship between numeracy skills and self-efficacy in the context of AKM physics assessments, focusing specifically on linear and parabolic motion. The novelty of this research lies in its dual focus on numeracy and self-efficacy within a specific educational framework, addressing a critical gap in existing literature. The study is scoped to grade 10 students at a public high school in Bekasi, Indonesia, employing a quantitative descriptive approach using AKM-based test instruments and self-efficacy questionnaires grounded in Bandura's theory. By analyzing the correlation between these variables, the research aims to contribute to the development of interventions

that enhance numeracy skills through self-efficacy-focused strategies, thereby improving AKM readiness and overall educational outcomes.

2. Method

2.1. Research Design

This study employed a quantitative descriptive design to analyze the relationship between self-efficacy and numeracy performance among high school students. The research aimed to describe students' numeracy abilities and self-efficacy levels in solving AKM-based physics problems, specifically focusing on linear and parabolic motion. Data were collected using survey methods and correlational analysis techniques as outlined by [35].

2.2. Participants

The participants comprised 140 grade 10 students from a public high school in Bekasi, Indonesia, selected using simple random sampling. A random number generator was employed to ensure unbiased selection. The study was conducted during the second semester of the 2021/2022 academic year, in February 2022. Participants were briefed on the study's purpose and provided informed consent before data collection.

2.3. Instrument

The numeracy skills of the participants were assessed using a test comprising 17 AKM-based physics questions designed specifically to evaluate competencies in linear and parabolic motion. The test adhered to national guidelines and focused on three main components: content mastery, context, and cognitive processes. Content mastery emphasized geometrical concepts, measurement, and data analysis, while the context dimension involved presenting information through text, images, graphs, and tables. The cognitive processes component tested students' abilities in understanding, application, and reasoning. The test included various question formats, such as multiple-choice, complex multiple-choice, fill-in-the-blank, matching, and essay questions, ensuring a comprehensive evaluation of students' abilities. The instrument underwent rigorous validation through expert review for content relevance and a pilot field test with 30 students, achieving a Cronbach's alpha of 0.85, indicating high reliability.

Self-efficacy was measured using a questionnaire adapted from [20]. This questionnaire assessed three dimensions of self-efficacy: level, generality, and strength. The level dimension referred to the difficulty of tasks participants believed they could accomplish, and generality measured the breadth of activities for which they felt efficacious. Strength captured their confidence in performing tasks. The questionnaire consisted of 20 statements formatted on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Reliability analysis of the instrument produced a Cronbach's alpha of 0.83, confirming its suitability for this study.

2.4. Data Collection

Data were collected by administering the AKM-based numeracy test and the self-efficacy questionnaire to the participants. The responses were scored, summed, and analyzed for each respondent. Descriptive statistics were used to categorize students' numeracy abilities and self-efficacy levels, following the methods proposed by [36].

2.5. Data Analysis

Responses were scored, summed, and analyzed for each participant. Descriptive statistics based on Azwar methods were used to categorize numeracy abilities and self-efficacy levels. Categorization intervals for scores were defined relative to the mean and standard deviation, as detailed in Tables 1 and 2.

2.5.1. Categorization of Numeracy Scores

Scores were categorized based on the mean (M) and standard deviation (SD), as shown in Table 1.

Table 1. AKM Numeracy score categorization.

Interval	Category	AKM Category
$X \leq M - 1.5 \text{ SD}$	Very Low	Needs Special Intervention
$M - 1.5 \text{ SD} < X \leq M$	Medium	Basic
$M < X \leq M + 1.5 \text{ SD}$	High	Capable
$X > M + 1.5 \text{ SD}$	Very High	Proficient

2.5.2. Categorization of Self-Efficacy Scores

Self-efficacy scores were categorized as Table 2.

Table 2. Self-efficacy score categorization.

Interval	Category
$X < M - 1 \text{ SD}$	Low
$M - 1 \text{ SD} \leq X < M + 1 \text{ SD}$	Medium
$X \geq M + 1 \text{ SD}$	High

Note: X = Individual student's score, M = Mean score of the group, and SD = Standard deviation.

The Respondent's Level of Achievement (TCR) was calculated using the formula:

$$\text{TCR}(\%) = \frac{\text{Total respondent answer scores}}{\text{Maximum score based on the number of respondent}} \times 100 \quad (1)$$

TCR was then categorized as shown in Table 3.

Table 1. Categories of respondent achievement levels.

Achievement Percentage	Category
85%-100%	Excellent
66%-84%	Good
51%-65%	Enough
36%-50%	Not good
0%-35%	Bad

Normality and linearity tests (Shapiro-Wilk and Pearson correlation tests, respectively) were conducted to ensure the data's suitability for parametric analysis. Pearson correlation coefficients were calculated to assess the relationship between self-efficacy and numeracy performance, while regression analysis determined how much self-efficacy predicted numeracy outcomes. All analyses were conducted using SPSS Version 26.

3. Result and Discussion

3.1. Numeracy Performance

140 grade 10 students completed a numeracy test consisting of 17 AKM-based physics questions covering linear motion (9 items) and parabolic motion (8 items). Table 4 presents the distribution of students' numeracy performance.

Table 4. Students' numeracy performance.

Score Range	Number of Students	Percentage	AKM Category
≤ 15	8	6%	Needs Special Intervention
16–35	74	53%	Basic
36–56	47	34%	Capable
> 57	11	8%	Proficient

The majority of students (53%) were categorized at the "Basic" level, indicating they possess fundamental numeracy skills necessary for understanding direct equations and basic concepts related to geometry and statistics. Only 8% of students reached the "Proficient" level, demonstrating their ability

to reason and solve complex, non-routine problems based on numeracy concepts. Analysis of the numeracy test components revealed varying achievement levels across content areas. Figure 1 illustrates the Respondents' Level of Achievement (TCR) in different numeracy content areas.

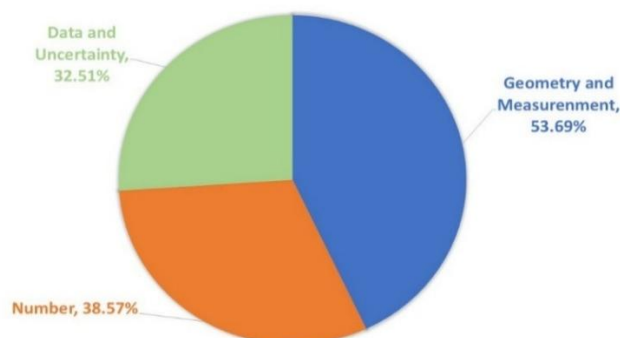


Figure 1. Respondents' level of achievement in numeracy content.

Students showed higher achievement in geometry and measurement content, aligning with competencies in using directions and coordinate systems relevant to linear and parabolic motion. Conversely, lower achievement was observed in numbers and data uncertainty, suggesting difficulties with scientific notation, arithmetic operations, and data interpretation. Figure 2 presents the TCR based on the contexts provided in the numeracy problems.

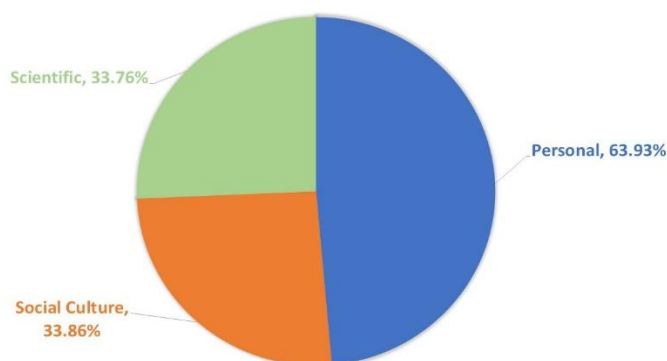


Figure 2. Respondents' level of achievement in numeracy contexts.

Students performed better in personal contexts, which relate directly to daily activities, enabling easier interpretation and problem-solving. However, performance in social-cultural and scientific contexts was poor. The low achievement in social-cultural contexts indicates a need to enhance students' recognition of mathematics' role in society. In contrast, the difficulties in scientific contexts highlight a lack of familiarity with literacy-based scientific problems.

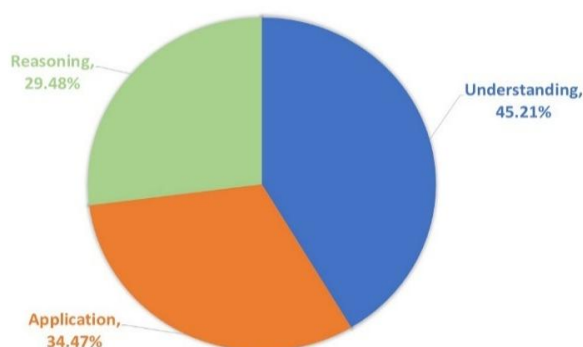


Figure 3. Respondents' level of achievement in cognitive processes.

Figure 3 depicts the TCR concerning cognitive processes. A declining trend was observed from understanding (C2) to application (C3) and reasoning (C4–C5). The highest scores were in understanding, yet still below optimal levels. Students struggled significantly with higher-order reasoning tasks, indicating a need to improve cognitive skills for problem-solving and numeracy proficiency.

3.2. Self-Efficacy Levels

Following the numeracy test, students completed a self-efficacy questionnaire, and the results are summarized in Table 5.

Table 5. Students self-efficacy levels.

Score Range	Number of Students	Percentage	Category
<53	23	16%	Low
53–69	94	67%	Moderate
≥ 69	23	16%	High

Most students (67%) exhibited moderate self-efficacy, suggesting an average level of persistence and resilience when facing challenging AKM numeracy problems. Equal proportions of students (16%) were categorized as having low and high self-efficacy. To gain deeper insights into these categories, practical problem-solving tasks were analyzed to assess their application of theoretical knowledge to real-world scenarios.

Students with low self-efficacy exhibited significant challenges in both performing calculations and interpreting results. As illustrated in Figure 4, one student attempted to calculate the stopping distance but struggled with the expected framework, misinterpreting units and making errors in their calculations. This lack of systematic problem-solving reflected low confidence and an inability to apply theoretical knowledge to practical tasks effectively, consistent with their low self-efficacy classification.

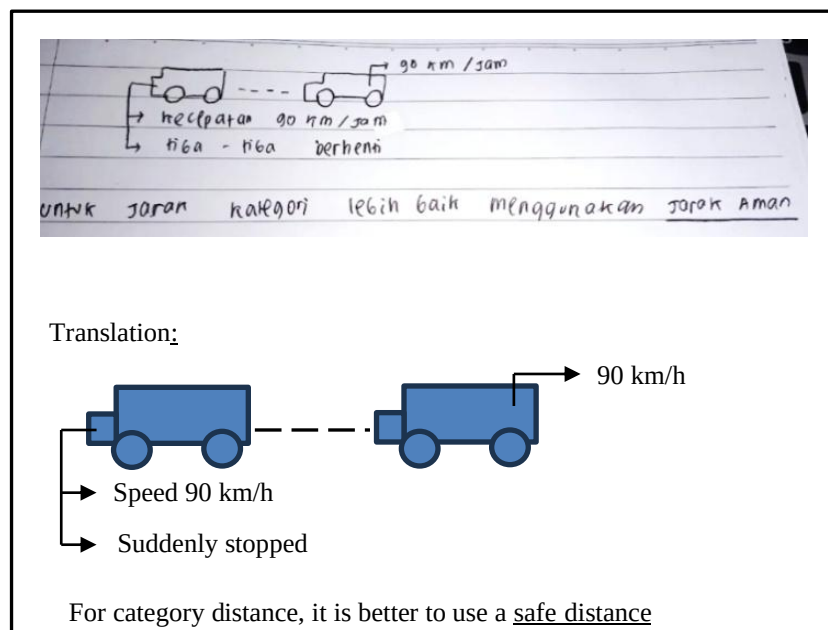
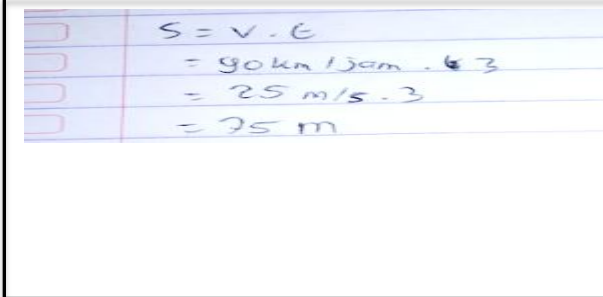


Figure 4. Students with low self-efficacy answered.

In contrast, students with moderate self-efficacy displayed a more systematic but incomplete approach to problem-solving. For instance, as shown in Figure 5, a student successfully converted 90 km/h into 25 m/s and applied the formula $S = v \times t$ to calculate the stopping distance. However, their analysis lacked depth, with superficial or absent comparisons to established benchmarks. This highlights moderate levels of persistence and understanding, reflecting their need for further development in critical thinking and analysis.

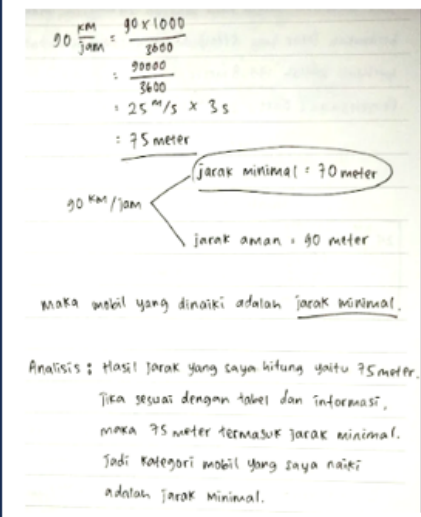


Translation:

$$\begin{aligned}
 s &= v \cdot t \\
 &= 90 \frac{\text{km}}{\text{h}} \cdot 3 \text{ s} \\
 &= 25 \frac{\text{m}}{\text{s}} \cdot 3 \\
 &= 75 \text{ m}
 \end{aligned}$$

Figure 5. Students with moderate self-efficacy answers.

Students with high self-efficacy, however, demonstrated strong confidence, precision, and resilience when solving problems. As shown in Figure 6, one student accurately calculated stopping distances using provided parameters and benchmarks, such as identifying the safe stopping distance of 90 meters and comparing it to their calculated results. These students also offered logical, insightful analyses of their findings, effectively connecting theoretical knowledge with practical applications. Their responses indicated a high level of persistence and problem-solving ability.



Translation:

$$\begin{aligned}
 90 \frac{\text{km}}{\text{h}} &= \frac{90 \times 1000}{3600} \\
 &= \frac{90000}{3600} \\
 &= 25 \frac{\text{m}}{\text{s}} \times 3 \text{ s} \\
 &= 75 \text{ meters}
 \end{aligned}$$

90 $\frac{\text{km}}{\text{h}}$ $\swarrow$ minimum distance = 70 meters
 $\searrow$ safe distance = 90 meters

The car that is ridden is the Minimum Distance.

Analysis: the result of the Distance that I calculated is 75 meters. if it is in accordance with the table and information, then 75 meters is included in the Minimum Distance. The category of the car that I rode is the Minimum Distance.

Figure 6. Students with high self-efficacy answers.

The varying levels of persistence, confidence, and problem-solving abilities across self-efficacy categories highlight the importance of targeted interventions. In particular, students in the low and moderate self-efficacy categories would benefit from strategies aimed at improving their confidence, critical thinking, and resilience. Strengthening self-efficacy is crucial to enhancing students' ability to address challenging numeracy tasks and improve their overall academic performance.

3.3. *Correlation Between Self-Efficacy and Numeracy Performance*

A significant positive correlation ($r = 0.743$) was found between self-efficacy and numeracy performance, indicating a strong relationship between the two variables. This suggests that higher levels of self-efficacy are associated with better numeracy performance among students. Further analysis of the self-efficacy dimensions revealed varying degrees of correlation with numeracy performance, as shown in Table 6.

Table 6. Correlation between self-efficacy dimensions and numeracy performance.

Numeracy Performance	Self-Efficacy Dimension	Correlation Coefficient (r)	Strength of Relationship
AKM Numeracy	Level	0.485	Moderate
AKM Numeracy	Generality	0.479	Moderate
AKM Numeracy	Strength	0.716	Strong

The "Strength" dimension of self-efficacy strongly correlated with numeracy performance ($r = 0.716$), indicating that students' confidence and perseverance significantly impact their ability to solve numeracy problems. The "Level" and "Generality" dimensions exhibited moderate correlations, suggesting that while they influence performance, their impact is less pronounced than the "Strength" dimension. The coefficient of determination suggests that self-efficacy accounts for approximately 55.8% of the variance in numeracy performance, indicating that other factors contribute to the remaining 44.2% of the performance outcomes.

3.4. *Discussion*

This study found a significant positive correlation between self-efficacy and numeracy performance among high school students, supporting Bandura's self-efficacy theory [23,33]. Bandura posits that self-efficacy, defined as an individual's belief in their capacity to execute behaviors necessary to achieve specific outcomes, plays a pivotal role in motivation, learning, and academic success [25,33,34]. Consistent with this theory, students with higher self-efficacy demonstrated superior numeracy performance, suggesting that confidence in one's abilities enhances persistence, resilience, and problem-solving skills.

The "Strength" dimension of self-efficacy exhibited the strongest correlation with numeracy performance, indicating that students' resilience and conviction significantly impact their ability to tackle complex problems. This finding aligns with previous research, which highlights the influence of self-efficacy on students' choices, effort, and persistence in academic tasks [23,24]. For example, Mellyzar reported a strong positive correlation between self-efficacy and numeracy literacy, reinforcing the importance of confidence in mathematical proficiency [38]. Similarly, Fast et al. (2010) found that students with higher self-efficacy levels performed better in mathematics, supporting the current study's results [23]. These findings underscore the critical role of self-efficacy, particularly the "Strength" dimension, in academic achievement and problem-solving.

Despite the positive associations observed, this study also highlighted significant weaknesses in students' higher-order reasoning (C4 - C5) and contextual problem-solving abilities. A declining trend in cognitive process achievement from understanding (C2) to application (C3) and reasoning (C4 - C5) was identified, revealing deficiencies in critical thinking skills. These findings mirror those of prior studies, which suggest that challenges in interdisciplinary learning and traditional teaching methods may hinder students' development in these areas [9,29,30]. Furthermore, low performance in social-cultural and scientific contexts suggests that students struggle to apply mathematical knowledge to real-world situations, a key competency for holistic education and AKM readiness.

The relationship between self-efficacy and numeracy performance highlights the need for targeted educational interventions that integrate numeracy across disciplines. Enhancing self-efficacy can improve students' persistence and problem-solving skills, which are essential for success in AKM assessments and broader academic contexts [1,39]. Strategies such as mastery experiences, modeling, social persuasion, and positive feedback can bolster students' confidence and improve academic performance [40,41]. For example, early numeracy activities and interventions aimed at fostering self-efficacy have been shown to enhance mathematical achievement, emphasizing the importance of starting such programs early in a student's educational journey [42].

Professional development programs for teachers are also critical to addressing gaps in reasoning and contextual problem-solving. Educators should be equipped with skills to integrate numeracy-rich tasks into science subjects, such as physics, and adopt interdisciplinary teaching practices [9,43]. Collaborative reasoning and meaning construction can further promote critical thinking and problem-solving abilities, making these methods vital for effective interdisciplinary learning [9].

These findings align with research emphasizing the interplay between psychological factors and academic outcomes. For example, Bandura's theory underscores that self-efficacy influences students' motivation and learning outcomes, further validating this study's results [25,33]. Additionally, the emphasis on the "Strength" dimension of self-efficacy highlights the importance of students' conviction in their abilities, which has been consistently supported in educational literature [17,25,44–46].

While this study provides valuable insights, certain limitations should be acknowledged. The sample was limited to a single public high school in Bekasi, Indonesia, which may restrict the generalizability of the findings to other regions or educational contexts. Additionally, the focus on physics-based numeracy assessments may not fully capture interdisciplinary challenges or numeracy skills required in other subjects. Future research should expand to include diverse educational settings and larger, more varied samples to enhance the external validity of the findings.

This study contributes valuable insights into the relationship between numeracy skills and self-efficacy in the context of the Minimum Competency Assessment (AKM) in physics. It highlights the importance of self-efficacy, particularly the "Strength" dimension, in enhancing students' numeracy performance. By focusing on a specific educational framework and applying it to high school students in Bekasi, Indonesia, the research provides a localized perspective that could inform future educational interventions. However, the study is limited by its narrow sample, drawn from only one school, which may not fully represent the diversity of student populations across different regions. Furthermore, the exclusive focus on physics-based numeracy assessments does not account for the broader interdisciplinary challenges students face in other subjects. Future research should consider larger, more diverse samples and explore other subject areas to improve the generalizability and applicability of the findings.

4. Conclusion

This study established a significant positive correlation between self-efficacy and numeracy performance in AKM physics assessments among grade 10 students. Among the self-efficacy dimensions, the "Strength" dimension emerged as the most critical predictor of numeracy success, underscoring the importance of fostering confidence and perseverance in students. These findings emphasize the need for targeted educational interventions that enhance self-efficacy, particularly in areas requiring advanced reasoning and problem-solving skills. The results have broader implications for improving numeracy skills and AKM readiness through interdisciplinary approaches integrating self-efficacy-building strategies into the curriculum. Educators and policymakers should prioritize initiatives that support students in developing confidence and resilience, such as mastery-based learning, positive feedback mechanisms, and collaborative problem-solving activities. Future research should explore additional factors influencing numeracy performance, including teaching methods, peer interactions, and technology integration. Expanding these studies to diverse educational contexts and subjects will help refine strategies for fostering numeracy and self-efficacy, contributing to enhanced academic outcomes and better preparation for real-world challenges.

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