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The Relationship Between Numeracy and Mathematics Self-Efficacy of Senior High School Students in Pekalongan Regency

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Abstract

This study aims to describe the numeracy profile and mathematics self-efficacy (MSE) of high school students in Pekalongan Regency based on school strata and examine the relationship between the two. The study used a quantitative survey method with 366 grade 11 students selected through stratified proportional random sampling. Data analysis included descriptive statistics, ANOVA, correlation, crosstab and chi-square. The results showed that students' numeracy was in the basic category, with significant differences between school strata ($p < 0.05$). Students' MSE is in the moderate category, with the strength dimension as the highest achievement. There was a significant positive relationship between numeracy and MSE ($r = 0.407$, $p < 0.05$), as well as a linear relationship between numeracy and MSE categories with $\chi^2 = 49.626$ ($p < 0.05$). This study underscores the importance of educational interventions to improve numeracy and MSE simultaneously.

Keywords: *Numeracy; Mathematics Self-Efficacy; School Strata*

Introduction

Twenty-first century capabilities are key for individuals and organizations to compete in an era of globalization and rapid technological development. These capabilities include knowledge, skills, work culture and character that are essential for students' success in college, careers and the workplace (Mahmud & Wong, 2022). The World Economic Forum divides them into three main categories: basic literacies, competencies, and character qualities. One of the essential basic literacies is numeracy, which is the ability to use mathematical concepts and tools to solve everyday problems. Numeracy also supports creativity, critical thinking, problem solving, communication and collaboration (Luo, 2022).

As part of basic literacy, numeracy plays an important role in the success of students, both academically and in everyday life. In the context of education in Indonesia, the importance of numeracy is reflected in various policies, such as the 2022 Permendikbudristek number 5 on Graduate Competency Standards in Early Childhood Education, Basic Education and Secondary Education which places numeracy as one of the competencies of secondary education graduates. Numeracy is also a major focus in the National Assessment through the Minimum Competency Assessment (AKM). This instrument is designed to evaluate students' basic skills in reading literacy and numeracy. AKM is designed not only to evaluate students' achievements but also to provide an overview of the quality of education at school, district and national levels.

AKM has been widely implemented, but the resulting data do not fully reflect the specific conditions of individuals or groups of students, especially in the relationship between numeracy and non-cognitive factors, such as mathematics self-efficacy, which are important for successful mathematics learning. In addition, although the PISA 2022 survey showed a slight improvement in the numeracy rankings of Indonesian students, their average scores are still below the average of OECD countries. Therefore, a more in-depth numeracy mapping by considering noncognitive factors is needed to comprehensively improve numeracy achievement.

Mathematics self-efficacy has been identified as a strong predictor of math achievement, especially when compared to math anxiety and initial math ability (Recber et al., 2018). Bandura (1977) divided the dimensions of self-efficacy into three, namely level/magnitude, generality, and strength. The indicator for the level/magnitude dimension is the belief in the ability to be able to solve numeracy problems with different levels of difficulty, the indicator for the generality dimension is the belief in being able to solve numeracy problems in various situations, and the indicator for strength is persistent, diligent, and resilient in solving the numeracy problems given, and believes that the efforts that have been made have a positive impact (Muhazir et al., 2021). Therefore, it is necessary to further analyze the mapping of students' mathematics self-efficacy categories.

Numeracy and mathematics self-efficacy have been the focus of various studies, but in-depth studies on the relationship between these two variables are still limited, especially in the context of secondary education in Indonesia. Most of the previous studies were descriptive or limited to measuring correlations without exploring the relationship between each category of mathematics self-efficacy and the numeracy category. In addition, the studies conducted often used small samples or were not representative of the wider population (Ariawan & Nufus, 2023; Kurniawati & Mahmudi, 2019; Ridwan et al., 2023). Therefore, given the limitations of previous research samples and methodologies, as well as the need to understand the relationship between numeracy and mathematics self-efficacy in more depth, this study aims to fill the gap by conducting a more in-depth analysis of the relationship between numeracy categories and mathematics self-efficacy categories, especially in high school students.

Analyzing the relationship between numeracy categories and students' mathematics self-efficacy categories is important. Studies show a strong correlation between high mathematics self-efficacy and advanced numeracy skills, where students perform better in numeracy tasks when they believe in their mathematical abilities (AlAli & Wardat, 2024). In contrast, students with low mathematics self-efficacy often perform poorly in numeracy tests, indicating that self-efficacy has a significant impact on their numeracy (Mumfaza & Setyaningsih, 2024; Zulfayani et al., 2023). In contrast, Husna et al (2018) found that there was no significant relationship between mathematics self-efficacy and mathematics learning outcomes. This phenomenon suggests that the relationship between mathematics self-efficacy and numeracy achievement may be influenced by other factors. Previous research shows that disentangling the relationship between different numeracy categories and mathematical self-efficacy categories is crucial. The crosstab test, also known as contingency table analysis, is a commonly used technique to analyze the relationship between two categorical variables (Elliott & Woodward, 2007).

Numeracy at the high school level is the basis for dealing with complex mathematical, quantitative and statistical problems in higher education and everyday life, while mathematics self-efficacy plays an important role in test results and mathematics achievement (Gal et al., 2020; Özcan & Kültür, 2021). Research shows that the numeracy and mathematics self-efficacy of high school students in Indonesia still need improvement, including in Pekalongan Regency, although the average numeracy achievement in this regency is better than the national, but still slightly below Central Java Province. The lack of research exploring the relationship between numeracy and mathematics self-efficacy in this regency suggests the need for more in-depth studies to capitalize on the potential for significant improvement. Based on the findings of various problems, this study aims to map the level of mathematics self-efficacy and numeracy of students and analyze the relationship between the two in general and in each category of each variable. The results of this study are expected to be the basis for the development of numeracy learning approaches.

Method

This study used a quantitative survey method with a sample of 366 grade 11 high school students in Pekalongan Regency, who were selected using stratified proportional random sampling techniques based on school strata (high, medium, low). The research instrument had high content validity (Gregory index) and construct validity of the SE questionnaire tested using CFA with factor loadings > 0.7. The reliability of the numeracy instrument was 0.742 (high) and the reliability of the mathematics self-efficacy questionnaire was 0.959 (very high).

The data collection process is in the form of numeracy tests and non-tests for mathematical self-efficacy. Numeracy data comes from the answers of students who have been given a score according to the numeracy assessment guidelines. Scores are given to students' answers related to numeracy questions in accordance with the established assessment criteria, then analyzed through descriptive statistical methods which include calculating the average, standard deviation, and maximum and minimum values. The question consists of 20 items covering various types of questions, such as multiple choice (PG), complex multiple choice (PGK), matching, essay, and short fill-in questions. Full credit is scored (score 2) on each item of the description question if the answer is correct, and score 1 for other types of questions if the answer is correct. After the score is obtained, the value is converted in the range 0-100. Here are more details about the numeracy questions used.

Table 1. Total Numeracy Test Score

Question Type	Item Number	Number of Items	Maximum Score	Score
Multiple Choice	7, 10, 13, 17	4	1	4
Complex Multiple Choice	1, 4, 15, 18, 19	5	1	5
Matching	9, 16,	2	1	2
Essay	3, 5, 6, 11, 14, 20	6	2	12
Fill in the blank	2, 8, 12	3	1	3
Total		20		26

In addition to general, numeracy is also described for each of its aspects (domain, cognitive level, context). The domain aspect consists of number, geometry and measurement, algebra, data and uncertainty. The cognitive level aspect consists of knowing, applying, and reasoning. The context aspect consists of personal, socio-cultural, and scientific. Furthermore, based on the total score that has been converted, students' numeracy is categorized into four categories, namely needing special intervention (PIK), basic, proficient, and advanced (Kemendikbud, 2020).

Table 2. Numeracy Categorization

Kategori	Description	Interval Score
Advanced	Able to reason to solve complex and non-routine problems based on mathematical concepts.	$X > 75$
Proficient	Able to apply their mathematical knowledge in more diverse contexts.	$50 < X \leq 75$
Basic	Have basic math skills: basic computation in the form of direct equations, basic concepts related to geometry and statistics, and solving simple routine math problems.	$25 < X \leq 50$
PIK	Has limited mathematical knowledge (partial mastery of concepts and limited computational skills).	$X \leq 25$

The source of data on students' mathematical self-efficacy comes from filling out a questionnaire containing positive and negative statements that can describe students' mathematical self-efficacy. In this study, mathematical self-efficacy is grouped based on categorization guidelines according to Azwar (2012) where the data is categorized into 5 categories with the following guidelines.

Table 3. Mathematics Self-Efficacy Categorization

Category	Interval Score
Very High	$X > 81,25$
High	$68,75 < X \leq 81,25$
Medium	$56,25 < X \leq 68,75$
Low	$43,75 < X \leq 56,25$
Very Low	$X \leq 43,75$

Data analysis included descriptive to map numeracy and mathematical self-efficacy, Welch ANOVA test to test for differences in numeracy means and ANOVA test for mathematical self-efficacy, interval estimation to predict numeracy and mathematical self-efficacy means in the population, correlation test to see the relationship between numeracy and students' mathematical self-efficacy, and crosstab and chi-square tests to analyze the relationship between numeracy and mathematical self-efficacy categories, all at the 5% significance level.

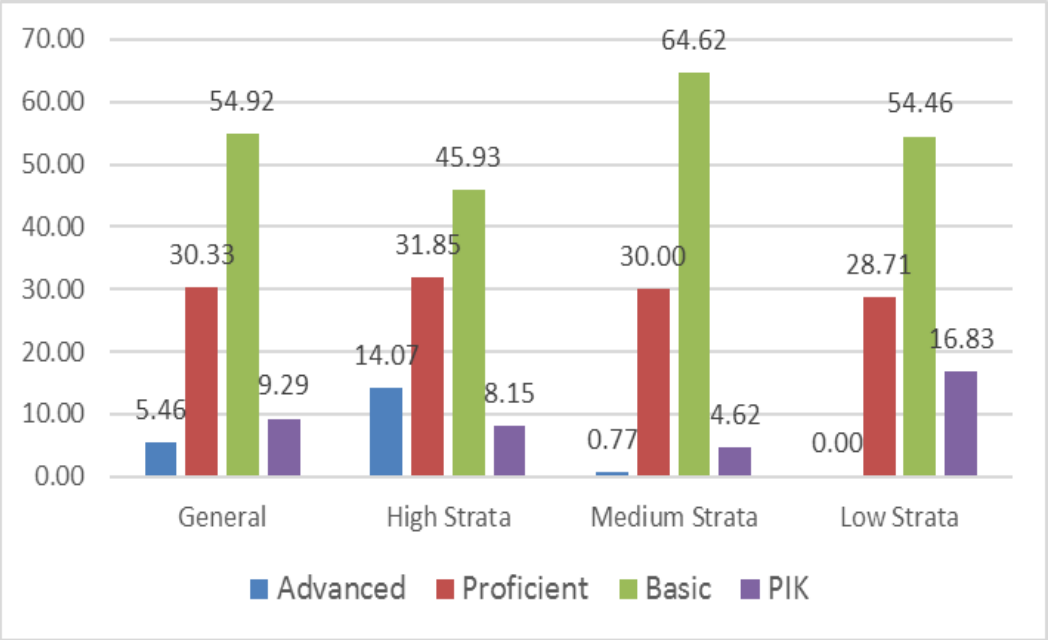
Results and Discussion

The results of the description of the average numeracy of students obtained from the research sample are presented in the following table.

Table 4. Numeracy in General and School Strata

Descriptive Statistics	School Strata			General
	High	Medium	Low	
Average	52,31	43,50	40,18	45,83
Standard Deviation	16,99	12,67	15,71	16,02
Category	Proficient	Basic	Basic	Basic
Ideal Highest Score	100	100	100	100
Highest Score	92	85	73	92
Ideal Lowest Score	0	0	0	0
Lowest Score	19	8	8	8
Number of Students	135	130	101	366

Based on the data above, the average numeracy score of students based on the research sample in general is 45.83. The score is included in the basic category. When viewed based on school strata, the average numeracy score for schools with high strata is 52.31 in the proficient category. Meanwhile, schools with medium (43.50) and low (40.18) strata are in the basic category. Furthermore, the learners' numeracy data are grouped into four categories, ranging from needing special intervention (PIK), basic, proficient, to advanced. The distribution of learners' numeracy categories in general and by school strata is shown in the following figure.



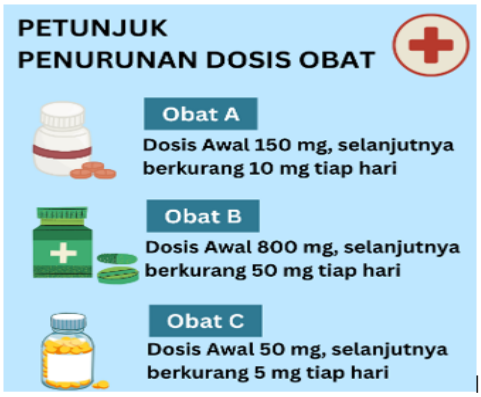
Picture 1. Percentage of Students in Each Category Numeration

The numeracy test results showed that most of students were in the basic category (54.92%), followed by the proficient category (30.33%), and only a few reached the advanced category (5.46%), while 9.29% required special intervention. The high strata had the highest proportion of students in the advanced (14.07%) and proficient (31.85%) categories with low percentages in the basic (45.93%) and PIK (8.15%) categories, indicating a better level of numeracy. In the medium strata, most were in the basic category (64.62%), with 30% in the proficient category, 0.77% in the advanced category, and PIK at 4.62%. The low stratum had the majority in the basic category (54.46%), 28.71% in the proficient category, with no participants in the advanced category (0%), and the highest PIK (16.83%), indicating a greater need for specialized interventions in this stratum.

Various data results obtained from the research sample above, it can be concluded that students' numeracy still needs to be improved because in general, students' numeracy is still in the basic category. This applies to schools from various strata but especially to medium and low strata. The results of the study also found that there are still learners who in working on numeracy problems are trapped in the reality bound, a condition where students are too focused on the context aspect of the problem without paying attention to relevant mathematical content and no mathematization is applied. Here is one of the answers of students who are trapped in the reality bound.

Penurunan Dosis Obat

Tapering off merupakan salah satu metode pemberian obat untuk mengurangi berbagai efek samping yang mungkin timbul bila dilakukan penghentian konsumsi obat secara mendadak. Penurunan dosis bertahap ini dilakukan untuk meminimalkan gejala putus obat, yaitu gejala yang dapat muncul ketika obat dihentikan secara tiba-tiba, seperti kecemasan, pusing, dan gangguan tidur. Berikut contoh penurunan dosis obat secara bertahap.



11. Dokter ingin memastikan bahwa total dosis selama periode pengobatan dengan obat C tidak melebihi 2000 mg, karena jika melebihi pengobatan harus dihentikan. Setelah menganalisa total konsumsi obat selama hari tertentu hingga dosis obat mencapai 0 mg, pada titik tersebut dokter tetap merekomendasikan pengobatan dengan obat C karena sesuai dengan aturan total dosis tidak melebihi 2000 mg. Setujukah kamu dengan analisa dan rekomendasi dokter tersebut? Jelaskan alasanmu pada kotak berikut!

Setuju karna arahan docter

Picture 2. Reality Bound Sample Answer

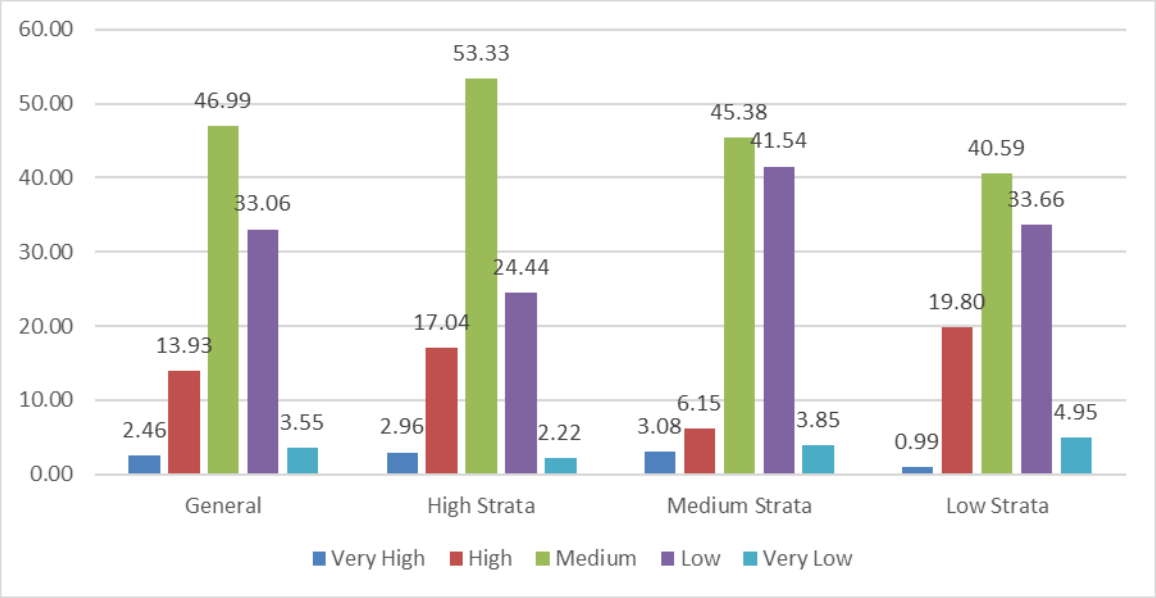
The question tests students' understanding of the pattern of decreasing dose of drug C by 5 mg each day (50, 45, 40, to 0) and its relationship to the total dose of 275 mg to evaluate the doctor's recommendation. Students were expected to analyze the pattern and use mathematization to support their answers. However, the results showed that the students focused more on the context of the doctor's recommendation without considering the relevant mathematical content, thus not applying the concept of number patterns. This may be due to misinterpretation of the question or limited understanding of number pattern concepts.

Furthermore, a description of the average mathematical self-efficacy of students is shown in the following table.

Table 5. Mathematics Self-Efficacy in General and School Strata

Descriptive Statistics	School Strata			General
	High	Medium	Low	
Average	61,81	58,96	60,06	60,32
Standard Deviation	9,23	9,06	10,12	9,48
Category	Medium	Medium	Medium	Medium
Ideal Highest Score	100	100	100	100
Highest Score	90	88	85	90
Ideal Lowest Score	25	25	25	25
Lowest Score	40	35	38	35
Number of Students	135	130	101	366

Data on students' mathematics self-efficacy levels were grouped into five categories, ranging from very low to very high. The distribution of categories of students' mathematics self-efficacy level in general and based on school strata is shown in the following figure.



Picture 3. Percentage of Students in Each Category of Mathematics Self-efficacy Levels

The results of the students' mathematics self-efficacy questionnaire show the dominance of the medium category with the highest percentage in general (46.99%), followed by the low (33.06%) and high (13.93%) categories, while the very high (2.46%) and very low (3.55%) categories have the lowest percentage. By strata, the medium category is most dominant in the high strata (53.33%), the medium strata has the highest percentage for the very high (3.08%) and low (41.54%) categories, while the low strata shows the highest distribution in the high category (19.80%).

To see how the numeracy and mathematics self-efficacy of the population, an interval estimation analysis was carried out to convert the research data from the sample. Numeracy and mathematics self-efficacy mean interval estimation data of the population are presented in the following table.

Table 6. Estimation of Interval Mean Numeracy and Mathematics Self-Efficacy

Variable	Interval	Category
Numerasi	$44{,}19 < \mu < 47{,}48$	Basic
Matehmatics Self-Efficacy	$59{,}34 < \mu < 61{,}29$	Medium

The results of the numeracy mean difference test with a significance level of 5% using Welch ANOVA showed a significant difference between students from schools with high, medium, and low strata ($p = 0.000 < 0.05$). The Games-Howell test showed significant differences in the pairs of high-medium and high-low strata, but not significant between the medium-low strata. Meanwhile, the test of mean differences in mathematics self-efficacy levels using ANOVA showed significant results ($p = 0.047 < 0.05$). Tukey test indicated a significant difference between high and medium strata, but there was no significant difference between high-low and medium-low strata.

Based on the correlation test, the correlation coefficient value is 0.407, meaning that the correlation is classified as moderate. Then, the sig value. = 0.000 <0.05, then the correlation is statistically significant. That is, there is a significant linear relationship between numeracy and mathematics self-efficacy of 11th

grade high school students in Pekalongan Regency. The relationship between numeracy category and mathematics self-efficacy level was analyzed using crosstab analysis with the help of SPSS application. The relationship between numeracy category and mathematics self-efficacy level can be observed from the crosstab and chi-square results in the following table.

Table 7. Crosstab Results of Numeracy and Mathematics Self-Efficacy

			Numeracy				Total
			PIK	Basic	Proficient	Advanced	
Mathematics Self-Efficacy	Low	Count	25	80	26	3	134
		Expected Count	12,4	73,6	40,6	7,3	
	Medium	Count	7	98	60	7	172
		Expected Count	16,0	94,5	52,2	9,4	
	High	Count	2	23	25	10	60
		Expected Count	5,6	33,0	18,2	3,3	
Total			34	201	111	20	366

Table 8. Chi-Square Results of Numeracy and Mathematics Self-Efficacy

	Value	df	Asymtotic Sig. (2-sided)
Pearson Chi-Square	49,626*	6	0,000
Likelihood Ratio	45,523	6	0,000
N of Valid Cases	366		

*1 cell (8.3%) had an expected count of less than 5. The minimum expected count was 3.28.

The results of the analysis using the Chi-Square test showed a linear relationship between the numeracy category and the level of mathematics self-efficacy, with a Pearson Chi-Square value of 49.626 ($p < 0.05$). This indicates a highly significant relationship between mathematics self-efficacy and numeracy. This is consistent with previous research showing that positive beliefs in the ability to succeed in mathematical tasks are associated with higher math achievement in children and adolescents (Singh et al., 2002; Živković et al., 2023).

As explained by Dixon et al (2020), increased confidence in solving mathematical problems can be achieved through authentic learning, which involves discussing concepts that are meaningful and relevant to real problems. This reinforces the importance of developing math self-efficacy through authentic learning experiences, where students not only learn mathematical theory, but also connect it to real applications that show the relevance of mathematics in everyday life. This development of mathematics self-efficacy, in turn, will lead to improved student numeracy, which is reflected in the significant relationship between the two.

Conclusion

The results showed that the numeracy of high school students in Pekalongan Regency was in the basic category with an average achievement of 45.83, where there were significant differences between school strata, especially between high strata and other strata. Students' mathematics self-efficacy is in the medium category with an average achievement of 43.39, and there are significant differences between school strata, especially between high and medium strata. This study also found a significant positive relationship between numeracy and mathematics self-efficacy ($r = 0.407$, $p < 0.05$), as well as a linear relationship between numeracy category and mathematics self-efficacy level ($\chi^2 = 49.626$, $p < 0.05$).

Based on the research results, some suggestions are given for various parties. For teachers and schools, the numeracy limitations of students in the basic category need to be addressed by developing learning strategies that are varied, relevant to personal and socio-cultural contexts, and focus on domains and cognitive levels that are still weak, such as geometry, measurement and reasoning. Teachers are also advised to use strong scientific contexts to support learning in other domains. Low and medium strata schools need to improve learning facilities such as teaching aids, technology and access to online learning resources, and organize regular training for teachers. Improving students' mathematics self-efficacy through authentic learning relevant to real problems also needs to be implemented. For the government, programs to strengthen numeracy and mathematics self-efficacy need to pay attention to the specific needs of each school strata by distributing resources equally, including teacher training and learning tools. The government is also expected to support further research to make the relationship between mathematics self-efficacy and numeracy the basis of educational policy. For researchers, further research is recommended to adapt numeracy questions to the AKM framework, explore other variables related to numeracy and mathematics self-efficacy, and develop innovative learning media that support the improvement of both aspects.

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