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Research Article

Enhancing Criminology Students' Mathematics Problem-Solving Ability Through Criminology-Based Word Problem Strategy (CBWPS)

Joy T. Mosquiter-Bentoy[1], Orville J. Evardo Jr.[2]*, Estela C. Itaas[3]

[1]Criminology Department, Davao de Oro State College – Compostela (Main Campus), 8803, Philippines
[2]Teacher Education Department, Davao de Oro State College – Compostela (Main Campus), 8803, Philippines
[3]College of Education Graduate Studies, Bukidnon State University, 8700, Philippines

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**Corresponding author:*
E-mail:
orvilleevardo@gmail.com

ABSTRACT

The study aimed to enhance criminology students' mathematics problem-solving abilities using a criminology-based word problem strategy (CBWPS) and to explore their experiences and coping mechanisms with this approach. Employing a mixed-method explanatory sequential design, the quantitative phase utilized a quasi-experimental one-group pretest-posttest framework with 38 participants, while the qualitative phase involved phenomenological in-depth interviews with 10 students. Results revealed a significant improvement in students' problem-solving skills, with a marked increase in post-test scores compared to pre-test results (mean gain: 8.11, $p<0.05$). The intervention fostered critical thinking and engagement by contextualizing mathematical concepts in criminology scenarios, making learning more relevant. However, students faced challenges such as unfamiliar terminologies and difficulties with complex calculations. They coped by analyzing problems carefully and drawing motivation from their aspirations. The study recommends training mathematics educators in implementing CBWPS and integrating such strategies into criminology curricula to enhance analytical skills and professional preparedness.

Keywords: *Criminology, Problem Solving, Criminology-based word problem strategy*

Introduction

Problem-solving abilities are the most valuable skills in learning Mathematics, for they help the students make decisions and solve daily life problems. According to Musdi et al. (2023), problem-solving abilities were essential for learning mathematics, which is highly regarded as a fundamental skill across various disciplines. Proficiency in mathematical problem-solving is necessary at all educational

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levels, as Szczygieł (2020) and Ukobizaba et al. (2021) emphasize. Furthermore, students equipped with this capability can approach problems with intelligence and effectiveness, recognizing that mathematical challenges demand suitable solutions to positively influence both the learning process and its outcomes (Rezeki et al., 2021).

According to Ester et al. (2021), students frequently encounter significant challenges in solving mathematical problems, underscoring the importance of understanding these difficulties to develop effective strategies for finding solutions. This issue persists across all levels of education, including higher education institutions. Mathematical problem-solving is recognized as one of the most challenging aspects for students, with senior high school learners struggling to establish mathematical connections (Jailani et al., 2020) and college students demonstrating low proficiency levels, which hinders their ability to tackle mathematical problems effectively (Nasir et al., 2021).

The ability to solve problems is a fundamental component of mathematics education, as it not only equips students to address specific problems but also facilitates the acquisition of various concepts in the subject (Palmér & van Bommel, 2020; Son et al., 2020). This emphasis is reflected in Indonesia's educational standards, as outlined in the Minister of National Education Regulation No. 22 of 2006, which identifies mathematical problem-solving skills as a primary goal of mathematics instruction. Furthermore, the 2013 Indonesian curriculum highlights the critical role of problem-solving abilities, aligning with the demands of the 21st-century industrial landscape (Ahdhianto et al., 2020; Nakakoji & Wilson, 2020; Rini et al., 2020).

Thus, to help the students, especially in the criminology program, learning Mathematics plays a vital role in terms of its application. Additionally, the general mathematics subject, specifically mathematics in the modern world taught in the Criminology Program, was taught through routine word problems, which was taught the same way in all other programs. The researcher observed that the criminology students' mathematical performance in the previous term was average only, and some got below-average grades in dealing with the specified lessons about problem-solving. With this, the researcher wants to help criminology students enhance their mathematical abilities by relating mathematical word problems to contextualized practical problems. This can build a great connection, and the students can see the importance of learning for their future reference.

The primary purpose of this research is to enhance the problem-solving ability of the criminology students specifically on inductive and deductive reasoning using criminology-based word problems. Specifically, this action research aimed to answer the following questions:

1 What is the problem-solving ability of the students after the implementation of contextualize word problem strategy?
2 Is there a significant difference between problem solving ability of the criminology students before and after the implementation of the criminology-based word problem strategy?
3 What are the experiences of criminology students in solving problems using criminology-based word problem strategy?
4 What are the coping mechanisms utilized by the criminology students when using criminology-based word problem strategy in solving mathematical problems?
5 What insights can be derived from the experiences in using criminology-based word problem strategy?

Methods

Research Design

This study employed a mixed-methods approach utilizing an explanatory sequential design. Initially, quantitative data were gathered, followed by qualitative data collection. The quantitative phase adopted a quasi-experimental one-group pretest-posttest design to assess the effectiveness of a criminology-based word problem strategy. Campbell (1969) emphasizes the importance of using pretest and posttest measurements to establish a baseline level of the outcome variable before the implementation of the strategy and to measure the change in the outcome variable after the implementation of the strategy. Moreover, this study

used phenomenological approach to understand the experiences, challenges and coping mechanism, and insights of the criminology students in the implementation of the criminology-based word problem strategy (Creswell, 2001; Richards & Morse, 2007). This method promotes the advocacy and participatory paradigm, which relies on the participant voices and results change in practice (Creswell, 2001).

Participants and/or Sources of Data

The study respondents were the thirty-eight (38) 1st year criminology students enrolled in a state college in the province of Davao de Oro, Philippines. The respondents were enrolled in the Mathematics in the Modern World (MMW) subject for the 2nd semester of academic year 2022-2023. The study respondents were asked to sign an informed consent and participation to study is voluntary and no sanction was imposed to those who opt out of the study.

Data Gathering Procedure

The researchers sent a request letter to the dean of the criminology department. This was done to ask for permission for the conduct of the study. Once approval is secured, researchers developed a module which implements the use of criminology-based word problem. The developed module was subjected to expert's validation and comments. The module was validated by the associate deans of the mathematics and criminology program. Based on expert's comments, the developed module was revised and adjusted. At the same time, a teacher-made test was created and subjected to validation. After validation, the researcher-made test was pilot tested the other 1st year criminology section which is not part of the study. The test items were adjusted based on the result of the pilot test.

Once the teacher-made test and module were ready for implementation, the researchers conducted a pre-test to assess the initial problem-solving ability of the criminology students. After the pre-test, the intervention started. Following the implementation of the criminology-based word problem strategy module, a post-test was conducted. The results from both the pre-test and post-test were systematically organized, analyzed, and interpreted. Additionally, the researchers performed an in-depth interview, selecting ten (10) participants randomly from the pool of 38 students. After the interviews, the data was transcribed, translated, and encoded.

Data Analysis

To provide valid and accurate findings from the generated data, appropriate statistical tools and analysis for the qualitative data were employed by the researcher. To interpret the problem-solving ability of the Criminology students before and after the intervention the interpretation was used:

Table 1. Problem Solving Ability of the 1st year Criminology Students

Score Range	Proficiency Level	Interpretation
23.50-30.00	Advanced	The student exceeds the core requirements in terms of the knowledge and greatly developed problem-solving ability.
17.50-23.49	Proficient	The student developed an advanced knowledge in problem solving and can work independently in analyzing the problem.
11.50-17.49	Approaching Proficiency	The student developed the fundamental knowledge, problem solving ability, and core understanding.
5.50-11.49	Developing	The student processes the minimum knowledge, problem solving ability, and core understanding.
0.00-5.49	Beginning	The student struggles with his/her problem-solving ability.

After determining level of students' problem-solving ability, frequency count, percentage, and mean were utilized to present the result of the data. Additionally, a paired samples T-test was used to determine the significant difference between problem solving ability of the criminology students before and after the

implementation of the criminology-based word problem strategy.

A thematic analysis was conducted to determine the salient themes on the experiences of the students, their coping mechanism, and insights in learning through criminology-based word problem strategy. Thematic analysis is an effective way to learn about people's perspectives, opinions, knowledge, experiences, and values (Caulfield, 2020).

Result and Discussion

Problem-solving Ability of Criminology Students

A teacher-made test that aimed to determine problem-solving ability was administered to 38 criminology students. Table 2 reflects the results of the pre- and post-test with its corresponding frequency per proficiency level, mean, standard deviation, and interpretation.

Table 2. Problem-solving Ability of Criminology Students Before and After Intervention

Score Range	Proficiency Level	Pretest		Post-test	
		Frequency	Percentage	Frequency	Percentage
23.50-30.00	Advanced	0	0%	21	55.3%
17.50-23.49	Proficient	9	23.7%	17	44.7%
11.50-17.49	Approaching Proficiency	27	71.0%	0	0%
5.50-11.49	Developing	2	5.3%	0	0%
0.00-5.49	Beginning	0	0%	0	0%
N		38	100%	38	100%
Mean		15.42		23.53	
SD		2.554		2.719	
Interpretation		Approaching Proficiency		Advanced	

Table 2 provides a comprehensive overview of participants' proficiency levels before and after the utilization of criminology-based word problem strategy (CBWPS). Categorized into different proficiency levels ranging from "Beginning" to "Advanced," the data showcases a notable shift in participants' skills over the course of the intervention. Before the intervention, the majority of participants, 71.0%, were classified as "Approaching Proficiency," with a significant portion also falling into the "Proficient" category, 23.7%. Remarkably, after the intervention, there was a remarkable transformation in proficiency levels, with a considerable increase in participants categorized as "Advanced", 55.3%. Notably, no participants remained in the "Developing" proficiency level or below after the intervention, indicating a significant improvement across the board.

The mean scores and standard deviations further support these observations, with a clear upward trend in proficiency. The pretest mean score of 15.42 suggests that, on average, the students had a basic level of proficiency in solving contextualize word problems prior to the intervention. However, the post-test mean score of 23.53 indicates that the students' problem-solving abilities improved significantly after using the Contextualize Word Problem Strategy, with an increase of 8.11 points. Overall, the data suggests that the intervention has had a positive impact on participants' proficiency levels, facilitating their progression towards higher levels of mastery.

According to Rusnilawati (2016) students with basic problem solving abilities should be strengthened and higher-order thinking skills should be developed through the application of mathematical problems. Hassan et al. (2019) contends that in order to effectively teach mathematics in all levels, teachers must place a strong emphasis on students' ability to solve mathematical problems using word problems. Word problem-based math problem-solving techniques can help students become more proficient at solving a variety of mathematical problems that arise in everyday life (Gurat, 2018), as well as increase their imagination and creativity (Wibowo et al., 2017),

develop their creativity (Suastika, 2017), and improve their comprehension (Mulyati et al., 2017). This supports the importance of enhancing problem-solving abilities among Criminology students through strategies like the Contextualize Word Problem Strategy.

Difference between Problem Solving Ability before and after the implementation of the Criminology-based Word Problem Strategy

A paired samples t-test was conducted to test whether there is a significant statistical difference between the pre- and post-test scores of the criminology students. Table 3 presents t-test result summary.

Table 3. Paired Samples T-Test Result Summary

	n	M	SD	Gain Score	df	t	p	Interpretation
Pre-test	38	15.42	2.554	8.105	37	-14.698	.000	There is a significant difference.
Post-test	38	23.53	2.719					

The result in Table 3, indicated that the paired mean difference is 8.105 with t(37)= -14.698 and p<0.05, it means that there is a significant difference between the pretest and posttest scores of the Criminology students. From these results, it could be deduced that the use of criminology-based word problem strategy enhanced the problem-solving abilities of the criminology students. Hence, employing such strategy would eventually increase the problem solving ability of the students. This result is the same with Argaw et al. (2016) which was revealed in their study concerning the of problem- based learning in improving the problem-solving skills of learners. Using the quasi-experimental method, they are able to determine the significant effect of problem-based learning on students' motivation and problem-solving skills.

The results of this study have implications for the use of the criminology-based word problem strategy in criminology education. The strategy can be considered as an effective tool to improve the problem solving abilities of Criminology students, and can be incorporated into the curriculum as a way to enhance their critical thinking and analytical skills. It can also be used by criminology instructors as a means of assessing the problem-solving abilities of their students, and to identify areas where students may need additional support. Wahyuddin (2017) emphasized that the ability to solve mathematical problems is essential for students, as it enables them to connect mathematics with other disciplines and apply it to real-life situations.

Similarly, Ismail et al. (2021) highlighted the significance of problem-based learning in mathematics as an effective approach to enhance students' problem-solving abilities. They noted that these skills are akin to higher-order thinking, empowering students to address challenges with creativity and critical thinking. Additionally, Sudarmo and Mariyati (2017) described problem-solving as an activity that involves selecting appropriate strategies to transition from the current situation to the desired outcome.

The results of this study suggest that the criminology-based word problem strategy is a promising intervention that can help criminology students develop their problem-solving abilities and reach proficiency in this area. It highlights the importance of using evidence-based strategies in teaching and learning, and the potential benefits of incorporating such strategies into the criminology curriculum.

Student's Experiences in Criminology-based Word Problem Strategy

From the data collected among the participants on the experiences in solving problems using criminology-based word problem strategy, five main themes emerged which are the following as shown in figure 1.

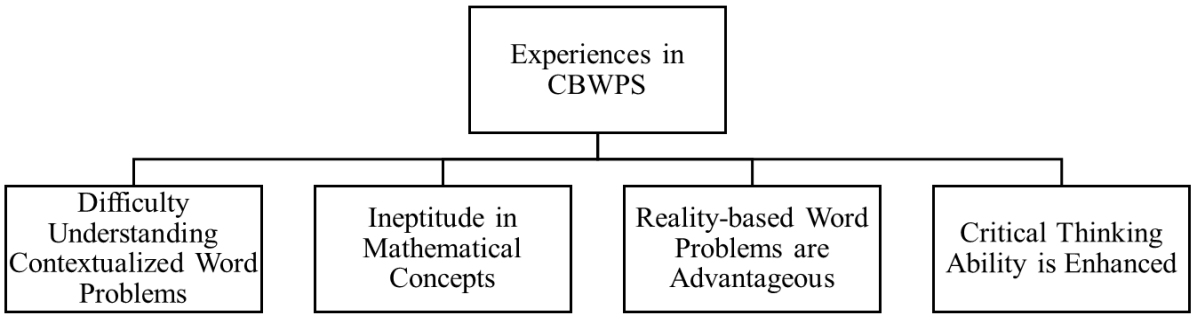

Figure 1. Themes on students' experiences in CBWPS

Difficulty Understanding Contextualized Word Problems

Most of the participants emphasized their generally perceived difficulty in solving contextualized problems especially since it is their first-time solving math problems incorporated with contextualized criminology scenarios. Students have difficulty understanding the problem because they are not yet familiar with all criminology jargons.

> "*It is very challenging because we are not yet used and familiar to some contextualize words*." – P2

> "*It was difficult for I me understanding the problems that is related to crime*." - P1

Moreover, the same sympathy was shared by other participants who stressed on their difficulty in understanding the unfamiliar terminologies and misinterpretations.

> "*Difficulty in understanding the problem, I find it difficult because sometimes, I misinterpret it, and there are some terminologies that I am not familiar*." - P4

> "*Difficulty in understanding the problem, the unfamiliar words in the context of contextualize word problem strategy*." - P5

The primary challenge in acquiring math skills often lies in the inability to grasp fundamental concepts. This aligns with the findings of Wangdi and Pelden (2020), who identified that difficulties in solving competency-based items in contextualized mathematics word problems stem from challenges in comprehending the problem and translating real-world scenarios into mathematical representations. Problem-solving in mathematics typically requires a systematic, step-by-step approach. Without a clear understanding of the initial steps, students struggle to tackle more complex problems (Alvi, 2019).

However, Roth (1996) argues that merely embedding contextual word problems within elaborate story situations does not enhance learning. Instead, mathematical practices become more effective when students integrate them into a broader array of meaningful, real-world practices, emphasizing the importance of connecting mathematical problem-solving to authentic contexts.

Ineptitude in Mathematical Concepts

The students also express the challenges encountered in using criminology-based word problem strategy in solving mathematical problems. Most students can understand the contextualized word problem but, they are not confident in solving problems that involves complex calculations.

> "*I am not good at math, so I have problems involving complex calculations requiring multiple mathematical formulas and operations*." - P5

> "*I admit I'm not really good at math I only knew the basics but when it comes to the more complex problems, I sometimes don't know what to do because I can't always remember the formulas*." - P8

One significant cause of failure in creating mathematical concepts is the rigidification of concept cores. This rigidity limits students' ability to identify and understand atypical examples and problems, creating a disconnect between everyday concepts and formal mathematical concepts. This gap hinders both the application of mathematics to real-world situations and the comprehension of mathematical ideas (Trzcieniecka-Schneider, 1993).

Ester et al. (2021) emphasize that students frequently encounter significant difficulties when solving mathematical problems, underlining the importance of addressing these challenges to develop effective strategies for solutions. These difficulties are not confined to specific educational levels but are pervasive across various stages, including higher education.

Furthermore, students often struggle due to a lack of mastery in essential mathematical concepts, such as the correct application of formulas and the ability to analyze complex calculations. Jailani et al. (2020) similarly observed that problem-solving in mathematics remains one of the most challenging aspects for learners. Senior high school students, in particular, face difficulties in establishing meaningful mathematical connections, further compounding their challenges in solving problems.

Reality-based Word Problems are Advantageous

Despite the challenges and difficulties students faced in understanding mathematical concepts involving complex calculations and contextualized problems, they recognized the significant advantages of integrating criminology-based word problem strategies. This approach provided real-world relevance, making mathematical concepts more relatable and engaging. Students found the strategy both helpful and effective in enhancing their problem-solving abilities, as it bridged the gap between abstract mathematical theories and practical criminology scenarios, simplifying the learning process and fostering a deeper connection to the subject matter.

> "*It can make mathematical concepts more interesting and relevant by presenting them in the context of criminology*." - P7

> "*It provides real-world examples that I as a student can relate to understand making mathematical concepts more relevant and engaging*." - P5

> "*The advantage of criminology-based word problem strategy is that we can easily imagine the situation, also for us as a criminology student that has a field of crime situation processing*." - P6

Using contextual mathematics based on local wisdom has been shown to significantly enhance students' ability to solve word problems in mathematics (Zahrah & Febriani, 2020). This approach helps bridge the gap between abstract mathematical concepts and real-world applications, making learning more relevant and engaging.

Indriani and Julie (2017) emphasize that mathematics becomes more meaningful for students when its concepts are connected to everyday life scenarios. Recognizing the strong connection between mathematics and practical applications not only motivates students to engage with the subject but also lays a foundation for integrating and utilizing mathematical principles in real-world contexts.

Similarly, Utami et al. (2024) highlight that contextualizing and personalizing math word problems within authentic contexts significantly improves learning performance. This improvement is particularly evident in students' understanding of problem contexts and their ability to identify relevant contextual information, further enhancing their problem-solving skills and making mathematics more accessible.

Critical Thinking Ability is Enhanced

Integrating criminology-based word problem strategy in solving-problem task in the classroom develop students critical thinking ability. It was supported with the statements of the participants:

"*It offers us a situation that will make us think more and analyze the problem, it helps us to brainstorm and enhance our critical thinking*." – P8

"*It develops my critical thinking where students analyze complex scenarios, identify key information, and apply mathematical concepts to arrive at a solution. This can help also develop our analytical skills*." - P10

"*It's a very effective way of enhancing my critical thinking ability to solve real life problems*." - P4

Sunaryo and Fatimah (2020) proposed that a contextual approach combined with scaffolding enhances students' mathematical critical thinking abilities more effectively than traditional classroom methods. This approach not only fosters deeper engagement but also equips students with the tools to approach problems intelligently and develop suitable solutions. These solutions, in turn, have a significant impact on both the learning process and its outcomes (Rezeki et al., 2021).

Furthermore, Toheri et al. (2020) highlighted that contextual learning is more effective for improving critical thinking skills in mathematics compared to other approaches, such as problem posing and exposure to traditional problem-solving methods. This evidence underscores the importance of incorporating contextual and scaffolded approaches in mathematics education to cultivate critical thinking and problem-solving abilities in students.

The study's findings highlight the necessity of aligning mathematics instruction with authentic, real-world criminology practices. By creating assignments that simulate actual criminology scenarios—such as crime scene analysis, statistical crime pattern identification, and forensic calculations—instructors can not only improve critical thinking abilities but also foster critical thinking skills that are directly applicable to professional contexts.

Coping Mechanisms of Students in CBWPS

Students have applied some coping mechanism as they dealt with the challenge and difficulty encountered in CBWPS. There were three main themes that emerged from the data collected from the responses of the participants. These themes are depicted in figure 2.

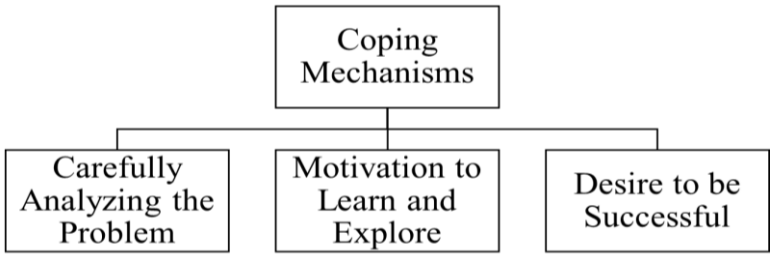

Figure 2. Themes on coping mechanisms of students in CBWPS

Carefully Analyzing the Problem

As learners navigated the challenges and complexities of solving criminology-based word problems, they adopted a variety of coping mechanisms to enhance their understanding and problem-solving abilities. Participants emphasized the importance of carefully analyzing each problem, breaking it down into manageable components to better grasp its concepts and overcome difficulties. This deliberate and thoughtful approach proved essential in tackling the intricate nature of contextualized scenarios.

"*I analyze it carefully and comprehend to solved it until I get the right answer*." – P2

"*I comprehend the problem thoroughly and pointing out what is being asked to determine the question*." – P8

Language comprehension, working memory, attention, mathematics vocabulary, and mathematics computation are distinct predictors of word-problem solving success (Lin, 2020). These cognitive factors work in tandem to influence students' ability to interpret and solve mathematical problems effectively.

Suseelan et al. (2022) highlighted that the primary objective of mathematics instruction is to engage students actively in discovering mathematical concepts and developing structured problem-solving strategies. A critical component of mathematics education is its potential to cultivate higher-order thinking skills, which are indispensable for addressing complex problems and puzzles. Such challenges not only ignite curiosity but also foster creativity, encouraging students to think beyond conventional methods.

Integrating problem-solving activities into the classroom environment enhances students' abilities by encouraging creative, logical, and critical thinking. This approach equips learners with essential skills for real-world applications, making mathematics instruction more impactful and relevant.

Educators must acknowledge that students may face initial challenges in understanding contextualized word problems due to unfamiliar criminology jargon and scenarios. To address this, instructors can incorporate a scaffolding approach, introducing students gradually to criminology-related terminology alongside mathematical concepts. Providing glossaries, real-world examples, and guided practice sessions can bridge this gap effectively.

Motivation to Learn and Explore

Motivation plays a crucial role in students' success, serving as a driving force behind their learning and exploration. Participants shared how their determination to learn and their curiosity to overcome challenges fueled their engagement with the complex and demanding concept of contextualized problems. Despite the difficulties, their motivation became a vital factor in sustaining their efforts and fostering growth in problem-solving skills.

> "*I just put myself on how the authorities think when they encounter a culprit and at the same time applying mathematics to solve the problem*." – P2

> "*The curiosity motivates me because we are human who is always curious about what happened, why it happened, what we're going to do, like we want to know all*." – P3

Moreover, studies by Jaafar et al. (2022) and Fabian et al. (2018) highlight that motivation plays a critical role in driving students' learning and exploration, especially when tackling challenging contextualized mathematics problems. Intrinsic factors, such as curiosity and determination, enhance students' persistence and problem-solving abilities by fostering connections between learning and real-world contexts, such as applying mathematics in investigative scenarios.

Additionally, Widjaja (2013) emphasizes that contextual problems have the potential to engage and motivate students in learning mathematics. However, for such engagement to translate into meaningful mathematical thinking, explicit connections between the context and mathematical ideas are necessary. This alignment helps students progress effectively in their understanding and application of mathematical concepts.

To enhance motivation and student engagement, educators can design problems that not only contextualize mathematics within criminology scenarios but also establish clear, explicit connections between the context and the mathematical ideas being taught. This approach ensures that students can translate real-world criminology problems into mathematical frameworks more confidently.

Desire to be Successful

To overcome the challenges of solving contextualized word problems, students drew inspiration from their aspirations for success in their chosen profession. They recognized that criminology demands a high level of analytical thinking, requiring the ability to navigate complex scenarios and solve intricate problems. This awareness reinforced their engagement with contextualized word problems, as they saw them as a practical tool for developing the

skills essential for their future careers. Many participants acknowledged that their strong desire to succeed motivated them to persist through difficulties, using their professional goals as a driving force to enhance their problem-solving abilities.

> "*I motivate myself that I am a criminology student and as I proceed to the next level of my studies, I need to overcome this*." - P4

> "*I eagerly want to solve the problem because I dream to be successful person someday*." - P6

Bowden et al., (2019) stated that the desire to succeed motivates students to persevere through challenges, such as solving contextualized word problems, by aligning academic tasks with their professional aspirations in criminology. This drive fosters engagement and skill development, reflecting research that emphasizes the need for holistic support to enhance student success and retention. Early identification of at-risk students and targeted interventions further reinforce persistence and achievement (Alyahyan & Düştegör, 2020).

Conclusion

This study demonstrated the effectiveness of integrating criminology-based word problem strategies (CBWPS) in enhancing the mathematical problem-solving abilities of criminology students. Key findings revealed a significant improvement in students' proficiency levels after implementing CBWPS. The strategy also fostered critical thinking and analytical skills by providing real-world, contextualized scenarios that made mathematical concepts more engaging and relevant. Despite initial challenges in understanding criminology-related terminology and mastering complex mathematical concepts, students developed coping mechanisms such as careful problem analysis and intrinsic motivation to overcome these obstacles.

However, this study had certain limitations. The research was conducted with a relatively small sample size of 38 students from a single academic institution, which may limit the generalizability of the findings. Furthermore, the quasi-experimental one-group pretest-posttest design, though effective, lacked a control group, which would have provided a more robust comparative analysis of the strategy's impact.

Theoretically, this study supports the value of contextualized learning approaches in mathematics education, highlighting how real-world relevance can enhance cognitive engagement and skill development. Practically, it underscores the importance of integrating interdisciplinary strategies, such as CBWPS, into curricula to prepare students for the analytical demands of their professional fields.

Future research should address the study's limitations by incorporating a larger, more diverse sample and employing experimental designs with control groups to validate and expand upon these findings. Additionally, exploring the long-term effects of CBWPS on students' problem-solving and professional skills, as well as its applicability to other disciplines, would provide valuable insights. Future studies could also investigate the integration of digital tools and adaptive learning technologies to further enhance the efficacy of contextualized learning strategies in mathematics education.

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