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Research Article

Numerical Literacy Orientation and Mathematical Problem-Solving Skills among Senior High School Students

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Abstract

While problem-solving skills are critical for academic and lifelong success, limited research explores how factors like numerical literacy orientation and sex influence these skills among senior high school students, particularly in the Philippine context. Grounded in Mathematical Cognition Theory, this study aimed to investigate the predictive power of sex and numerical literacy orientation on students' problem-solving skills. Using a correlational design, a total of 70 respondents participated in the study and employed stratified simple random sampling in the selection of the respondents. Data were collected using a contextualized instrument adapted from published international research, with face and content validity established through expert validation and pilot testing. Multiple linear regression with dummy coding for sex was used for analysis. The findings revealed a moderate level of numerical literacy orientation and a high level of problem-solving skills among students. Numerical literacy orientation was significantly related to problem-solving skills. Moreover, both sex and numerical literacy orientation significantly predict problem-solving skills, with numerical literacy orientation being the stronger predictor. Female students outperformed males in problem-solving skills. The study underscores the importance of fostering numerical literacy in curricula and addressing gender-specific learning needs to enhance problem-solving competencies.

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1. Introduction

Problem-solving skill is broadly defined as an individual's capacity to engage in cognitive processes to understand and resolve challenging situations where the solution is not immediately apparent (Jonassen, 2011). This ability has become increasingly crucial in the 21st century, especially in science, technology, engineering, and mathematics (STEM) education. Grounded in Mathematical Cognition Theory, which emphasizes the interplay of knowledge systems and cognitive processes in learning mathematics (Butterworth, 2005), problem-solving skills area understood to be influenced by both cognitive and affective factors.
Recent international assessments, such as the Programme for International Student Assessment (PISA), reveal persistent gaps in students' mathematical problem-solving performance. For example, Filipino students ranked among the lowest globally in mathematics in both the 2018 and 2022 PISA cycles (OECD, 2023). Similarly, American students continue to lag in problem-solving compared to peers from other developed nations (Schleicher, 2020). These findings highlight the urgent need to explore underlying factors influencing students' mathematical competencies, particularly in problem-solving.

Mathematical problem-solving is fundamental not only to academic achievement but also to practical life skills, including financial literacy, technological fluency, and analytical reasoning (UNESCO, 2021). Scholars emphasize that success in problem-solving requires integration of factual, procedural, and conceptual knowledge (Polya, 2020; Phonapichat et al., 2020).

Among the cognitive components of mathematical cognition, numerical literacy plays a foundational role. Defined as understanding and applying number relationships, representations, and operations, is a foundational skill closely linked to mathematical performance. Students lacking in numerical literacy are at a significant disadvantage across all domains of mathematics, including geometry, algebra, and data interpretation (Shumway et al., 2020; Bailey et al., 2021). Hence, evaluating numerical literacy orientation becomes essential when investigating students' problem-solving abilities.

Equally important are the sociocultural and psychological factors, such as gender dynamics and math anxiety. Studies show that gender stereotypes in math can trigger underperformance in female students, especially when they find themselves outnumbered by males in high-stakes academic environments (Flore & Wicherts, 2015; Master et al., 2021). Stereotype threat, often exacerbated by classroom composition, can negatively impact female students' confidence and performance in mathematical problem-solving (Stoet & Geary, 2022). Such gender-based performance gaps persist despite comparable abilities, underscoring the need to include sex as a moderating variable in educational research related to problem-solving.

In the local context, the researcher has observed that many Senior High School (SHS) students struggle not only with solving computation-based problems but also with interpreting questions and selecting appropriate strategies. The inability to identify the correct mathematical procedure often stems from weak numerical foundations. While international studies have extensively examined math anxiety and gender effects, few have focused on numerical literacy orientation with sex as a variable in predicting problem-solving skills. Therefore, this study aims to fill this gap by constructing a regression model to explain and predict the problem-solving skills of SHS students based on their numerical literacy orientation and sex.

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2. Materials and Methods

This study employed a descriptive-correlational research design to examine the relationship between numerical literacy orientation, sex, and problem-solving skills among Senior High School (SHS) students. The descriptive component provided a snapshot of current levels of these constructs, while the correlational design enabled analysis of the strength and direction of relationships among variables (Creswell & Creswell, 2018; Creswell & Poth, 2017). Regression analysis was also conducted to assess the predictive value of numerical literacy and sex on students' mathematical problem-solving skills (Hair et al., 2020).

The respondents were SHS students enrolled in one private school in Davao City, selected through simple random sampling to ensure each student had an equal chance of participation. Inclusion criteria allowed for participation across different genders and academic strands, while exclusion criteria were applied to prevent data quality issues, following ethical research standards (Ioannidis et al., 2014). A sample size of 70 was determined using the 20:1 rule for regression analysis, based on the presence of two independent and one dependent variable (Burmeister & Aitken, 2012). The research locale comprised various academic departments, with the SHS department offering strands such as STEM, ABM, GAS, and TVL.

For data collection, two standardized instruments were used: a numerical literacy orientation scale by Skwarchuck et al. (2014), and a problem-solving skills inventory adapted from Medina et al. (2019), which used a 5-point Likert scale to measure levels of agreement with problem-solving skills and numerical literacy orientation. These tools underwent content validation and pilot testing, with internal consistency confirmed via Cronbach's alpha, meeting the acceptable threshold of ≥0.70 (Huck, 2015; Tavakol & Dennick, 2011).
Data were collected online with consent from school administrators and analyzed using descriptive statistics (mean and standard deviation), Pearson's r for correlation, and regression analysis with dummy coding applied to categorical variables. These procedures allowed for both relational and predictive interpretations of how numerical literacy orientation and sex influence mathematical problem-solving skills.

3. Results

The overall mean of numerical literacy orientation as shown in Table 1 is 3.13, interpreted as moderate. This suggests that, overall, students sometimes demonstrate behaviors associated with numerical literacy orientation. The moderate result is due to the moderate ratings of the majority of the items on numerical literacy orientation. Only two items received high mean scores: learning simple sums through the help of parents (M = 3.51) and listening to parents' talk on the topic "Time" with the use of clocks and calendars (M = 3.41). These results suggest that these practices are more frequently observed among students compared to the other indicators.

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Table 1. Numerical Literacy Orientation

Indicator		SD	Mean	Description
1.	learning simple sums through the help of parents	1.05	3.51	High
2.	being encouraged by parents to do math mentally	1.13	3.21	Moderate
3.	listening to parents' talk on the topic "time" with the use of clocks and calendars	1.15	3.41	High
4.	learning to measure height, weight and compare quantities through the help of parents	1.13	3.10	Moderate
5.	playing games that involve counting, adding, or subtracting together with parents	1.15	2.66	Moderate
6.	being taught by parents to recognize printed numbers	1.24	3.03	Moderate
7.	being stimulated by parents to collect things (e.g. cards, stamps, rocks)	1.18	2.84	Moderate
8.	reciting numbers in order with the help of the parents	1.30	3.23	Moderate
9.	singing counting songs (e.g., five little monkeys) with parents	1.43	2.93	Moderate
10.	being encouraged by the parents to use fingers to indicate how many	1.31	3.36	Moderate
Total Mean		**0.81**	**3.13**	**Moderate**

The overall mean of problem-solving skills as shown in Table 3 is 4.13, categorized as high. This indicates that students frequently engage in strategies and behaviors conducive to effective mathematical problem-solving. Four indicators received very high ratings, including: repeatedly reading the problem if it is difficult (M = 4.64), solving step-by-step (M = 4.34), trying to illustrate the problem to understand it better (M = 4.30), and seeking help from knowledgeable people on how to solve difficult problems (M = 4.21). These scores reflect students' metacognitive awareness and flexible use of heuristics.

Table 2. Problem-Solving Skills

Indicator		SD	Mean	Description
1.	repeatedly reading the problem if it is difficult	0.51	4.64	Very High
2.	trying to illustrate the problem to understand it better	0.75	4.30	Very High
3.	making sure that there is a goal in mind when solving	0.78	4.10	High
4.	seeking help from knowledgeable people on how to solve difficult problems	0.72	4.21	Very High
5.	trying to figure out if the problem is already discussed in class or not	0.79	4.19	High
6.	determining what series of operations to use	0.80	4.00	High
7.	solving step-by-step	0.76	4.34	Very High

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8.	recalling past lessons to apply on the given problem	0.89	3.96	High
9.	associating the given problem to the real world to come up with practical ways to solve the problem	0.77	3.76	High
10.	manipulating the formula after determining what variables are missing	0.84	3.76	High
Total Mean		**0.52**	**4.13**	**High**

Table 3 presents the Pearson product-moment correlation between the independent and dependent variable. The analysis revealed a significant positive correlation between numerical literacy orientation and problem solving skills (r = .409, p < .05). Indicating that students with higher numerical literacy orientation tend to exhibit stronger problem-solving skills.

Table 3. Correlation between Variables

Pair of Variables		r-value	p-value
Independent Variable	**Dependent Variable**		
Numerical Literacy Orientation	*Problem-Solving Skills*	*.409**	*.000*
Sex	*Problem-Solving Skills*	*.266**	*.026*

Table 4 summarizes the regression analysis. Both numerical literacy orientation (B = .289, p < .05) and sex (B = -.334, p < .05) significantly influence problem-solving skills. The positive coefficient for numerical literacy indicates that greater orientation toward numerical literacy predicts higher problem-solving performance. The negative coefficient for sex (coded as 1 = male, 0 = female) indicates that, when controlling for numerical literacy, male students tend to score lower in problem-solving than female students. The overall model is significant (F = 12.431, p < .05) and yields R^2 of .271, meaning 27.1% of the variance in problem –solving skills is explained by the combination of sex and numerical literacy orientation.

Table 4. Regression Analysis on Numerical Literacy orientation and Sex as Predictors of Problem-Solving Skills

	Coefficients	Standard Error	t stat	p-value	
Intercept	3.387	.218		.000	sig
Sex	-.334	.108	-.324	.003	sig
NLO	.289	.068	.451	.000	sig

R square = .271
F value = 12.431
p value = 0.000 (significant)

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3.1. The Regression Model

The multiple regression analysis revealed that numerical literacy orientation and sex significantly predicted students' problem-solving skills, $F(2,67) = 12.431$, $p < .001$, with $R^2 = 0.271$. This indicates that 27.1% of the variance in problem-solving skills can be explained by the combined influence of these two variables.

The regression equation for the general model is:

Y = 3.387 - .334 (Sex) + .289 (NLO) **Model 1**

Where:

Y = predicted problem-solving score,

Sex is dummy coded (0 = female, 1 = male),

NLO = numerical literacy orientation score

A positive coefficient for NLO ($B = 0.289$, $p < .001$) suggests that students with higher levels of numerical literacy orientation tend to demonstrate stronger problem-solving skills. The negative coefficient for sex (B = -0.334, p = .003) indicates that, controlling for NLO, male students are predicted to score 0.334 points lower than female students.

To further explore how the relationship between numerical literacy orientation and problem-solving skills may vary by sex, the dataset was stratified. This allowed for construction of two additional models: one for male students and another for female students.

Model for Male students (Sex = 1):

Y = 3.053 + .289(NLO) **Model 2**

Model for Female students (Sex = 0):

Y = 3.387 + .289(NLO) **Model 3**

These equations demonstrate that, for the same level of numerical literacy orientation, female students are predicted to have problem-solving scores that are, on average, 0.334 points higher than those of male students. This finding highlights a consistent predictive advantage among female students, despite identical slope for NLO across sexes.

4. Conclusion

4.1. Numerical Literacy Orientation

The moderate rating of respondents for numerical literacy orientation suggests that this skill is only sometimes demonstrated among the student population. This finding may be associated with the limited parental involvement in children's mathematical development, a concern often reported in Filipino households. Recent studies have shown that parental engagement in children's academic activities remains inconsistent due to various socio-economic factors. Many parents are preoccupied with work responsibilities or lack the educational background and confidence to assist with schoolwork (Bernardo et al., 2022; UNICEF Philippines, 2021). In some cases, the perception that education is solely the school's responsibility still prevails in Filipino communities, leading to minimal home support for academic learning. Furthermore, Caballo et al. (2024) emphasized that students' technological readiness plays a crucial role in adapting to self-paced learning—suggesting that

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students exposed to digital tools at home may have more opportunities to develop numerical skills informally.

Despite the overall moderate ratings, students reported higher parental involvement in learning simple calculations, indicating that some parents continue to play a supportive role in early numeracy development. This is significant, as recent research emphasizes that even basic home-based math activities, such as counting or simple addition, foster positive attitudes and improved cognitive engagement in mathematics (Caviola et al., 2021). Students who engage in math-related discussions or activities at home tend to show greater effort, motivation, and enjoyment in mathematics classrooms (Kim et al., 2020). These three domains—cognitive, behavioral, and emotional engagement—are critical predictors of sustained academic success and are strongly correlated with better learning outcomes and higher school completion rates.

The results reaffirm the importance of home numeracy practices and suggest that enhancing numerical literacy orientation requires a collaborative effort between schools and families. Schools may consider implementing programs that empower parents to participate in their children's mathematical learning, especially for those with limited educational backgrounds. Targeted interventions can help bridge the gap in numeracy support and build students' confidence in problem-solving tasks, ultimately contributing to higher achievement and reduced math anxiety among learners.

4.2. Problem-Solving Skills

Respondents rated their problem-solving skills high overall, with some items receiving very high ratings. This suggests that students frequently demonstrate the behaviors and strategies associated with effective problem-solving. These findings align with current definitions of problem-solving as the ability to apply prior knowledge, cognitive skills, and adaptive thinking to navigate unfamiliar or complex situations (Lester & Cai, 2016; OECD, 2023). The most highly endorsed strategy in this study—repeatedly re-reading the problem when it is difficult—illustrates metacognitive regulation, a key characteristic of proficient problem solvers (Chai et al., 2021). Re-reading signals not only persistence but also a reflective approach, as students monitor their comprehension and adjust their strategies accordingly.

Students also reported using various heuristics such as trial-and-error, skip counting, guessing, and applying basic operations, which reflect flexible thinking and diverse strategy use. Tan's (2018) earlier observations about Filipino students' use of multiple informal strategies continue to be evident, and are now supported by more recent research emphasizing the importance of strategy diversity in building mathematical resilience and adaptability (Callejo & Zapatera, 2022). Contemporary findings show that students who use a repertoire of solution strategies are more likely to succeed in novel problem contexts, particularly when they can switch or combine strategies based on situational demands (Boaler & Williams, 2020). This adaptability is crucial for higher-order thinking in real-world problem-solving scenarios.

Overall, the high ratings across items suggest that many SHS students exhibit an active and varied engagement with mathematical tasks, although further development may be needed in formal strategy refinement. These findings underscore the importance of cultivating not just procedural fluency but also strategic and metacognitive skills in mathematics education. Integrating classroom practices that support open-ended problem-solving, collaborative reasoning, and reflective thinking can strengthen these cognitive competencies and further elevate students' problem-solving proficiency.

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4.3. Correlation

The hypothesis stating that there is no significant relationship between numerical literacy orientation and problem-solving skills was rejected in this study. Results revealed a statistically significant positive correlation between the two variables, as evidenced by a Pearson r values of .409 with a p-value less than the .05 significance level. This indicates that students with higher numerical literacy orientation are more likely to demonstrate stronger problem-solving abilities.

This findings aligns with the work of Shumway (2016), who emphasized a strong relationship between numerical literacy and problem-solving skills in students. According to Shumway (2011), students with a well-developed numerical sense, understanding number relationships, representations, and operations, are better equipped to succeed across various mathematical domains. In contrast, those lacking this foundational number sense often struggle with key areas such as measurement, geometry, data analysis, and algebra, all of which are essential for effective mathematical problem-solving.

4.4. Influence

The study rejected the null hypothesis of no significant relationship between numerical literacy orientation and problem-solving skills, as the Pearson r yielded a p-value below the .05 threshold. This confirms a statistically significant relationship between the two variables. This finding supports recent research indicating that students with strong numerical literacy tend to excel in problem-solving tasks due to their deeper understanding of number relationships, representations, and operations (Bailey et al., 2021; Caviola et al., 2021). Conversely, students with poor numerical foundations often face difficulties across all mathematical domains, including problem-solving.

Regarding the relationship between sex and problem-solving skills, the study also found a significant but inverse correlation, with female students outperforming males in overall problem-solving scores. This outcome contrasts with earlier studies that suggested males typically perform better in spatial or analytical problem-solving (Zhu, 2007; Siregar et al., 2018). However, recent literature increasingly reports narrowing or reversing gender gaps, particularly in learning environments that support collaboration and metacognition (Master et al., 2021; Stoet & Geary, 2022). While males may still offer more concise solutions, the current results suggest that female students demonstrate stronger overall problem-solving strategies.

Given the limited sample size, caution should be exercised in generalizing these findings to a broader population. Nevertheless, the results imply that sex-based instructional support—especially in enhancing functional and reflective thinking—could further bridge performance gaps. Educators are encouraged to adopt inclusive strategies that support both genders in developing critical problem-solving competencies.

4.5. Regression Model

The regression analysis established that both numerical literacy orientation and sex are statistically significant predictors of students' mathematical problem–solving skills, as indicated by the overall model, $F(2, 67) = 12.431$, $p < .001$, with an $R2 = 0.271$. This

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means that approximately 27.1% of the variation in students' problem-solving performance can be explained by the combined influence of the numerical literacy orientation and sex. While R2 may appear modest, it represents a meaningful effect size in educational research, particularly in behavioral studies, where explained variances often range between 10% and 30% (Cohen, 1988).

The positive coefficient for NLO confirms that the students with higher levels of numerical literacy orientation tend to perform better in problem-solving tasks. This supports previous findings that emphasize the importance of early numerical skills in enhancing mathematical reasoning and higher-order problem-solving (Bailey et al., 2021; Caviola et al., 2021). The negative coefficient for sex indicates that, holding numerical literacy constant, male students are predicted to score 0.334 points lower than female students.

These findings support the Mathematical Cognition Theory (Dubinsky et al., 1999), which explains that numerical understanding develops progressively—starting from conceptual competence (basic numeracy) to procedural and eventually logical competence, which underpins complex problem-solving. The model for female students (Model 3) showed that the effect of numerical literacy on problem-solving skills remains consistently positive, while the inclusion of sex in Models 1 and 2 suggested that male students may underperform relative to their female counterparts in this domain.

These results contradict earlier claims of innate male superiority in mathematical cognition (e.g., Benbow & Stanley, 1980), a view now widely contested by modern research. Recent studies emphasize that gender differences in math performance are more likely attributed to social, cultural, and environmental factors rather than biological determinism (Hyde, 2016; Gunderson et al., 2021). Furthermore, growing evidence suggests that girls often outperform boys in classroom-based assessments, especially in environments that foster metacognitive awareness, self-regulation, and collaborative problem-solving (Master et al., 2021). As such, the current findings add to the body of research advocating for equity-focused pedagogy and challenge long-standing gender stereotypes in mathematical ability.

5. Conclusion and Recommendation

5.1. Conclusion

Based on the findings of this study, several key conclusions can be drawn. First, senior high school students frequently demonstrate (high level) their problem-solving skills, as reflected in their positive engagement and persistence when tackling mathematical problems. In contrast, their numerical literacy orientation was found to be moderate, particularly in activities that involve interactive learning with parents, such as games related to counting, addition, or subtraction. This disparity suggests that while students may be confident in applying strategies, their foundational numerical exposure and support, especially at home, may be lacking.

Second, a significant positive relationship was confirmed between numerical literacy orientation and problem-solving skills, indicating that students with stronger numerical foundations are more likely to perform better in solving mathematical problems.

Finally, the regression analysis resulted in the development of three predictive models: a general model, a model for male students, and a model for female students. These models consistently revealed that female students demonstrate higher levels of problem-solving skills, thereby challenging the assumptions of the theoretical framework used in this study,

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particularly those rooted in outdated claims of innate male superiority in mathematics. The findings emphasize the need for instructional strategies that enhance numerical literacy and gender-sensitive interventions to support all learners in developing critical mathematical thinking skills.

5.2 Recommendations

1. Schools and local education authorities should initiate programs that involve parents in supporting early numeracy development at home. These may include parent workshops, take-home math kits, and guidance on incorporating math into daily routines (e.g., cooking, shopping, scheduling).

2. Teachers should foster metacognition by encouraging students to plan, monitor, and evaluate their problem-solving processes. Classroom practices such as "think-aloud", error analysis, journaling, and collaborative problem-solving can enhance self-regulation and strategic flexibility.

3. Schools should provide a supportive environment that mitigates gender stereotypes and promotes equal participation. This may involve mentorship programs, inclusive grouping strategies, and classroom norms that affirm the mathematical abilities of both male and female students.

4. To address moderate numerical literacy orientation, especially in students with limited home-based support, schools should enhance early-grade numeracy programs and offer remedial or enrichment sessions focused on conceptual understanding of numbers and operations.

5. Future studies should include larger and more diverse samples across multiple schools or regions to validate the generalizability of the models and further explore the moderating role of sex and other sociocultural variables in mathematical problem-solving.

6. Limitations of the Study

While this study employed rigorous sampling and validated instruments, several limitations should be acknowledged. First, the findings have limited generalizability, as data were collected from a single private school in Davao City with a relatively small sample size. Second, the study relied on self-reported data, which may be subject to social desirability or recall bias. Third, the cross-sectional design limits the ability to infer causal relationships between numerical literacy orientation, sex, and problem-solving skills. Future research may benefit from longitudinal or experimental designs to establish causal pathways and enhance external validity.

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