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# Self-Regulation, Mathematics Self-Efficacy, Learning Behavior, and Problem-Solving Skills of Senior High School Students: A Path Analysis

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## ABSTRACT

This study determined the best-fit path model involving self-regulation, mathematics self-efficacy, learning behavior, and problem-solving skills among senior high school students in public secondary schools in Region XI, Philippines. A descriptive correlational research design was utilized, involving senior high school students enrolled in selected public secondary schools. Also, adapted research questionnaires were employed. Data were analyzed using mean, standard deviation, Pearson r, multiple regression, and path analysis. The results revealed that mathematics self-efficacy was moderate, while the self-regulation, learning behavior, and problem-solving skills were high. Moreover, mathematics self-efficacy and learning behavior had a strong positive correlation with problem-solving skills, while self-regulation and problem-solving skills had a moderate positive relationship. Additionally, in a singular capacity, self-regulation, mathematics self-efficacy, and learning behavior significantly influenced the problem-solving skills of senior high school students. Also, the best-fit path model demonstrated satisfactory performance, as evidenced by favorable goodness-of-fit indices. Further, significant associations among the variables were identified: learning behavior and mathematics self-efficacy, and self-regulation and learning behavior. In addition, learning behavior had an indirect positive influence on problem-solving skills through mathematics self-efficacy.

**Keywords:** Education, self-regulation, mathematics self-efficacy, learning behavior, problem-solving skills, path analysis, Philippines

## INTRODUCTION

Problem-solving skills refer to the ability to determine, understand, and calculate problems adeptly and proficiently (Kaitera & Harmoinen, 2022). The significance of problem-solving skills in academic and career advancement is undeniable; however, it remains a complex and demanding skill (Xu et al., 2023). According to a study by Septriansyah et al. (2022), only 28 percent of the student population mastered a mathematical problem, while the remaining students struggled with the process and demonstrated a lack of basic problem-solving skills. A study by Makwakwa et al. (2023) reported that students' problem-solving skills across different areas of mathematics were low, indicating a major lack of skills to address mathematical challenges.

Research by Carpenter and DeLiema (2024) found that students in Minnesota lacked confidence in their ability to solve problems, which led them to feel nervous and reluctant to understand and choose solutions to mathematical problems. Similarly, Indian students who struggled to solve problems showed a lack of self-confidence when seeking help and contributing to class discussions, which hindered their ability to apply and connect mathematical concepts (Vijayakumar, 2024). Additionally, Sarkingobir and Bello (2024) reported that 51 percent of secondary school students in Nigeria could not solve mathematical problems. Likewise, findings by Disparrilla and Afriansyah (2022) and Murniati et al. (2024) showed that 65 percent of Indonesian students had difficulty with problem-solving skills, as they failed to complete diagnostic tests with routine and non-routine problems.

In the Philippines, there is a serious problem in mathematics education, as evidenced by the Trends International Mathematics and Sciences Study (TIMSS), which found that 96 percent of Filipino students needed to improve their problem-solving skills (Mullis et al., 2020). Moreover, a study by Lagria and Pañares (2023) in Gingoog City revealed that 40 percent of students struggled to solve mathematics problems because they were not using mathematical concepts in real-world situations (Dinglasan et al., 2023). Supporting this notion, a study by Verzosa-Quinto and Mabansag (2023) found that many Filipino students had difficulty solving mathematical problems due to a high likelihood of errors.

In Region XI, the SDO Davao City (2024) reported that Grade 12 students achieved an average problem-solving score of 43.50 percent in mathematics during the National Achievement Test (NAT), which did not meet the minimum proficiency level of 50 to 74 percent. Moreover, a study conducted in Davao del Norte by Enerosa and Abuzo (2024) revealed that only 44 percent of secondary learners answered the six problem-solving questions correctly, resulting in a proficiency level of 43.69 percent, which is below the 75 percent standard, indicating a significant shortcoming in their problem-solving skills. To add, in the recent NAT for Grade 12, administered during the school year 2023-2024, students in Davao de Oro scored only 32.15 percent in problem-solving for mathematics, which reflected a low proficiency level, suggesting that students had difficulty in demonstrating a good understanding and application of mathematical concepts (SDO Davao de Oro, 2025).

The abovementioned situations were alarming, as problem-solving skills are considered the most important mathematics skills, helping learners catch up in this competitive, modern world. The results of the study by Lester and Cai (2016) pointed out that problem-solving skills help learners develop a deeper understanding of mathematics by navigating and relating their learning to practical concepts. Specifically, Sukariasih et al. (2020) and Fitriani et al. (2020) stated that problem-solving skills help learners develop their own solutions and gain excellent knowledge of solving real-life situations. Indeed, problem-solving skills foster innovation and creativity in the 21st century, helping learners to solve complex problems, generate new outcomes, and succeed academically and professionally (Adeoye & Jimoh, 2023).

A study conducted by Hacker and Bol (2019) mentioned that it is essential for learners to facilitate their learning processes, especially during self-study periods when the instructor is not present. Self-regulation is an important factor, as it helps learners develop the skill of directing and controlling themselves when modifying their actions, especially when solving problems (Cai et al., 2020). Additionally, according to Mafaza (2024), students with strong self-regulation can proficiently meet all four of Polya's problem-solving criteria, indicating a direct correlation between self-regulation and problem-solving skills.

Furthermore, Tende et al. (2022) argued that problem-solving skills depend on mathematics self-efficacy. Notably, observation and evaluation signaled the kind of problem-solving in this most complicated process (Sun et al., 2022). Further, Elballah (2024) found that the relationship between mathematics self-efficacy (MSE) and problem-solving skills (PSS) is significant, indicating that higher PSS is associated with higher MSE, which, in turn, is associated with improved academic performance, critical thinking, and creativity.

Moreover, Kim (2022) noted that learning behaviors facilitate the development of problem-solving skills. Such behavior meant that when learning took place, problem-solving skills were enabled through intrinsic empowerment, entrustment, and functional skills, allowing the learner to reflect critically on achievements, manage resources, and collaborate to enhance academic performance and problem-solving skills (Ghani et al., 2021). Also, Zheng et al. (2024) stated that learning behavior is key to problem-solving skills because it allows the application of theoretical knowledge and fosters personal development, thereby enhancing actual problem-solving skills.

A study by Rumin found that problem-solving skills remain difficult to master despite efforts such as workshops and exercises. Several studies have examined which factors are associated with problem-solving skills (Silao, 2018; Bhadargade et al., 2020; Malangtupthong et al., 2022; Wang et al., 2023). Research by Valdez and Buhingan (2019) and Andal and Hermosa (2024) highlighted that these abilities can be enhanced through problem-based learning, while Yao (2021) explored the relationship among problem-solving skills, academic self-efficacy, and self-directed learning. Additionally, Ragudo (2024) emphasized the relationship between logical thinking and problem-solving.

Further empirical investigations have examined related constructs using varied research designs. Maksum et al. (2021) conducted a path analysis of self-regulation, social skills, critical thinking, and problem-solving ability among elementary students in DKI Jakarta Province. The effects of self-regulated learning on the problem-solving abilities of private high school students in Makassar, Indonesia, were also explored by Rahayuningsih et al. (2021) through an explanatory mixed-method design. Likewise, Kohen et al. (2022) found a relationship between self-efficacy and problem-solving skills in mathematics among 9th-grade students in Israel, through the effects of instruction-based dynamic and static visualization. Moreover, Ghani et al. (2021) conducted a scoping review using the Arksey and O'Malley (2005) protocol to examine the effectiveness of learning behavior in problem-based learning.

However, few studies have yet examined which model best fits the problem-solving skills of senior high school students regarding self-regulation, mathematics self-efficacy, and learning behavior, especially in Region XI. Addressing this gap is crucial, as this skill is important in developing analytical thinking, creativity, and innovation, which are highlighted as important aspects of 21st-century skills. In addition, the Department of Education could implement regular capacity-building programs and student retooling initiatives to enhance self-regulation, self-efficacy, and learning behavior, ultimately improving problem-solving skills. Teachers would have a clear way to assess how students develop problem-solving skills, while senior high school students would learn self-discipline and the strategies needed to succeed in school and future careers. By making this a priority in education, students would be prepared to face challenges in local, national, and even global settings.

The findings of this study are intended to support the academic community and its stakeholders, including parents, teachers, and students, by strengthening problem-solving skills to address pressing educational needs. These results are aligned with Sustainable Development Goal 4 on Quality Education, which promotes inclusive and equitable education and advances the development of skills relevant to employment, decent work, and entrepreneurship. In the same way, the study's implications align with the Department of Education's Five-Point Reform Agenda, which was laid out in 2024 under the leadership of Sonny Angara. This reform agenda emphasizes the creation of an enabling learning environment through collaboration, the promotion of teachers' welfare through capacity-building and assessment frameworks, and the enhancement of students' well-being through self-regulation and resilience. Through these contributions, the study also supports efficient learning delivery across modalities and helps cultivate a future-ready workforce equipped with critical thinking, creativity, and problem-solving skills necessary for academic and career success.

More so, sharing the results through community activities can be a good first step to inform everyone about the study and its findings. This may be done through division mathematics meetings and Learning Action Cell (LAC) sessions, where teachers can meet to discuss the findings and apply them in their classroom practice. Through these discussions, stakeholders can better understand the results and use them meaningfully. The researcher intends to organize a public forum or conference for parents, teachers, and students to encourage collaboration and open dialogue about the findings. Presenting research results at conferences can strengthen the credibility of the study and create opportunities for professional exchange. Furthermore, publishing the findings in reputable educational journals will add to the existing knowledge in mathematics education and help other researchers and teachers use the results in their own studies and teaching practice.

**Statement of the Problem**

1. What is the status of the self-regulation of senior high school students in terms of:

1.1 forethought; and

1.2 volitional control and self-reflection?

2. What is the level of mathematics self-efficacy of senior high school students in terms of:

2.1 mastery experience;

2.2 vicarious experience;

2.3 social persuasions; and

2.4 physiological state?

3. What is the status of learning behavior of senior high school students in terms of:

3.1 engagement;

3.2 motivation;

3.3 independence;

3.4 responsiveness;

3.5 collaboration; and

3.6 participation?

4. What is the level of problem-solving skills of senior high school students in terms of:

4.1 self-confidence about solving problems;

4.2 putting effort into solving problems; and

4.3 procedure followed to solve problems?

5. Is there a significant interrelationship between the variables?

6. What model best fits the problem-solving skills of senior high school students?

7. What are the implications of the significant causal links in problem-solving skills?

## METHODOLOGY

### Research Design

This study followed a quantitative, non-experimental descriptive-correlational research design. Since this method did not involve changing or controlling any conditions, it was well-suited for exploring real-life situations and seeing how things naturally related to one another.

Quantitative design focuses on collecting and analyzing numerical data to find patterns, test ideas, and draw conclusions (Creswell & Creswell, 2022). In this study, structured questionnaires were used to gather measurable information from senior high school students. Standardized Likert-scale instruments measured all variables. The collected data were analyzed using statistical tools and then interpreted.

Descriptive design is quantitative research that provides systematic descriptions of a population, a situation, or a phenomenon collected in such a manner that data truly reflect the existing conditions or characteristics (Creswell, 2014). The focus was on observing and documenting what was at hand. Structured questionnaires were distributed in this descriptive study. The levels of self-regulation, mathematics self-efficacy, learning behavior, and problem-solving skills of the students were quantified using these tools. The data was analyzed using descriptive statistics, and the mean and standard deviation were used to summarize the student profiles for each of the variables mentioned above. This design provided an overall picture of these major parameters within the student target group.

A correlational research design is a quantitative method of determining the relationship between two or more variables without changing them (Miksza et al., 2023). It can be determined if a certain relationship exists, for example, if the increase of one variable is related to the increase of another, but it cannot prove a cause and effect. The correlation between students' self-regulation, mathematics self-efficacy, learning behavior, and problem-solving skills was examined throughout the study using a correlational design. The strength and direction of the relationship between the variables were determined by measuring and analyzing the responses using statistical techniques, such as Pearson's correlation coefficient.

**Population and Sample**

The respondents in this study were 460 senior high school learners enrolled in the first semester of the 2025–2026 school year in very large public secondary schools in Region XI (Davao Region). These schools are defined as institutions with 100 or more teaching personnel and with more than 2,000 senior high school students enrolled. The respondents were drawn from the estimated total population of 202,326 senior high school students in Region XI to ensure that the sample reflects the wider student body. They represented diverse geographical locations and socioeconomic backgrounds, which supports a fair and comprehensive representation of learners across the region.

Inclusion in the study was based on specific criteria. Eligible respondents were senior high school students enrolled in a very large public secondary school in Region XI during the first semester of the 2025–2026 school year. They were required to complete the assent form, secure parental or guardian consent, and voluntarily agree to participate. Students were excluded if they were enrolled in private schools, residing outside Region XI, not part of the senior high school program, refused to participate, failed to submit the required consent or assent, or withdrew from the study without a valid justification.

The sample size of 460 was appropriate, given the 46 estimated parameters included in the study. Following the 10:1 respondent-to-parameter ratio in Structural Equation Modeling, as recommended by Jöreskog and Sörbom (1993) and Byrne (2016), this ratio ensured adequate statistical power, stable parameter estimation, and reliable model fit. Adhering to this standard strengthened the validity and generalizability of the findings and ensured that the results meaningfully represent the broader student population.

To identify the respondents, a multistage sampling method was employed. Multistage sampling is a hierarchical probability sampling technique that selects samples in successive stages, moving from large clusters to smaller units until reaching the target group, making it suitable for large, geographically dispersed populations (Sedgwick, 2015). In this study, the population was first organized into five provincial clusters corresponding to the 11 Schools Division Offices in Region XI. From these clusters, two provinces were randomly selected. Very large public secondary schools in the selected provinces were identified, and students were randomly selected from them. Based on the senior high school population in each province, 45,572 in Davao del Norte and 28,047 in Davao de Oro, the sample was proportionally allocated, resulting in 285 respondents from Davao del Norte and 175 from Davao de Oro. This procedure ensured transparency, proportional representation, and equal opportunity for eligible students to be included in the study.

Since the respondents were minors, they were considered a vulnerable group in the research. Their age limits their legal and psychological capacity to make fully independent decisions regarding participation. Therefore, the study strictly adhered to ethical protocols by obtaining informed consent from parents or legal guardians and assent from students. The researcher explained the purpose, procedures, and limits of confidentiality in clear and age-appropriate language. The choice between written and verbal consent was determined by context, with the protection of respondents' rights, welfare, and dignity as the primary consideration.

**Research Instruments**

The first instrument, which measured self-regulation, was adapted from Sarikaya et al. (2023). The Cronbach's Alpha internal consistency coefficient was calculated as 0.88. Further, it had two indicators: forethought, and volitional control and self-reflection. This instrument consisted of nine items: four for forethought and five for volitional control and self-reflection, with responses ranging from 1—Never to 5—Always.

The second instrument, which assessed mathematics self-efficacy, was adapted from Usher and Pajares (2009). A Cronbach's Alpha of 0.94 was obtained from this measure. It had four indicators: mastery experience, vicarious experience, social persuasions, and physiological state. Moreover, it consisted of 24 items, six per indicator. This is a six-point Likert scale ranging from 1 (definitely false) to 6 (definitely true).

The third instrument, which measured learning behavior, was adapted from Kunwar's (2023) study and had a Cronbach's Alpha of 0.92. It had six indicators: engagement, motivation, independence, responsiveness, collaboration, and participation. It had 30 items in total, five for each indicator. This was a five-point Likert scale, ranging from 1—Strongly Disagree to 5—Strongly Agree.

The fourth instrument, problem-solving skills, was adapted from Erdem-Keklik's (2013) study and had a Cronbach's alpha of 0.95. This included three indicators, totaling 28 items. The first indicator, self-confidence in solving problems, had 10 items. The second, putting effort into solving problems, had 11 items. The third indicator, procedure followed to solve problems, had seven items. In this study, responses for each item ranged from 1 (Never) to 5 (Always).

**Statistical Tool**

**Mean**. This was utilized to assess the levels of self-regulation, self-efficacy, learning behavior, and problem-solving abilities of senior high school students in Region XI.

**Standard Deviation**. This was used to show how varied students' levels are in self-regulation, mathematics self-efficacy, learning behavior, and problem-solving skills around the average.

**Pearson Product Moment Correlation**. This was applied to determine the significant relationship between the dependent variable, problem-solving skills, and the independent variables, self-regulation, self-efficacy, and learning behavior. Moreover, the strength of the correlation coefficients was interpreted according to the criteria of Schober et al. (2018): 0.00-0.09 is negligible; 0.10-0.39 is weak; 0.40-0.69 is moderate; 0.70-0.89 is strong; and 0.90-1.00 is very strong.

**Multiple Linear Regression Analysis**. This was employed in data description and relationship explanation. It was used to identify the variables that predict the problem-solving skills of senior high school students.

**Path Analysis**. This was used to test the hypothesized model of relationships among self-regulation, mathematics self-efficacy, learning behavior, and problem-solving skills. This method allowed the examination of both direct and indirect effects among variables. Also, it was used to estimate the strength of hypothesized paths, assess model fit using indices such as CMIN/df (Chi-Square/Degrees of Freedom), Normed Fit Index (NFI), Tucker Lewis Index (TLI), Comparative Fit Index (CFI), Goodness-of-Fit Index (GFI), Root Mean Square of Error Estimation (RMSEA), and p-CLOSE, and determine how well the theoretical model explains variations in problem-solving skills among senior high school students. More importantly, a model is said to be the best-fit if it satisfies the following criteria: CMIN/df≤5 for acceptable, ≤3 for good and <3 for fit; NFI≥0.90; TLI≥0.90; CFI≥0.90; GFI≥0.90; RMSEA≤0.08 is good, ≤0.10 acceptable; p-CLOSE>0.05.

## RESULTS AND DISCUSSION

**Status of Self-regulation among Senior High School Students in Region XI**

The status of self-regulation among senior high school students in Region XI is shown in Table 1. As presented, self-regulation has an overall mean of 3.93, indicating a high level of self-regulation, with a standard deviation of 0.47. This indicates that the self-regulation of senior high school students is oftentimes manifested. Further, this result suggests that students can manage their learning independently, make thoughtful decisions, and adapt their actions to achieve their academic goals.

Table 1. Status of Self-regulation among Senior High School Students in Region XI

| | **Mean** | **SD** | **Description** |
|---|---|---|---|
| Forethought | 3.75 | 0.75 | High |
| Volitional Control and Self-reflection | 4.11 | 0.58 | High |
| **Overall Mean** | **3.93** | **0.47** | **High** |

The present results confirm the findings of de la Fuente et al. (2020) that students exhibit a high level of self-regulation and often plan, set goals, track their progress, and revise their methods accordingly. These results are likewise consistent with Youssef and Alibraheim (2025), who indicated that students demonstrate a high level of self-regulation and can manage their own learning process. In addition, these findings align with those of Magsino (2021), which showed that students possess a high level of self-regulation and can adapt to disruptions, reinforcing the view that self-regulation is consistently evident across contexts.

**Level of Mathematics Self-efficacy among Senior High School Students in Region XI**

Presented in Table 2 is the status of mathematics self-efficacy among senior high school students in Region XI. As reflected, the senior high school students in Region XI have a moderate level of mathematics self-efficacy, with an overall mean of 3.77 and a standard deviation of 0.86. This means that students' mathematics self-efficacy is sometimes evident. This suggests that students have a fair degree of confidence in their mathematical abilities but still experience uncertainty in certain aspects of learning mathematics.

Table 2. Level of Mathematics Self-efficacy among Senior High School Students in Region XI

| | **Mean** | **SD** | **Description** |
|---|---|---|---|
| Mastery Experience | 3.80 | 0.85 | Moderate |
| Vicarious Experience | 4.51 | 0.87 | High |
| Social Persuasions | 3.27 | 1.30 | Moderate |
| Physiological State | 3.48 | 1.04 | Moderate |
| **Overall Mean** | **3.77** | **0.86** | **Moderate** |

The results are in accordance with Fetalver and Merano (2021), who reported that senior high school students exhibited a moderate level of mathematics self-efficacy. Similar patterns were observed by Vergara (2025), who also found a moderate level of mathematics self-efficacy among students. Likewise, the findings align with those of Purwati et al. (2025), who noted that more than half of the students demonstrated moderate mathematics self-efficacy. In a similar way, this supports Pendon's (2022) claim that students possess a moderate level of self-efficacy and tend to feel uncertain when faced with challenging mathematics problems. Furthermore, this aligns with Campanilla (2025), who reported that learners demonstrate a moderate degree of mathematics self-efficacy, believing they can succeed in mathematics but lacking full confidence in their abilities across all situations.

**Status of Learning Behavior among Senior High School Students in Region XI**

The status of learning behavior among senior high school students in Region XI is presented in Table 3. The learning behavior of senior high school students in Region XI had an overall mean of 3.50 and a standard deviation of 0.60, indicating a high level of learning behavior. It means that learning behavior among senior high school students is oftentimes observed. This shows that senior high school students in Region XI are actively engaged, motivated, involved, and interactive with both teachers and peers.

The findings of this study align with Liu et al. (2023), who reported a high level of learning behavior among senior high school students. Moreover, these results are consistent with those of Li et al. (2022), who reported that students demonstrated a high level of learning behavior, which aligns with Gomes et al. (2023), who found strong learning behaviors, particularly in group projects and critical thinking exercises. These findings align with Li et al. (2024), who reported that students exhibited high levels of learning behavior during their studies.

Table 3. Status of Learning Behavior among Senior High School Students in Region XI

| | Mean | SD | Description |
|---|---|---|---|
| Engagement | 3.74 | 0.75 | High |
| Motivation | 3.77 | 0.73 | High |
| Independence | 3.25 | 0.83 | Moderate |
| Responsiveness | 3.40 | 0.81 | High |
| Collaboration | 3.49 | 0.73 | High |
| Participation | 3.37 | 0.66 | Moderate |
| **Overall Mean** | **3.50** | **0.60** | **High** |

**Level of Problem-Solving Skills of Senior High School Students in Region XI**

Presented in Table 4 is the status of problem-solving skills of senior high school students in Region XI. As reflected, the problem-solving skills of senior high school students in Region XI were rated at a high level of 3.49 with a standard deviation of 0.62. This means that the students' problem-solving skills are very satisfactory. In other words, the senior high school students of Region XI are capable of approaching mathematical challenges with persistence, strategic planning, and reflective thinking.

This high level aligns with the findings of Jamilah et al. (2021), who noted high problem-solving skills among senior high school students and similar advanced skills in reasoning and the application of concepts learned. Likewise, these findings are consistent with those of Ermac and Tan (2023), who reported that students have high problem-solving skills. These are similar to the findings of Karataş et al. (2017), who reported that high school students had high levels of problem-solving skills.

Table 4. Level of Problem-Solving Skills of Senior High School Students in Region XI

| | Mean | SD | Description |
|---|---|---|---|
| Self-confidence about Solving Problems | 3.48 | 0.70 | High |
| Putting Effort in Solving Problems | 3.60 | 0.66 | High |
| Procedure Followed to Solve Problems | 3.40 | 0.74 | High |
| **Overall Mean** | **3.49** | **0.62** | **High** |

**Interrelationship of the Connection between the Variables**

The nature of the relationships among the variables, namely, self-regulation, mathematics self-efficacy, learning behavior, and problem-solving skills, is reflected in Table 5.1 and Table 5.2. In Table 5.1, it is shown that self-regulation, mathematics self-efficacy, and learning behavior are significantly related to problem-solving skills

($p<.05$). In particular, self-regulation is positively and significantly related to problem-solving skills ($r=.41$, $p<.05$). The strength of the correlation between the two variables is moderate. This suggests that students' ability to regulate their learning processes alone may not be sufficient to substantially enhance problem-solving skills unless it is supported by other cognitive, motivational, and instructional factors.

These findings concur with the results of Rezaei et al. (2024), which demonstrated a direct correlation between self-regulation and problem-solving skills, suggesting that students with a higher degree of self-regulation tend to solve problems more successfully. This is comparable to the research conducted by Losenno et al. (2020), which discovered a direct correlation between students' problem-solving skills and self-regulation.

Table 5.1 Significance of the Characteristics of the Connection between the Variables

| **Variables** | **Problem-Solving Skills** | | |
|---|---|---|---|
| | r | p-value | Remarks |
| Self-regulation | 0.41 | .00 | Significant |
| Mathematics Self-efficacy | 0.72 | .00 | Significant |
| Learning Behavior | 0.75 | .00 | Significant |

On the other hand, there is a significant positive relationship between mathematics self-efficacy and problem-solving skills ($r = .72$, $p < .05$). With an r-value of 0.72, the two variables have a strong correlation. This suggests that students with greater confidence in their mathematical abilities are more likely to excel at problem-solving. The findings align with a study by Pendon (2022), which stated that students with higher mathematics self-efficacy also exhibited stronger problem-solving skills, demonstrating a significant positive relationship between the two.

Further, learning behavior and problem-solving skills are significantly correlated ($r = .75$, $p < .05$). The r-value of 0.75 indicates a strong correlation between the two variables. This implies that positive learning behaviors such as persistence, engagement, and effective study strategies are strongly associated with higher problem-solving skills. These findings align with Xu et al. (2022), who reported a significant correlation between learning behaviors and problem-solving skills and noted that personal characteristics that influence social interactions foster constructive behaviors that enhance problem-solving abilities.

Table 5.2 Significance of the Influence of Self-regulation, Mathematics Self-efficacy, and Learning Behavior on Problem-Solving Skills

| **Variables** | | **Problem-Solving Skills** | | | |
|---|---|---|---|---|---|
| | | β | r | p-value | Remarks |
| Self-regulation | | 0.11 | 3.46 | .00 | Significant |
| Mathematics Self-efficacy | | 0.34 | 8.08 | .00 | Significant |
| Learning Behavior | | 0.46 | 10.80 | .00 | Significant |
| Combined Influence of Predictors | | | | | |
| R | 0.80 | | | | |
| $R^2$ | 0.63 | | | | |
| F | 262.52 | | | | |
| p | .00 | | | | |

Furthermore, it is indicated in Table 5.2 that the combined effect of self-regulation, mathematics self-efficacy, and learning behavior on problem-solving skills is a good fit for the empirical data in this study, as revealed in the results of F(3,456)=262.52,p=.00. The R-squared value is reported at 0.63, indicating that 63 percent of the variability in students' problem-solving skills can be explained by the combined influence of the three exogenous variables. The remaining 37 percent is attributable to the unexplained variance or other factors not included in this study.

**Best-Fit Model of Problem-Solving Skills of Senior High School Students**

The goodness-of-fit measures of the revised model are presented in Table 6, which shows the indices as a basis for overall model evaluation. The results of the model fit analysis revealed that the revised model demonstrated an acceptable overall fit to the empirical data. The chi-square value (CMIN=5.247,df=1,p=.022) was significant. However, because this statistic is sensitive to large sample sizes, a significant result does not always mean the model fits poorly.

Table 6. Goodness of Fit Measures of the Best-Fit Model of Problem-Solving Skills of Senior High School Students

| Index | Criterion | Model | Remarks |
|---|---|---|---|
| CMIN/df | ≤5 for acceptable, ≤3 for good fit<3 | 5.247 | Marginally acceptable range |
| NFI | ≥0.90 | 0.994 | Excellent |
| TLI | ≥0.90 | 0.971 | Excellent |
| CFI | ≥0.90 | 0.995 | Excellent |
| GFI | ≥0.90 | 0.943 | Good |
| RMSEA | ≤0.80 is good; ≤0.10 acceptable | 0.096 | Acceptable |
| p-CLOSE | >.05 | 0.112 | Acceptable |

Additionally, the model appears to be reasonably consistent with the observed data, as indicated by the relative chi-square (CMIN/df= 5.247) falling within the marginally acceptable range. With RMR = 0.011, GFI = 0.994, and AGFI = 0.943, the absolute fit indices indicated strong fit, suggesting a close match between the observed and predicted covariance structures. Furthermore, the strong comparative fit of the model over the independence model was confirmed by the incremental fit indices, which included NFI (.994), RFI (.965), IFI (.995), TLI (.971), and CFI (.995), all of which exceeded the suggested cutoff of 0.95.

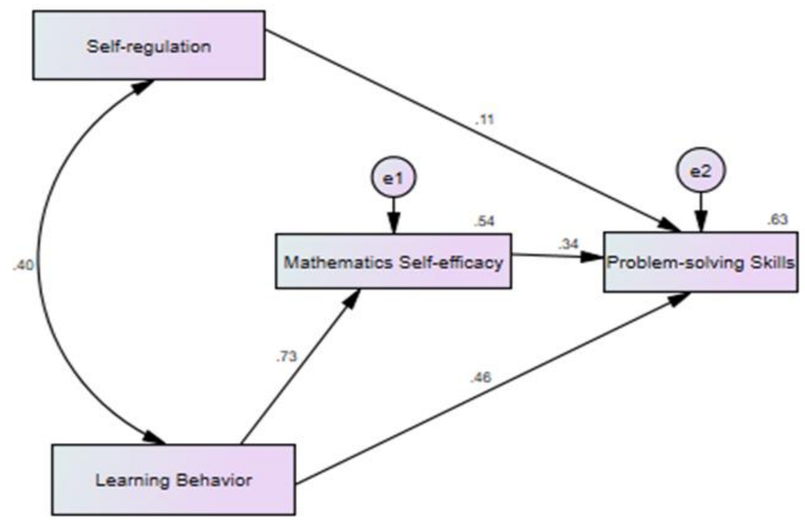


Figure 1. The Best Fit Model of Problem-Solving Skills

The RMSEA value of.096 (90% CI=.029-.184, PCLOSE=.112) indicates a fair but respectable model fit in terms of error approximation. The non-significant PCLOSE indicates that the model does not deviate significantly from a close fit, even though this is somewhat above the optimal threshold of 0.08. The simplicity and predictive validity of the model are supported by the significantly lower AIC (23.247) and ECVI (.051) values compared to the independence model. Furthermore, Hoelter's critical N of 337 at $p < .05$ suggests that the model is stable and the sample size is sufficient.

The best-fit model, shown in Figure 1, presents the direct and indirect effects of self-regulation, mathematics self-efficacy, and learning behavior on problem-solving skills. The revised model demonstrates a good fit to the data, providing both theoretical and empirical support for the relationships among these key factors. It offers a comprehensive explanation of how these variables work together to influence senior high school students' problem-solving skills.

Specifically, the findings suggest that students' problem-solving skills are not solely the result of their learning behaviors; rather, they are also shaped by their confidence in performing mathematical tasks and their ability to regulate their own learning. Moreover, the significant path coefficients indicate that these factors operate as an integrated system rather than as separate influences. For instance, learning behavior strengthens mathematics self-efficacy, which in turn enhances problem-solving skills, while self-regulation exerts both direct and indirect effects, underscoring its foundational role in supporting effective learning and performance.

This integrated structure aligns with Bandura's (1986) Social Cognitive Theory, which highlights the interaction among personal factors, behaviors, and outcomes. In this model, self-efficacy represents students' beliefs, learning behavior reflects their actions, and problem-solving skills represent performance outcomes, demonstrating how beliefs and behaviors reinforce each other in a dynamic process. At the same time, the model is consistent with Flavell's (1979) Metacognitive Theory, particularly in emphasizing the role of self-regulation in planning, monitoring, and evaluating learning strategies. Through these metacognitive processes, students are better able to adjust their approaches, strengthen their confidence, and improve their problem-solving performance.

**Underlying the Significant Causal Links in the Problem-Solving Skills of the Senior High School Students**

The standardized path estimates for the best-fit model are displayed in Table 7, along with the correlations between variables. Additionally, it demonstrates how the variables impact students' ability to solve problems both directly and indirectly, as well as overall. Students with effective learning behaviors typically exhibit higher mathematics self-efficacy, as shown in Table 7, which indicates that learning behavior has a strong direct effect on mathematics self-efficacy.

Table 7. Underlying the Significant Causal Links in the Problem-Solving Skills of the Senior High School Students

| **Path** | **β** | **p** | **Interpretation** |
|---|---|---|---|
| **Direct** | | | |
| Learning Behavior → Mathematics Self-efficacy | 0.733 | .000 | Significant |
| **Direct** | | | |
| Learning Behavior → Problem-Solving Skills | 0.462 | .000 | Significant |
| **Direct** | | | |
| Mathematics Self-efficacy → Problem-Solving Skills | 0.340 | .000 | Significant |

| | | | |
|---|---|---|---|
| **Direct** | | | |
| Self -regulation → Problem-Solving Skills | 0.108 | .000 | Significant |
| **Indirect** | | | |
| Learning Behavior → Mathematics Self-efficacy → Problem-Solving Skills | 0.249 | .000 | Significant |
| **Total** | | | |
| Learning Behavior → Problem-Solving Skills | 0.711 | .000 | Significant |

Meanwhile, problem-solving skills are impacted by learning behavior both directly and indirectly. While the indirect effect (.249) through mathematics self-efficacy efficacy suggests that some of this improvement stems from increased confidence in math, the direct path (.462) suggests that active learning behavior improves problem-solving skills. The findings of Chi and Wylie (2014), who demonstrated that improved learning behaviors result in greater success in problem-solving at work and in school, are comparable to this outcome.

As a result, the standardized path ($\beta$ = .340) for the direct relationship between mathematics self-efficacy and problem-solving skills indicated a moderately positive effect. Pupils are more likely to improve their problem-solving skills if they have greater confidence in their mathematical skills. This is in connection with the findings of Eccles and Wigfield (2020), who discovered that self-assured students put forth more effort and persevere, leading to their improvement. It is also consistent with the findings of Salazar and Hayward (2018), who found that students with higher self-efficacy are more inclined to take on and persevere through challenging tasks, resulting in better outcomes.

Furthermore, the weak but significant direct effect of self-regulation on problem-solving skills ($\beta$ = 0.108, p =.00) indicates that self-regulation alone has a limited effect on problem-solving skills. It might affect mathematics self-efficacy and learning behavior. This result is comparable to that of Maksum et al. (2021), who found that self-regulation helped students approach problem-solving in a methodical, consistent, logical, and comprehensive manner. Additionally, it supports the notion that problem-solving skills require methodical thought processes, with self-regulation helping students manage memory, select strategies, and verify solutions.

Through mathematics self-efficacy, learning behavior influences problem-solving abilities, as evidenced by the positive and significant indirect effect ($\beta$ = 0.249). This suggests that students who engage in learning activities not only improve their problem-solving abilities but also increase their confidence in their mathematical skills. This outcome is consistent with the findings of Talsma et al. (2018), who discovered that self-efficacy is developed through positive learning behaviors, such as self-monitoring and strategy use, and that this leads to improved academic performance and problem-solving skills. The idea that learning engagement enhances problem-solving by boosting confidence is further confirmed by the findings by Ziliwu and Mahmudi (2025), which showed that students with high math self-efficacy performed better when solving algebraic derivative problems.

Apart from that, self-regulation and learning behavior have a moderately positive correlation ($\beta$ = 0.399), indicating that students who are more self-reliant also typically exhibit more adaptive learning behaviors. This finding is consistent with the results of Rodzin et al. (2024), who also discovered that students' learning behaviors are positively impacted by efficient self-regulation, including planning and assessment.

As a result, learning behavior had the largest overall impact on problem-solving skills ($\beta$ =.711), as indicated in Table 7. This influence was both direct ($\beta$ =.462) and indirect ($\beta$ =.249) through mathematics self-efficacy. This suggests that students who engage in learning activities not only enhance their problem-solving skills but also increase their confidence in their mathematical abilities. In particular, problem-solving skills were moderately impacted by mathematics self-efficacy itself ($\beta$ =.340), highlighting the significance of self-belief in enhancing cognitive function. As evidenced by their significant correlation (r =.399), self-regulation showed a weak direct effect (β =.108) on problem-solving, suggesting that its influence primarily operates through learning behavior.

The findings support a mediated pathway in which effective learning behavior leads to higher mathematics self-efficacy, which in turn improves problem-solving skills. Students who actively engage in learning activities tend to develop stronger confidence in their ability to solve mathematical problems. This result is consistent with the study of Macalinda (2024), which identified mathematics self-efficacy as a key link between learning-related factors and problem-solving ability. It also aligns with the findings of Cano and Lomibao (2023), who reported that students exposed to phenomenon-based learning showed stronger beliefs in their capacity to reason and solve problems.

## CONCLUSIION AND RECOMMENDATIONS

### Conclusions

Based on the findings of the study, the following conclusions were drawn.

1. The high level of self-regulation indicates that setting goals, planning learning strategies, maintaining focus, managing time, and adjusting actions when disruptions occur are oftentimes manifested by senior high school students. This suggests that students establish clear goals, plan ahead, and deliberately apply learning strategies before engaging in tasks.

2. The moderate level of mathematics self-efficacy indicates that students' mathematics self-efficacy is sometimes evident, meaning that while students occasionally believe in their mathematical abilities, they may still experience uncertainty, particularly when confronted with difficult or complex tasks. This suggests that students' beliefs in their mathematical competence may fluctuate depending on factors such as task difficulty, previous success or failure, social comparison, and their emotional and physiological responses to mathematical challenges.

3. The result indicating a high level of learning behavior among senior high school students suggests that positive learning behavior is oftentimes observed. This further implies that students actively ask questions when clarification is needed, respond responsibly during mathematics activities, and show enjoyment in learning through friendly competition and collaborative problem-solving with peers.

4. The high level of problem-solving skills indicates that students' problem-solving skills are very satisfactory and are characterized by strong confidence, effective use of strategies, persistence, and reflective thinking. This suggests that students are confident in their abilities, capable of planning and evaluating their approaches, and able to apply suitable strategies to solve problems.

5. The findings indicating that self-regulation, mathematics self-efficacy, and learning behavior are significant predictors of students' problem-solving skills reveal that although all three variables contribute to problem-solving performance, their levels of influence vary. Self-regulation shows a positive but relatively small effect, suggesting that while students' ability to plan, monitor, and control their learning supports problem-solving, it alone may not be sufficient to produce substantial improvements. Mathematics self-efficacy demonstrates a stronger influence, highlighting that students who believe in their mathematical abilities tend to be more confident, persistent, and willing to apply effective strategies. Learning behavior emerges as the strongest predictor, emphasizing that active engagement, sustained effort, and effective study habits play a crucial role in enhancing problem-solving skills.

6. The findings showing that the initially hypothesized model did not adequately fit the data indicate that direct relationships alone were insufficient to fully explain students' problem-solving skills. Following modifications, the revised model demonstrated an acceptable to excellent fit. This reveals that self-regulation influences problem-solving skills primarily through learning behavior and mathematics self-efficacy rather than through a strong direct effect. Students with higher self-regulation tend to develop more positive learning behaviors, which subsequently enhance their confidence in mathematics and, in turn, improve their problem-solving skills.

Learning behavior emerged as a key factor that directly strengthens problem-solving performance while also reinforcing mathematics self-efficacy.

**Recommendations**

1.To maintain self-regulation through structured planning activities, teachers may require students to create simple weekly or task-based work plans before starting major mathematics activities, indicating goals, strategies, and time allotments. Students may be guided to regularly revise or reschedule their plans when disruptions occur, such as missed classes or unexpected tasks, to practice adjusting actions and managing time effectively.

2. To enhance mathematics self-efficacy, teachers may provide graduated problem sets, beginning with, manageable tasks and progressing to more complex ones, allowing students to experience success through sustained effort while emphasizing that improvement comes from studying hard and practicing consistently. More so, teachers may use modeling and visualization strategies by explicitly demonstrating step-by-step problem-solving processes and encouraging students to visualize themselves solving problems in the same way, supported by guided practice where students verbalize or write the steps they imitate.

3. To promote positive learning behavior through varied learning modes, mathematics lessons may balance independent work and collaborative activities, allowing students to enjoy exercises individually while sharing ideas with peers during group problem-solving. Teachers may encourage active participation and immediate communication by fostering an open classroom environment and establishing clear routines for asking questions, such as designated clarification moments during lessons. Increasing enjoyment and engagement through friendly competitions, problem-solving challenges, and discussion-based activities can further enhance students' happiness and willingness to participate in mathematics lessons.

4. Teachers are encouraged to strengthen students' problem-solving skills through sustained practice and purposeful enrichment activities. Teachers can regularly provide non-routine problems, logical puzzles, and real-life application tasks that require students to analyze data carefully, identify relevant information, and connect concepts meaningfully. In addition, teachers can facilitate creative problem-construction activities in which students modify given conditions, alter numerical values, or design entirely new problems based on previously solved tasks. Through these structured experiences, students deepen conceptual understanding, strengthen reflective thinking, and improve their ability to transfer problem-solving strategies to unfamiliar situations.

5. Teachers and school administrators are encouraged to implement integrated instructional approaches that connect self-regulation, learning behavior, and mathematics self-efficacy. Teachers can design structured tasks that require planning, monitoring, and active engagement, allowing self-regulation to translate into observable learning behaviors. School administrators can support these efforts by developing coordinated intervention programs that provide academic guidance, structured practice, and emotional support aligned with the proposed model to promote sustained improvements in problem-solving skills.

6. Future researchers are encouraged to explore additional variables, such as mathematics anxiety, motivation, teacher support, and classroom climate, that may further explain students' problem-solving skills. Longitudinal and mixed-methods designs may be employed to examine how self-regulation, learning behavior, and mathematics self-efficacy develop over time and interact across contexts. Similar studies may also be conducted among diverse student populations and educational settings to enhance the generalizability of the findings and to test alternative models or intervention-based approaches that strengthen students' mathematical problem-solving skills.

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