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Problem-Solving Appraisals as Predictors of Mathematics Performance among College Students

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study explored the relationship between problem-solving appraisals and mathematics performance among first-year college students using a descriptive correlational design. Data were gathered from 329 students through a survey. The mean, Spearman correlation analysis, and multiple regression analysis were used to analyze the data. The findings revealed that students exhibited a moderate level of problem-solving appraisals overall, with high confidence in problem-solving, but moderate levels in approach-avoidance style and personal control. Students generally demonstrated strong mathematics performance, with most achieving a "very good" level, though few reached a superior level of achievement. Correlation analysis indicated positive relationships between problem-solving confidence, approach-avoidance style, personal control, and mathematics

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performance, with confidence showing the strongest link. Regression analysis further identified problem-solving confidence, approach-avoidance style, and personal control as significant predictors of mathematics performance, explaining 21% of the variance. These results highlight the importance of building problem-solving confidence, promoting proactive engagement with challenges, and enhancing students' sense of control to improve their mathematics outcomes.

Keywords: Problem-solving appraisals; mathematics performance; predictive factors in college students.

1. INTRODUCTION

The current state of mathematics education in the Philippines, spanning elementary, secondary, and higher education, is structured to equip learners with a comprehensive understanding and appreciation of its principles. The curriculum emphasizes the practical application of mathematics through problem-solving, critical thinking, communication, reasoning, making connections, representations, and real-life decision-making [1]. However, despite these positive aims, a significant problem persists—an increasing deficiency in mathematical abilities among students [2,3], even in college [4,5,6]. The persistent perception that mathematics is difficult is largely due to the inherent complexity of its concepts and the abstract nature of the subject, which many students find challenging to comprehend [7].

This issue is critical because mathematics is not just a subject in isolation, it holds an important role as a mandatory component in almost every field of study [8]. The importance of addressing this problem is underscored by the fact that failure could adversely impact students' progress, particularly considering the heightened mathematical foundation demanded by most undergraduate programs [9]. It is, therefore, important to identify and integrate non-cognitive factors that significantly affect learning outcomes. Understanding both cognitive and non-cognitive factors offer the potential to enhance mathematics education through targeted learning interventions [10].

The challenges in mathematics proficiency are not unique to the Philippines, as evident in the TIMSS (Trends in International Mathematics and Science Study) results. The Philippines scored 297 in Mathematics and 249 in Science in the 2019 Trends in International Mathematics and Science Study (TIMSS), the lowest among 58 participating countries [11]. These scores highlight a significant proficiency gap, indicating severe deficiencies in the country's mathematics and science education. This proficiency gap is not confined to early education but continues to impact college students, underscoring the persistent issues in mathematics education throughout higher education levels [12]. Numerous reports and studies consistently note that students struggle with learning mathematics, further confirming the widespread nature of this problem even in college [13]. These results emphasize the importance of understanding the factors influencing students' performance, particularly in higher education.

Moreover, a concerning claim has also emerged where Filipino students excel in acquiring knowledge but face significant difficulties when confronted with tasks requiring higher-order thinking skills [14,15,16]. This issue becomes particularly evident in the college setting, emphasizing the critical nature of assessing problem-solving processes. Such assessments evaluate individuals' aptitude in applying mathematical knowledge, reasoning, and critical thinking skills to analyze and solve mathematical problems across various contexts [17]. These higher-order skills often challenge students, particularly those who may have a strong grasp of basic knowledge but lack the deeper conceptual understanding and flexibility needed to tackle complex, non-routine problems. Consequently, students' ability to navigate and solve more intricate problems becomes a key determinant of their overall success in mathematics, highlighting the need for instructional strategies that enhance problem-solving skills at various levels of complexity [18,19].

Effective problem-solving strategies are essential for improving mathematics performance. According to recent literature, individuals who proficiently evaluate problem demands and perceive themselves as competent problem solvers are more likely to engage in effective strategies. For instance, Santos-Trigo [20] highlights the significance of foundational problem-solving skills in mathematics education,

emphasizing that a strong foundation is crucial for tackling complex problems. Similarly, Klang et al. [21] demonstrate that cooperative learning and peer support play a pivotal role in enhancing problem-solving abilities, fostering a sense of competence and engagement among students. Moreover, Lopez [22] discusses the challenges teachers face in developing higher-order thinking skills, noting that students who possess strong problem-solving strategies are better equipped to handle complex mathematical tasks. These studies collectively underscore the importance of effective problem-solving strategies and the role of self-perception in driving mathematics performance.

Despite the growing research on mathematics education, gaps remain in understanding the role of problem-solving appraisals among college students. While cognitive factors such as mathematical knowledge and problem-solving skills are well-studied, limited attention has been given to how students' self-perception of their problem-solving abilities—such as confidence, approach-avoidance tendencies, and sense of control—affects their performance in mathematics. These non-cognitive factors can significantly influence how students engage with complex mathematical tasks, yet there is insufficient research exploring how problem-solving appraisals impact higher-order thinking and real-world problem-solving among college students. Addressing these gaps can provide deeper insights into developing targeted interventions that enhance both students' problem-solving skills and their confidence in applying them.

Therefore, this research seeks to establish and highlight the relationship between problem-solving appraisals and mathematics performance among first-year students in a state college in southern Philippines. Addressing this problem is important for enhancing college students' overall mathematical proficiency and ensuring their academic success.

2. OBJECTIVES

The study aimed to determine the level of problem-solving appraisals among first-year students and its relationship with their mathematics performance at a state college in Southern Philippines during the first semester of the school year 2022–2023. Specifically, it sought to:

1. Determine the respondents' problem-solving appraisals in terms of:
   1.1 Problem-solving confidence;
   1.2 Approach-avoidance style; and
   1.3 Personal control.

2. Assess the respondents' mathematics performance based on their grades in the Mathematics in the Modern World subject.

3. Determine the significant relationship between the students' problem-solving appraisals and their mathematics performance.

4. Develop a regression model to identify which domains of problem-solving appraisals significantly predict mathematics performance.

3. MATERIALS AND METHODS

Research design: This study employed a descriptive-correlational research design, which is used to describe variables and examine the natural relationships between them. As Creswell [20] explains, correlational designs are commonly used to explore the relationship between two or more variables, particularly in quantitative research, where data is collected from larger groups or samples. The primary aim of this study was to assess the level of respondents' problem-solving appraisals and to determine the significant relationship between these appraisals and their mathematics performance during the first semester of the School Year 2022-2023. Data collection involved the use of a descriptive survey, utilizing a questionnaire to assess students' problem-solving appraisals.

Research instrument: The research instrument used in this study was an adopted Mathematics Problem-Solving Appraisals Scale, developed by Centino and Sebial [21]. The scale consists of three domains with a total of 27 statements, rated on a Likert scale from "strongly agree" to "strongly disagree." The first domain, Problem-Solving Confidence, includes 14 statements; the second domain, Approach-Avoidance Style, comprises 7 statements; and the third domain, Personal Control, consists of 6 statements. The composite reliability of the instrument was reported at 0.655, indicating an acceptable level of internal consistency for measuring the constructs. Students' mathematics performance was assessed using their final grades in the course Mathematics in the Modern World, which were obtained from the registrar's office.

Respondents of the study: The researchers employed a stratified random sampling technique to select first-year college students from SPAMAST. This method involves dividing the population into smaller subgroups, or strata, based on specific characteristics, ensuring that each subgroup is proportionally represented. Slovin's formula was used to calculate the sample size, allowing for a statistically representative sample with a desired level of accuracy. To ensure proportional distribution of respondents across different institutes, the stratified random sampling technique was applied, using the lottery method to randomly select participants from each stratum, minimizing selection bias. The randomly selected students completed the adopted survey questionnaire. The distribution of respondents is detailed in Table 1.

Data gathering: The data gathering procedure began with the researchers submitting a formal letter to the Vice President for Academic Affairs (VPAA) and the Deans of the respective institutes, requesting permission to conduct the study on randomly selected first-year college students. A similar letter was also sent to the registrar's office to obtain the final grades of the selected respondents in the Mathematics in the Modern World subject for the first semester.

An adopted questionnaire was used as the data collection instrument. The researchers distributed the questionnaires to the respondents in person, administering them through survey forms while carefully supervising the process. Before completing the survey, the respondents were given a general orientation that explained the scope of the study and emphasized privacy considerations. The importance of honesty in answering the questionnaire was stressed, and respondents were assured that their participation was voluntary, and their identities could remain anonymous. Consent was obtained from respondents for the use of their grades, and they were informed of their right to decline or withdraw from the study at any time.

Upon completion of the questionnaire, the researchers ensured that all data collected were handled with respect and confidentiality. The data were then tallied, collated, and tabulated for further analysis. Tables were prepared to visually present the data, and the results were summarized and analyzed using appropriate statistical tools and software.

4. RESULTS AND DISCUSSION

Level of problem-solving appraisals of college students: The research results, as presented in Table 2, reveal the students' level of problem-solving appraisals across three key domains: problem-solving confidence, approach-avoidance style, and personal control. The overall mean score of 3.35 indicates a moderate level of problem-solving appraisals, suggesting that students possess an average level of competence in addressing mathematical challenges. This result aligns with the findings of Centino and Sebial [21], which similarly concluded that students tend to exhibit moderate engagement in problem-solving during their learning process. This moderate level of appraisals signifies the importance of fostering a stronger problem-solving mindset to enhance mathematical performance, as highlighted in [17], authors emphasized the need for strategies to develop students' problem-solving skills for better academic outcomes.

Problem-solving confidence: In terms of problem-solving confidence, the findings suggest that while students believe they can solve problems, there are moments of doubt or hesitation. This aligns with the observations of Veerasamy et al. [22], who noted that students with moderate problem-solving confidence tend to approach challenges with cautious optimism but may lack the full assurance needed to persist in more complex mathematical tasks. Encouraging students to build greater self-confidence in their problem-solving abilities is essential, as studies have shown that higher confidence levels are positively correlated with better performance in mathematics [7]. For instance, [23] found that effective problem-solvers achieved better final exam scores, highlighting the importance of self-perception in problem-solving success.

Approach-avoidance style: Regarding the approach-avoidance style, the results indicate that students exhibit a balanced tendency to both engage with and avoid challenging problems. This finding echoes the work of Gahi et al. [24], who noted that students often demonstrate a moderate visibility of mathematical problem-solving styles in academic settings, meaning that while students show a willingness to engage with mathematical problems, this approach is not always consistent or fully developed. Research by Ryan and Deci [25] emphasizes the importance of nurturing a proactive approach to

learning, as students who tend to avoid challenges may struggle with higher-order thinking skills. Therefore, creating an environment where students feel encouraged to take on more complex problems could promote deeper engagement and persistence.

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Personal control: The domain of personal control reflects students' perceived ability to influence their success in problem-solving. A moderate level of personal control, as seen in this study, suggests that students feel somewhat in control of their problem-solving outcomes but may not fully take ownership of the process. This finding aligns with the literature, as studies like that of Lopez [26] suggest that students with moderate personal control often rely on external factors, such as guidance from teachers or peers, to navigate mathematical challenges. Enhancing students' sense of personal control is crucial, as it fosters greater independence and motivation in tackling complex mathematical problems [27,28].

Level of mathematics performance of college students: The students' mathematics performance is shown in Table 3. A number of respondents displayed a very good level of mathematics performance, with a frequency of 119 students (36.17%), indicating that these students have developed fundamental knowledge and skills. In contrast, the superior level had the lowest frequency of 34 students (10.33%), meaning that these students exceed the core requirements in terms of knowledge and skills. The average Mathematics grade of the respondents is 1.99, with a descriptive level of "very good" and a standard deviation of 0.479. Thus, most of the respondents had a basic comprehension of mathematics, although some struggled to gain knowledge and proficiency in the subject. Moreover, no student has a grade point average lower than 3.00, which is advantageous. Several studies claimed that college students had a very good performance in Mathematics in the Modern World [10,13,29]. Additionally, Roman and Villanueva [29] stressed that when students perform satisfactorily in this subject, it is reasonable to say that they could apply it in solving real-world problems. Likewise, Gurat and Garcia [30] assert that using real-world problems is important not only to hone students' mathematical thinking and competency but also to prepare them in making well-grounded decisions that involve logical and mathematical reasoning.

Table 1. Distribution of respondents

Institute	Population (n)	Sample size (n)	Percentage (%)
1	436	77	23.40
2	655	116	35.26
3	191	34	10.33
4	574	102	31.00
Total:	1856	329	100.00

Table 2. The Respondents' Level of Problem-Solving Appraisals

Indicators	Mean	SD	Description
Problem-solving confidence	3.43	0.63	High
Approach-avoidance style	3.31	0.58	Moderate
Personal control	3.32	0.64	Moderate
Problem-solving appraisals (Overall)	**3.35**	**0.55**	**Moderate**

Table 3. The Respondents' Level of Mathematics Performance

Range of Scores	Description Level	Frequency (f)	Percentage (%)
1.49-1.00	Superior	34	10.33
1.99-1.50	Very Good	119	36.17
2.49-2.00	Good	95	28.88
2.50-3.00	Fair	81	24.62

n=329; %=100; Mean=1.99; SD=0.479

Relationship between the respondents' problem-solving appraisals and mathematics performance: Table 4 shows the relationship between problem-solving appraisals and mathematics performance among first-year college respondents of the study. The problem-solving appraisal indicator "problem solving confidence" was found to have a low correlation with mathematics performance, indicated by an r-value of 0.357, and a significant relationship, indicated by a p-value less than the 0.05 level of significance. It can be deduced that students' confidence toward problem-solving can affect their mathematics performance. This is supported by the study conducted by Sabug [31], which found that mathematics confidence has a significant positive relationship with mathematics performance, implying that students who are confident in mathematics tend to engage more in solving mathematical problems.

On the other hand, the problem-solving appraisal indicator "approach-avoidance style" was found to have a very low correlation with mathematics performance, indicated by an r-value of 0.152, and a significant relationship, indicated by a p-value of less than the 0.05 level of significance. This indicates that their relationship is notably weak yet positively correlates, which is supported by the study of Jenifer et al. [32], which revealed that students' problem-solving approaches greatly impact students' success.

The problem-solving appraisal indicator "personal control" was found to have a low correlation with mathematics performance, indicated by an r-value of 0.286, and a significant relationship, indicated by a p-value of less than 0.05. It depicts that their association is not particularly strong but significantly affects the students' mathematics performance nonetheless. This result is related to the study conducted by Vidad and Quimbo [33], which found that personal control has a significant relationship with mathematics performance as students deal with their problem-solving difficulties by employing emotional and behavioral control strategies.

The overall students' problem-solving appraisals towards mathematics have a low correlation to mathematics performance with an r-value of 0.313. Nevertheless, the relationship between problem-solving appraisals and mathematics performance is significant, as indicated by a p-value of less than 0.05. This implies that enhancing problem-solving appraisals in learning mathematics could lead to improved performance in the subject. Therefore, we can reject the null hypothesis and conclude that there is a significant relationship between college students' problem-solving appraisals and mathematics performance. This result is aligned with the claim of Centino and Sebial [21] that the correlation of problem-solving appraisals and mathematics performance is positive and significant, but its degree of relationship was not stated or shown. The result also reveals that the mathematics performance of the students is enhanced or affected by problem-solving appraisals, which implies that students with a high level of problem-solving appraisals will generally achieve high mathematics performance compared to those with a low level of problem-solving appraisals. Similarly, Gahi et al. [24] concluded that problem-solving style significantly affects mathematics performance and yet was moderately observed. Besides, the methods of assessment provide a significant contribution to the improvement of mathematical problem-solving abilities [17]. Moreover, there hasn't been a study found yet that addresses problem-solving appraisals and its relationship to the mathematics performance of first-year college students, resulting in no correlation.

Regression model that best fit problem-solving appraisals and mathematics performance: Table 5 summarizes the results of the stepwise multiple regression analysis, showing that all three domains of problem-solving appraisal—Problem-Solving Confidence, Approach-Avoidance Style, and Personal Control—have a significant impact on students' mathematics performance. The corresponding regression coefficients for these variables are 0.361, -0.254, and 0.143, respectively. Each of these coefficients has a p-value below 0.05, indicating that they make statistically significant contributions to predicting mathematics performance. The constant in the model is 3.138, and the regression equation is represented as:

$$y = 3.138 + 0.361x_1 - 0.254x_2 + 0.143x_3$$

where,
$x_1 = Problem - Solving\ Confidence$
$x_2 = Approach - Avoidance\ Style$
$x_3 = Personal\ Control$
$y = Mathematics\ performance$

Table 4. The relationship between the students' problem-solving appraisals and their mathematics performance

Indicators	r-value	description	p-value
Problem-Solving Confidence	0.357	Low Correlation	<0.001
Approach-Avoidance Style	0.152	Very Low Correlation	<0.001
Personal Control	0.286	Low Correlation	<0.001
Problem-Solving Appraisals (overall)	0.313	Low correlation	<0.001

Table 5. Summary of Stepwise Multiple Regression Analysis

Predictor	Unstandardized Coefficients	p-value	Interpretation
(Constant)	3.138	0.000	Significant
Problem-Solving Confidence	0.361	0.000	Significant
Approach-Avoidance Style	-0.254	0.000	Significant
Personal Control	0.143	0.023	Significant

$r^2 = 0.210$

The results of the regression model provide several key insights into how problem-solving appraisals influence mathematics performance among college students. First, problem-solving confidence emerged as a significant positive predictor, with a coefficient of 0.361. This suggests that students who are more confident in their problem-solving abilities tend to perform better in mathematics. Confidence-building interventions, such as providing positive reinforcement, opportunities for small successes, and fostering a supportive classroom environment, could help enhance students' mathematical performance [33,34]. Encouraging students to take risks and persevere through challenges may also contribute to better outcomes [7,27].

On the other hand, the negative coefficient for approach-avoidance style (-0.254) reveals that students who tend to avoid difficult problems are likely to perform worse in mathematics. This finding highlights the need for fostering a growth mindset, encouraging students to embrace challenges instead of avoiding them [35,36]. By incorporating more complex, engaging problem-solving tasks into the curriculum, educators can help students develop resilience and a more constructive approach to overcoming mathematical difficulties [37]. This strategy may build students' perseverance and ultimately improve their performance [36,37,38].

Additionally, the positive coefficient for personal control (0.143) underscores the importance of students believing in their ability to control their success through their efforts. Students with higher personal control are likely to be more motivated and persistent. This finding aligns with the concept of self-efficacy, which has been supported by research from Pajares and Graham [27], Yang et al. [39], and Khine and Nielsen [40]. To enhance personal control, teachers could teach students effective self-regulation, goal-setting strategies, and time management [41] empowering them to take charge of their learning and problem-solving processes.

The overall regression model explains 21% of the variance in mathematics performance (r^2 = 0.210), indicating that other factors also play a role in determining students' success. Factors such as socio-economic status [42], prior knowledge [43], students' preferences in teaching mathematics [44], teaching quality, and access to resources [45] may also influence mathematics performance, suggesting the need for a broader approach in educational interventions. Policymakers and educators may consider these additional factors when designing programs aimed at improving student outcomes.

5. CONCLUSIONS AND RECOMMENDATIONS

Conclusion: Based on the findings and statistical results of the study, the following conclusions were drawn:

1. The results of the study show that college students have a moderate level of problem-solving appraisals overall, with high problem-solving confidence and moderate levels in both approach-avoidance style and personal control. This means that students generally feel capable of solving problems but may sometimes avoid challenges or lack full control over their success in problem-solving.

2. The students' mathematics performance was mostly in the very good range, with few students achieving a superior level. This suggests that while most students have a strong understanding of mathematics, there is room for improvement in helping them reach higher levels of achievement.
3. The correlation analysis showed that all three problem-solving appraisals factors—confidence, approach-avoidance style, and personal control—have a positive relationship with students' mathematics performance. Confidence had the strongest link, while approach-avoidance style showed the weakest. This means that better problem-solving attitudes are associated with improved math performance, but the relationships are not very strong.
4. The regression analysis revealed that problem-solving confidence, approach-avoidance style, and personal control all significantly influence math performance. Confidence positively affects performance, while students who avoid challenges tend to perform worse. Personal control also has a positive impact. Together, these factors explain 21% of the variation in students' math performance, indicating that other influences are also important.

Recommendation:

1. Given that confidence plays a significant role in mathematics performance, it is recommended that teachers create an encouraging classroom environment that builds students' self-confidence. This can be achieved through frequent positive reinforcement, opportunities for small successes, and problem-solving activities that progressively increase in difficulty.
2. Since the tendency to avoid challenges negatively impacts performance, educators may introduce strategies that encourage a growth mindset. Students should be exposed to more complex and engaging problems to reduce avoidance behavior. Teachers can foster resilience by emphasizing that challenges are opportunities for growth and learning.
3. To improve students' personal control, it is recommended to incorporate self-regulation techniques in the learning process. Teachers can guide students in setting specific, achievable goals and teach them how to monitor their own progress. This can increase students' sense of ownership over their problem-solving success.
4. As most students performed well, but few reached the superior level, additional support should be provided for high-achieving students. Advanced problem-solving sessions or enrichment programs can help bridge the gap to superior performance.
5. Future research could explore other factors that contribute to mathematics performance, such as teaching methods, prior knowledge, or external motivational influences, to further understand the elements that influence academic success. This broader approach could offer more comprehensive insights into improving student outcomes.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors declare that generative AI technology, specifically GPT-4, was used exclusively for grammar correction and improving the clarity and composition of sentences and paragraphs in this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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