IJSAIR
International Journal of Sustainability and Advanced Integrated Research
Volume 2, Issue 3 (July-September 2026) | ISSN: 3107-7854
DOI: https://doi.org/10.65339/ijsair.V2.I3.769

Efficacy of Teach Project on the Mathematical Problem-Solving Proficiency of First-Year Criminology Students

Glenn Jhubert G. Ubaldo
Master of Arts in Education-Major in Mathematics, World Citi Colleges-Guimba Campus, Nueva Ecija, Philippines

Publication history: Received: June 17, 2026; Revised: March July 12, 2026; Accepted: July 16, 2026
Email of Corresponding Author: berttglenn16@gmail.com

Abstract

This study determined the efficacy of the T.E.A.C.H. Project—Think, Explore, Apply, Calculate, and Hone—in improving the mathematical problem-solving proficiency of first-year Bachelor of Science in Criminology students enrolled in Mathematics in the Modern World. Anchored in Polya's Four-Step Problem-Solving Model and organized through an Input–Process–Output framework, the study employed a quantitative, quasi-experimental pre-test–post-test design. The respondents were 51 students from two intact classes selected through purposive sampling, with 26 assigned to the experimental group and 25 to the control group. A validated and reliability-tested researcher-made mathematical problem-solving test was administered before and after the two-month intervention. Data were analyzed using frequency, percentage, mean, standard deviation, weighted mean, paired- and independent-samples t-tests, chi-square, and Spearman Rank-Order correlation. Both groups demonstrated significant improvement, but the experimental group achieved a higher post-test mean of 43.769 than the control group's 38.320, with a p-value of 0.000. Moreover, 80.8% of the experimental group attained an Excellent rating compared with 52% of the control group. The intervention positively influenced students' ability to understand problems, devise plans, carry out solutions, and look back at their answers. Gender was significantly related to problem-solving performance, whereas age, class section, and academic standing were not. Persistent difficulties involved measures of central tendency, mathematical reasoning, and complex tasks requiring analysis, evaluation, application, and synthesis. The study concluded that the T.E.A.C.H. Project is an effective structured instructional intervention, although the initial difference between the groups limits purely causal interpretation. Its continued integration into mathematics instruction, supported by teacher training, differentiated assistance, and targeted enrichment activities, was recommended. The study supports SDG 4: Quality Education by strengthening mathematical competence, critical thinking, and learner engagement. It contributes to educational and institutional sustainability by providing an evidence-based approach for addressing recurring learning gaps and improving mathematics instruction.

Keywords: Mathematics In The Modern World, Mathematical Problem-Solving Proficiency, Polya's Four-Step Problem-Solving Model, Quality Education, T.E.A.C.H. Project, Traditional Instruction

1. Introduction

Mathematical problem-solving is central to mathematics education because it enables learners to interpret information, apply concepts, select appropriate strategies, perform accurate computations, and evaluate solutions. However, many students can perform routine calculations but encounter difficulties when problems require conceptual understanding, critical thinking, systematic reasoning, and application to unfamiliar situations. These challenges are particularly relevant in Mathematics in the Modern World, where learners are expected to use mathematical knowledge in practical and real-world contexts. To address these difficulties, the study introduced the T.E.A.C.H. Project, which represents Think, Explore, Apply, Calculate, and Hone. The intervention provides a structured, learner-centered process that guides students from understanding a problem to exploring possible strategies, applying mathematical concepts, performing computations, and refining solutions through reflection and feedback. The study examined the efficacy of this intervention in improving the mathematical problem-solving proficiency of first-year Bachelor of Science in Criminology students.

Mathematical problem-solving is widely recognized as an essential means through which learners construct mathematical knowledge and develop reasoning and analytical abilities. According to Santos-Trigo (2024), contemporary problem-solving instruction encourages learners to engage in inquiry, examine multiple representations, and use different strategies in arriving at solutions. Students' problem-solving competence is reflected not only in their final answers but also in how they understand and perform each phase of the process (Melawati et al., 2022). Problem-solving requires an understanding of both the problem and the procedures needed to resolve it (Mandina and Ochonogor, 2018). Such understanding helps learners determine appropriate actions and succeeding steps (Laurens et al., 2018). Meaningful comprehension also allows students to develop their own interpretation of learning materials across mathematics and related disciplines (Wang et al., 2022), influencing their academic performance and enthusiasm for learning (Damopolii et al., 2018). Before selecting a solution, students must clearly understand the problem presented to them (Toll, 2017). This process requires learners to connect new mathematical situations with their prior knowledge (Simamora et al., 2017). Nevertheless, classroom observations showed that many students had difficulty understanding complex problems, identifying suitable procedures, organizing their reasoning, and determining whether their answers were correct. Although they could perform basic computations, they often struggled with non-routine tasks requiring higher-order thinking. Traditional instruction that concentrates mainly on formulas and procedural exercises may not sufficiently address these difficulties. The T.E.A.C.H. Project was therefore developed to provide structured and active learning experiences in which students think about the problem, explore possible solutions, apply relevant concepts, calculate systematically, and hone their answers through reflection and feedback.

Foundational mathematical knowledge is necessary for advanced reasoning and problem-solving. Basic competencies in number sense, mathematical procedures, and reasoning help students progress toward more complex tasks. Zhang and Li (2023) found that emphasizing conceptual understanding rather than rote memorization better prepares students to retain knowledge and apply mathematical ideas to unfamiliar problems. Mathematical proficiency extends beyond the correct use of formulas. It includes the ability to apply mathematical knowledge accurately across different contexts. Svane, Willemsen, and Krojggard (2023) reported that interventions focusing on number sense and problem-solving reasoning contribute to sustained mathematical proficiency. Similarly, the Trends in International Mathematics and Science Study (TIMSS) reports (2021) associated stronger mathematical performance with curricula that incorporate reasoning and real-world problem-solving activities. Mathematical proficiency therefore involves understanding and applying mathematical concepts to practical concerns rather than merely memorizing procedures (Mullis et al., 2021). Interactive and focused instructional interventions can also improve mathematical performance. Dela Peña and Doronio (2025) found that collaborative problem-solving activities produced greater post-test improvement than conventional lectures. Navarro and Lim (2024) likewise reported that interactive digital tools, including GeoGebra and mobile learning applications, strengthened conceptual understanding and student engagement, particularly in data analysis and statistics. Lee and Park (2023) demonstrated that metacognitive strategy training and group problem-solving workshops improved both performance and confidence in handling complex mathematical tasks.
Structured problem-solving strategies can improve mathematical ability, creativity, and conceptual understanding while reducing learning anxiety (Paldi & Khuzaini, 2024). Santos-Trigo (2024) emphasized that effective problem-solving instruction should guide students systematically from understanding a problem to reflecting on the solution. These principles are reflected in the five phases of the T.E.A.C.H. Project.

The “Think” phase activates prior knowledge and helps learners identify the given information, unknown quantities, and specific requirements of a problem. Critical thinking is an important twenty-first-century competency (Muthma'Innah et al., 2019) and involves applying prior knowledge and appropriate strategies to solve problems systematically (Nggaba, 2020). It requires repeated practice so that learners can make logical decisions and arrive at accurate conclusions (Anggraini and others, 2022). Activating prior knowledge and identifying known and unknown information can improve students’ preparedness to solve mathematical problems (Amanah et al., 2025). The “Explore” phase allows students to investigate different approaches, representations, and possible solutions. Santos-Trigo (2024) explained that exploration strengthens conceptual understanding by exposing learners to multiple methods and representations. Zuhaida et al. (2025) similarly found that exploratory and problem-based learning environments develop problem-solving ability by encouraging students to test ideas and compare alternative solutions. The “Apply” phase connects mathematical theory with practical or structured problems. Paldi and Khuzaini (2024) emphasized that applying strategies promotes mathematical creativity and meaningful learning. Khasanah et al. (2025) further found that application-oriented instructional approaches improve conceptual understanding and problem-solving ability. The “Calculate” phase focuses on the accurate and systematic execution of mathematical operations. According to Amanah et al. (2025), effective problem-solving requires both conceptual understanding and correct procedural execution. This phase develops computational accuracy, procedural fluency, and logical reasoning. The “Hone” phase involves checking, reflecting on, and refining solutions through feedback and additional practice. According to Santos-Trigo (2024), reviewing and improving solutions develops metacognitive awareness and independence in problem-solving. Masingila et al. (2025) also emphasized that guided reflection strengthens learner confidence and supports the long-term development of problem-solving competence. Collectively, the literature indicates that mathematical achievement is enhanced when foundational skills, structured practice, active engagement, collaboration, contextual application, and reflective learning are integrated into instruction. These findings support the T.E.A.C.H. Project as a systematic and learner-centered intervention for improving mathematical problem-solving proficiency.

At the local level, the study addressed the difficulties encountered by first-year Bachelor of Science in Criminology students at World Citi Colleges–Guimba Campus while taking Mathematics in the Modern World during Academic Year 2025–2026. Classroom observations indicated that some learners required instructional scaffolding, particularly when translating problems, selecting strategies, performing logical procedures, and evaluating their answers. Within the Philippine higher education context represented by the study, Mathematics in the Modern World requires college students to connect mathematical concepts with practical situations. Students must therefore develop quantitative reasoning, conceptual understanding, critical thinking, and problem-solving abilities that can be applied beyond routine classroom exercises. At the global level, the emphasis on mathematical reasoning, real-world problem-solving, and learner-centered instruction is consistent with findings from international mathematics education research. The Trends in International Mathematics and Science Study (TIMSS) reports (2021) indicate that stronger mathematical performance is associated with curricula that integrate reasoning and authentic problem-solving. The study also responds to the international objective of improving equitable access to quality education and strengthening essential learning outcomes.

The study was anchored in Polya's Four-Step Problem-Solving Model, which organizes mathematical problem-solving into understanding the problem, devising a plan, carrying out the plan, and looking back. Understanding the problem involves identifying what is known, what is unknown, and what must be determined. Devising a plan requires selecting an appropriate strategy. Carrying out the plan involves applying the chosen procedure and completing the necessary reasoning or computations. Looking back requires checking the accuracy of the result and considering other possible strategies or generalizations (Polya, 1957/2021). Although these steps provide a systematic structure, they are not strictly linear because students may return to earlier stages while refining their strategies. Recent studies continue to support the use of Polya's framework in strengthening mathematical reasoning and achievement (Lee et al., 2022; Tchoshanov et al., 2021). The framework is also consistent with constructivist principles because students actively connect prior knowledge with new problem situations while engaging in strategy selection and metacognitive reflection. Lee and Kim (2023) found that students taught through Polya's heuristic approach performed better on complex problem-solving tasks than those who received traditional instruction. Tchoshanov et al. (2021) also reported that activities aligned with Polya's stages encouraged deeper reasoning, particularly when students reviewed and reflected on their solutions. The T.E.A.C.H. Project operationalizes these theoretical principles through five instructional stages. Think supports problem comprehension; Explore facilitates strategy development; Apply connects concepts with the problem situation; Calculate supports the execution of mathematical procedures; and Hone promotes checking, reflection, and improvement. Conceptually, the study follows an Input–Process–Output framework. The inputs consist of the students, their initial mathematical problem-solving proficiency, and the two instructional approaches: the T.E.A.C.H. Project and traditional instruction. The process involves administering a pre-test, exposing the experimental group to the T.E.A.C.H. Project while the control group receives conventional instruction, and administering a post-test. The anticipated outputs include improved problem-solving proficiency, reasoning skills, conceptual understanding, and reduced difficulty in translating word problems, selecting suitable strategies, and applying logical reasoning.

Existing research supports learner-centered, collaborative, exploratory, metacognitive, and application-based strategies in mathematics instruction. However, few studies have directly evaluated the T.E.A.C.H. Project as an integrated instructional intervention consisting of the Think, Explore, Apply, Calculate, and Hone phases. Previous investigations have also concentrated largely on general mathematics achievement, number sense, conceptual understanding, digital tools, or selected problem-solving strategies. Fewer studies have examined how a structured intervention affects students' performance across the specific processes of understanding a problem, devising a plan, carrying out the plan, and looking back within a local college environment. This gap established the need to empirically compare students exposed to the T.E.A.C.H. Project with those taught through traditional instruction. The study was therefore conducted to determine whether the intervention could produce significant improvements in mathematical problem-solving proficiency and address persistent areas of difficulty among first-year Criminology students.

The study is directly aligned with Sustainable Development Goal 4: Quality Education, which promotes inclusive and equitable quality education and lifelong learning opportunities. The T.E.A.C.H. Project contributes to this goal by addressing learning difficulties in mathematics and strengthening problem-solving, critical thinking, conceptual understanding, analytical reasoning, and learner engagement. Its structured and learner-centered approach supports improved learning outcomes by providing students with systematic guidance rather than relying exclusively on procedural lectures. By determining the intervention's efficacy through empirical assessment, the study also provides evidence that may support the development of responsive instructional practices and mathematics intervention programs. The study contributes primarily to educational sustainability by examining an instructional approach that can support the continuous development of mathematical competence, higher-order thinking, and independent learning. Strengthening these abilities may help students manage academic and practical problems more systematically and confidently. It also contributes to institutional sustainability by providing teachers, curriculum developers, and school administrators with evidence that may guide mathematics instruction, intervention planning, curriculum improvement, and academic support programs. A structured intervention that can be integrated into regular classroom instruction may help institutions respond consistently to recurring learning gaps. The study has multidisciplinary relevance because mathematical reasoning is not limited to mathematics courses. It supports logical analysis, data interpretation, decision-making, and systematic problem-solving that may be applied in criminology, law enforcement, research, public service, and other professional fields. The intervention therefore supports the development of transferable competencies needed for academically capable and professionally prepared graduates.

The study aimed to determine the efficacy of the T.E.A.C.H. Project in improving the mathematical problem-solving proficiency of first-year Bachelor of Science in Criminology students. It examined the learners' initial and post-intervention proficiency, the difference between their pre-test and post-test performance, and the difference between students exposed to the T.E.A.C.H. Project and those who received traditional instruction. It also assessed the intervention's impact on the students' ability to understand problems, devise plans, carry out solutions, and look back at their answers. In addition, the study examined the relationship between selected demographic characteristics and problem-solving performance, identified difficulties that remained after the intervention, and used the findings as the basis for a proposed mathematical problem-solving intervention project.

The study focused on first-year students enrolled in the Bachelor of Science in Criminology program at World Citi Colleges–Guimba Campus during Academic Year 2025–2026. The participants were drawn from two intact classes enrolled in Mathematics in the Modern World. One class was exposed to the T.E.A.C.H. Project, while the other received traditional instruction. The investigation was limited to mathematical problem-solving proficiency and the instructional skills incorporated into the intervention. Factors such as student motivation, home environment, and teacher-training quality were acknowledged but were not directly measured as principal variables. The findings may benefit students by strengthening their confidence and ability to solve academic and real-world problems. Teachers may use the intervention as a framework for designing lessons that develop critical thinking and higher-order reasoning. Curriculum developers, administrators, and educational institutions may use the evidence as a basis for mathematics interventions and curriculum enhancement. The study may also support future investigations concerning innovative instructional approaches and the development of essential twenty-first-century competencies.

2. Material and methods

2.1 Research Design

The study employed a quantitative, quasi-experimental research design to measure the effect of the T.E.A.C.H. Project on students' mathematical problem-solving proficiency using numerical data from pre-test and post-test assessments. According to Creswell and Creswell (2018), quantitative, qualitative, and mixed-method approaches provide systematic frameworks for aligning research objectives with appropriate data-collection and analysis procedures. Quantitative research uses numerical data and statistical analysis to test hypotheses and examine relationships among variables. It is commonly applied in experimental and quasi-experimental studies in which researchers examine the effects of an intervention on selected outcomes (Creswell & Creswell, 2018). A quasi-experimental design was appropriate because the participants belonged to existing class sections and were not randomly assigned. One intact class served as the experimental group and received instruction through the T.E.A.C.H. Project, while another intact class served as the control group and received traditional instruction. Pre-test and post-test scores were compared to determine changes in mathematical problem-solving proficiency and differences between the two instructional groups.

2.2 Locale of the Study

The study was conducted at World Citi Colleges–Guimba Campus, where the respondents were enrolled in Mathematics in the Modern World. The institution was selected because it provided organized class sections, accessible participants, and an appropriate classroom setting for administering the pre-test, implementing the instructional intervention, and conducting the post-test. Conducting the investigation in the students' regular learning environment allowed the researcher to evaluate the T.E.A.C.H. Project under actual classroom conditions. The campus also had the facilities needed to implement the instructional activities and assess the students' mathematical problem-solving performance.

2.3 Respondents of the Study

The respondents were 51 first-year Bachelor of Science in Criminology students enrolled at World Citi Colleges–Guimba Campus during Academic Year 2025–2026. They belonged to two intact sections taking Mathematics in the Modern World. Criminology 1 Alpha, composed of 26 students, served as the experimental group and received instruction using the T.E.A.C.H. approach. Criminology 1 Bravo, composed of 25 students, served as the control group and received traditional classroom instruction. The two groups had comparable academic levels and were enrolled in the same mathematics subject. Both groups completed the same pre-test before the intervention and a post-test after the instructional period. Their scores were used to compare the learning outcomes of students exposed to the T.E.A.C.H. Project and those taught using conventional methods.

2.4 Sample and Sampling Procedure

Purposive sampling was used to select the respondents because the participants possessed characteristics directly relevant to the objectives of the study. The target participants were first-year college students formally enrolled in Mathematics in the Modern World at World Citi Colleges–Guimba Campus during Academic Year 2025–2026. Two intact Criminology classes were selected to preserve the natural classroom setting and avoid disrupting the regular class schedule. One class was designated as the experimental group and was exposed to the Think, Explore, Apply, Calculate, and Hone approach. The other class was designated as the control group and received traditional lecture-based instruction. Before the intervention, both groups completed a pre-test to establish their baseline mathematical problem-solving proficiency. After the instructional treatment, they completed a post-test to determine whether their performance had improved and whether a significant difference existed between the two groups.

2.5 Research Instrument

The primary research instrument was a researcher-made mathematical problem-solving test administered as both a pre-test and a post-test. It was designed to measure the proficiency of first-year college students enrolled in Mathematics in the Modern World. The pre-test assessed the students' initial ability to understand mathematical problems, perform basic computations, and identify appropriate problem-solving strategies. Its items were aligned with the Mathematics in the Modern World syllabus and lesson plan and were used to determine the respondents' initial strengths and difficulties. The instructional intervention was conducted over a period of two months. During this period, the experimental group received instruction through the T.E.A.C.H. Project, while the control group continued with the conventional lecture method. The post-test measured students' performance after the intervention. It assessed the components of the T.E.A.C.H. Project, including understanding the problem through Think, exploring possible strategies through Explore, applying concepts through Apply, performing accurate computations through Calculate, and reviewing and refining solutions through Hone. The pre-test and post-test were comparable in content and difficulty to support a fair assessment of performance changes. Subject-matter experts evaluated the instruments to establish content validity. The tests were also examined for reliability before their administration. The resulting scores provided the quantitative data used to determine whether the T.E.A.C.H. Project improved students' mathematical problem-solving proficiency.

2.6 Data Gathering Procedure

Before conducting the study, the researcher submitted a formal request to the Dean or Program Head and the concerned subject instructors. The respondents were informed of the purpose and procedures of the study, and their consent was secured before data collection. After approval, two intact first-year Criminology classes enrolled in Mathematics in the Modern World were selected. One class was assigned as the experimental group, while the other served as the control group. The researcher then developed the pre-test and post-test and submitted the instruments to subject-matter experts for validity and reliability assessment. The pre-test was administered to both groups before the instructional treatment to establish their baseline mathematical problem-solving proficiency and determine their initial comparability. The experimental group was subsequently taught using the T.E.A.C.H. Project, while the control group received traditional lecture-based instruction during regular class hours. After the intervention, both groups completed the post-test. The test papers were collected immediately, checked, scored, tallied, and systematically recorded. The resulting data were encoded and analyzed using appropriate statistical techniques to determine the efficacy of the T.E.A.C.H. Project.

2.7 Data Analysis Techniques

Frequency counts and percentage distributions were used to describe the respondents according to age, gender, program or course, and academic standing. These measures provided an overview of the participants' demographic characteristics. The mean and percentage distribution were used to determine the respondents' initial mathematical problem-solving proficiency based on their pre-test scores. Frequency, percentage distribution, mean, standard deviation, t-test, and p-value were used to assess their performance and evaluate the efficacy of the T.E.A.C.H. Project. A paired-samples t-test was applied to determine whether a significant difference existed between the pre-test and post-test scores of the students exposed to the T.E.A.C.H. Project. An independent-samples t-test was used to compare the post-test scores of the experimental and control groups. The mean, standard deviation, and weighted mean were used to determine the extent to which the intervention affected students' ability to understand the problem, devise a plan, carry out the plan, and look back at their solutions. The chi-square test of independence was used for categorical demographic variables, while Spearman Rank-Order correlation was applied to continuous variables such as age and academic performance. Frequency counts, percentages, and rankings were used to identify the most common mathematical problem-solving difficulties that remained after the intervention. No statistical test was used in developing the proposed intervention program; instead, it was formulated through the synthesis and interpretation of the study's quantitative findings.

2.8 Ethical Considerations

The researcher observed the principles of voluntary participation, informed consent, confidentiality, anonymity, safety, and research integrity throughout the study. The respondents were informed of the study's purpose, procedures, and their right to withdraw at any time without penalty or adverse consequences. Codes or pseudonyms were used instead of the respondents' real names. All collected information was securely stored and accessed only by the researcher for academic purposes. Digital records were deleted, and printed documents were properly destroyed after the completion of the study.

The researcher also maintained accuracy, transparency, honesty, and objectivity in reporting the procedures and findings. Discriminatory, offensive, and inappropriate language was avoided in all research instruments and communications.

3. Results and Discussion

3.1 Demographic Profile of the Respondents

3.1.1 Age

Among the 51 respondents, 31 or 60.8% were 19–20 years old, while 19 or 37.3% were 18 years old or younger. Only one respondent, representing 1.9%, was 21–22 years old, and none was 23 years old or older. The age distribution indicates that the participants were predominantly within the typical age range of first-year college students. The limited variation in age also means that the findings primarily represent young adult learners in the early stage of higher education.

3.1.2 Gender

The respondents consisted of 39 males or 76.5% and 12 females or 23.5%. Male students therefore constituted more than three-fourths of the sample. This distribution reflects the male-dominated composition of the participating Criminology classes. The unequal gender representation should be considered when interpreting findings involving gender and mathematical problem-solving performance.

3.1.3 Program and Class Section

Criminology 1 Alpha comprised 26 respondents or 51% of the sample, while Criminology 1 Bravo comprised 25 respondents or 49%. Criminology 1 Alpha served as the experimental group, whereas Criminology 1 Bravo served as the control group. The nearly equal number of respondents in the two sections provided a balanced sample size for comparing the instructional groups. However, comparability in group size did not necessarily indicate equivalence in their initial mathematical proficiency.

3.1.4 Academic Standing

In terms of academic standing, 17 respondents or 33.3% had grades of 85–89, interpreted as Very Satisfactory, while 16 or 31.4% had grades of 90–100, interpreted as Outstanding. Seven respondents or 13.7% were classified as Satisfactory, five or 9.8% as Fairly Satisfactory, and six or 11.8% did not meet expectations. The results show that 64.7% of the respondents belonged to the Very Satisfactory and Outstanding categories. Although most participants demonstrated favorable academic performance, the presence of students in the lower categories indicated differences in learning needs and supported the use of an instructional intervention responsive to varying proficiency levels.

3.2 Mathematical Problem-Solving Proficiency

3.2.1 Initial Mathematical Problem-Solving Proficiency

Before the intervention, 52% of the control group obtained scores classified as Fair, 40% as Satisfactory, and 8% as Needs Improvement. None reached the Very Satisfactory or Excellent levels. In the experimental group, 50% were classified as Satisfactory, 30.8% as Very Satisfactory, 15.4% as Fair, and 3.8% as Needs Improvement. None attained the Excellent level. The pre-test distribution shows that the experimental group began with a higher proficiency level than the control group. Nevertheless, neither group had students at the Excellent level, and both included learners in the Fair and Needs Improvement categories. These findings established the need for structured instruction aimed at strengthening higher-order mathematical problem-solving skills.

3.2.2 Mathematical Problem-Solving Proficiency After the Intervention

After the instructional period, no student in either group remained in the Needs Improvement or Fair categories. In the control group, 52% achieved an Excellent rating, while 24% were Very Satisfactory and 24% were Satisfactory. In the experimental group, 80.8% reached the Excellent level, 11.5% were Very Satisfactory, and 7.7% were Satisfactory. The post-test results indicate substantial improvement in both groups, particularly among students exposed to the T.E.A.C.H. Project. The experimental group's higher concentration at the Excellent level suggests that the structured Think, Explore, Apply, Calculate, and Hone process was associated with stronger mathematical problem-solving performance than conventional instruction.

3.2.3 Differences Between Pre-Test and Post-Test Performance

The control group's mean increased from 18.640 with a standard deviation of 4.786 in the pre-test to 38.320 with a standard deviation of 7.554 in the post-test. The computed t-value was -12.849, with a p-value of 0.000. The experimental group's mean increased from 27.000 with a standard deviation of 7.446 to 43.769 with a standard deviation of 5.609. Its computed t-value was -13.030, with a p-value of 0.000. Both differences were statistically significant at the 0.01 level, resulting in the rejection of the null hypothesis. The significant increases demonstrate that both instructional groups improved over the study period. However, the experimental group already had a higher pre-test mean, indicating that the two groups did not begin at equivalent proficiency levels. The higher post-test performance of the experimental group must therefore be interpreted together with its initial advantage, although the substantial improvement supports the usefulness of the T.E.A.C.H. Project.

3.2.4 Differences Between the Experimental and Control Groups

The pre-test comparison showed that the experimental group had a higher mean of 27.000 than the control group's mean of 18.640. The resulting t-value of -4.748 and p-value of 0.000 indicated a statistically significant difference before the intervention. In the post-test, the experimental group obtained a mean of 43.769, while the control group obtained 38.320. The computed t-value of -2.933 and p-value of 0.000 also indicated a significant difference at the 0.01 level. The null hypothesis was therefore rejected. The experimental group outperformed the control group before and after the intervention. Its higher post-test mean suggests that exposure to the T.E.A.C.H. Project was associated with stronger final proficiency. Nevertheless, the significant baseline difference limits a purely causal interpretation because some of the post-test advantage may reflect the experimental group's higher initial ability.

3.3 Impact of the T.E.A.C.H. Project on the Four Problem-Solving Stages

3.3.1 Understanding the Problem

The T.E.A.C.H. Project obtained an overall mean of 3.435, interpreted as Strongly Agree, for understanding the problem. The highest-rated indicator was understanding the purpose of the project, with a mean of 3.615. The students also strongly agreed that the intervention improved their ability to analyze problems, identify essential information, distinguish known from unknown details, and recognize relevant information. The lowest mean was 3.192 for understanding what was being asked in the activities, interpreted as Agree. The findings indicate that the project generally strengthened the first stage of problem-solving by helping students comprehend tasks before attempting solutions. However, the relatively lower rating for determining what a particular activity required suggests that some learners continued to experience difficulty interpreting problem statements. Clearer task construction and additional guided questioning may therefore be necessary.

3.3.2 Devising a Plan

The overall mean for devising a plan was 3.400, interpreted as Strongly Agree. Selecting appropriate problem-solving strategies received the highest mean of 3.615, followed by planning solution steps at 3.577. Students also reported improvement in choosing formulas, deciding which operations to use, predicting possible answers, organizing solutions, and developing confidence in planning. Thinking of different solution methods obtained a mean of 3.231, while breaking complex problems into simpler steps obtained the lowest mean of 3.192; both were interpreted as Agree. The results show that the T.E.A.C.H. Project improved procedural planning and strategy selection. However, the lower ratings for generating alternative approaches and decomposing complex problems indicate that flexible and creative problem-solving remained more difficult than following familiar procedures. These competencies require additional modeling, scaffolding, and exposure to problems with multiple possible solutions.

3.3.3 Carrying Out the Plan

Carrying out the plan obtained an overall mean of 3.473, interpreted as Strongly Agree. The highest indicator was becoming more careful in executing each solution step, with a mean of 3.577. The respondents also strongly agreed that they followed solution plans correctly, applied chosen strategies, used formulas properly, performed calculations with fewer errors, completed tasks independently, and finished activities within the allotted time. Adjusting a solution when difficulties were encountered received the lowest mean of 3.346, although it remained within the Strongly Agree category. The findings demonstrate that the intervention strengthened procedural fluency, computational accuracy, independence, and attention to detail. The relatively lower rating for modifying a solution when encountering difficulty indicates that adaptive problem-solving was still developing. Students were generally able to execute a selected plan but were less confident when the original approach required revision.

3.3.4 Looking Back

The Looking Back stage obtained an overall mean of 3.473, interpreted as Strongly Agree. Identifying where errors occurred received the highest mean of 3.577. Students also strongly agreed that they checked answers, reviewed solutions, evaluated whether answers were reasonable, reflected on mistakes, learned from previous experiences, assessed the effectiveness of their strategies, and corrected their work. Awareness of personal strengths and weaknesses obtained the lowest mean of 3.346. The results indicate that the project developed reflective problem-solving habits and encouraged students to evaluate and improve their solutions. However, the comparatively lower self-awareness rating suggests that deeper metacognitive reflection remained incomplete. Students could identify errors in specific solutions but may still require support in recognizing broader patterns in their own strengths, limitations, and strategy use.

3.4 Relationship Between Demographic Characteristics and Problem-Solving Performance

Gender was the only demographic variable significantly related to students' ability to perform the four problem-solving stages, with a correlation coefficient of -0.476 and a p-value of 0.000. Age had a correlation coefficient of -0.215 and a p-value of 0.130, program or class section had a coefficient of -0.209 and a p-value of 0.140, and academic standing had a coefficient of -0.162 and a p-value of 0.256. These three variables were not statistically significant. The findings suggest that problem-solving performance differed according to gender within the study sample, although the negative coefficient does not by itself explain the cause of the difference. In contrast, age, program or class section, and academic standing had no significant relationship with performance in the four structured stages. The T.E.A.C.H. Project therefore appeared broadly applicable across most demographic categories represented in the study, while the gender-related result requires further investigation and consideration of the unequal gender distribution.

3.5 Persistent Areas of Difficulty

The least-learned areas after the intervention were measures of central tendency, mathematical reasoning, and problem-solving. Students experienced difficulty analyzing and interpreting statistical information in measures of central tendency. They also encountered problems evaluating and applying mathematical concepts logically and synthesizing ideas to construct appropriate solutions. The affected cognitive skills were analyzing, evaluating, applying, and synthesizing. These remaining difficulties involve higher-order thinking rather than routine computation alone. The findings indicate that although the T.E.A.C.H. Project improved general proficiency, some learners still needed more intensive practice in interpreting data, defending mathematical reasoning, connecting multiple concepts, and completing complex multistep problems.

3.6 Proposed Mathematical Problem-Solving Intervention Project

The proposed intervention addressed difficulties in measures of central tendency, mathematical reasoning, and problem-solving through the five T.E.A.C.H. phases. For measures of central tendency, students would analyze real-world data, determine the appropriate use of mean, median, and mode, complete contextualized exercises, and improve their work through peer checking and error analysis. For mathematical reasoning, they would evaluate mathematical statements, explore alternative arguments, justify solutions through Socratic questioning and group discussions, and correct logical errors. For problem-solving, students would analyze word problems, identify given and required information, explore strategies using diagrams and organized data, apply appropriate formulas, perform accurate computations, and refine their answers through presentation, feedback, and reflection. The teacher would facilitate the activities and assessments, with support from the mathematics teacher, school head, and peer leaders. Overall, the intervention combined real-life data analysis, Polya's problem-solving process, Think-Pair-Share, guided exercises, peer assessment, and collaborative learning to strengthen students' skills in analyzing, evaluating, applying, and synthesizing mathematical concepts.

4 Conclusion & Recommendations

The study concluded that the T.E.A.C.H. Project effectively improved the mathematical problem-solving proficiency of first-year Criminology students. Although both groups initially demonstrated insufficient mastery and subsequently improved, the experimental group achieved significantly higher post-test performance than the control group, with p-values of 0.000 indicating statistically significant differences at the 0.01 level. The intervention enhanced students' ability to understand problems, devise and execute plans, and reflect on their solutions, supporting the importance of continual practice, strategic thinking, active discovery, guided learning, higher-order thinking, meaningful knowledge connections, and structured instruction emphasized by George Pólya's (1945), Jerome Bruner's (1961), Lev Vygotsky's (1978), Benjamin Bloom (1956), David Ausubel's (1968), and Robert Gagné (1985). Age, program or course, and academic standing were not significantly related to problem-solving performance, while gender showed a significant relationship. Despite the overall improvement, students continued to experience difficulty in measures of central tendency, mathematical reasoning, and complex problem-solving tasks requiring analysis, evaluation, application, and synthesis; thus, the proposed intervention was developed to address these competencies.

The T.E.A.C.H. Project should be continuously implemented, strengthened, and integrated into regular Mathematics instruction through learner-centered, interactive, collaborative, discovery-based, and contextualized activities. Teachers should provide diagnostic assessments, enrichment exercises, remedial programs, guided questioning, worked examples, multiple-solution activities, reflective discussions, and sustained practice, with particular emphasis on the Think and Hone phases and on measures of central tendency, mathematical reasoning, and problem-solving. School administrators should provide appropriate teacher training, seminars, instructional materials, monitoring, and implementation support. Differentiated assistance should be provided to learners who continue to experience difficulty, while future studies should include more balanced gender representation, broader age groups and academic programs, and additional variables to improve the generalizability and depth of the findings.

The study was limited to 51 first-year Bachelor of Science in Criminology students from two intact sections at World Citi Colleges–Guimba Campus who were enrolled in Mathematics in the Modern World during Academic Year 2025–2026. Its scope was confined to mathematical problem-solving and the skills and instructional strategies incorporated into the T.E.A.C.H. Project. The use of intact, non-randomly assigned classes, the unequal gender representation, and the groups' differing initial proficiency restricted the comparability and generalizability of the findings. Student motivation, teacher-training quality, home environment, and other possible influences on mathematical performance were acknowledged but were not directly measured.

Compliance with ethical standards

The study complied with institutional ethical standards, and permission was secured from the appropriate school authorities before data collection. Participation was voluntary, informed consent was obtained, and respondents were informed of their right to withdraw without penalty. Confidentiality and anonymity were maintained through coded data and secure record handling. The researcher declares no conflict of interest, acknowledges all individuals who contributed to the study, assumes responsibility for the accuracy and integrity of the work, and retains copyright ownership of the research subject to applicable institutional policies.

REFERENCES

Amanah, S. N., Junaedi, I., & Mulyono. (2025). Systematic literature review: Application of problem solving in the mathematics curriculum. *Postulat: Jurnal Inovasi Pendidikan Matematika, 6*(2), 184–197. https://doi.org/10.30587/postulat.v6i2.9147

Brungs, C. L., Buchholtz, N., Streit, H., Theile, Y., & Rott, B. (2025). Empirical reconstruction of mathematics teaching practices in problem-solving lessons: A multi-method case study. *Frontiers in Education, 10*, Article 1555763. https://doi.org/10.3389/feduc.2025.1555763

Ceci, S. J., Ginther, D. K., Kahn, S., & Williams, W. M. (2014). Women in academic science: A changing landscape. *Psychological Science in the Public Interest, 15*(3), 75–141. https://doi.org/10.1177/1529100614541236

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin, 143*(1), 1–35. https://doi.org/10.1037/bul0000052

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Cruz, R. D. (2025). Investigating undergraduate students' mathematical problem-solving techniques in mathematics education. *American Journal of Interdisciplinary Research and Innovation, 4*(3), 62–73. https://doi.org/10.54536/ajiri.v4i3.4506

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science, 24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Dela Peña, R. M. J., & Doronio, R. G. (2025). An experimental study on mathematics teaching strategies and academic performance of students. *International Journal of Research and Innovation in Social Science, 9*(7), 1188–1193. https://doi.org/10.47772/IJRISS.2025.90700097

Dinglasan, J. K. L., Caraan, D. R. C., & Ching, D. A. (2023). Effectiveness of realistic mathematics education approach on problem-solving skills of students. *International Journal of Educational Management and Development Studies, 4*(2), 64–87. https://doi.org/10.53378/352980

European Institute for Gender Equality. (2023). *Gender equality index 2023: Towards a green transition in transport and energy*. Publications Office of the European Union. https://doi.org/10.2839/64810

Gahi, L. J. S., Almagro, R. E., & Sudoy, R. R. C. (2023). Mathematical problem-solving style and performance of students. *International Journal of Research and Innovation in Social Science, 7*(11), 1804–1820. https://doi.org/10.47772/IJRISS.2023.7011142

Gao, H., Evans, T., & Fergusson, A. (2025). Student explanation strategies in tertiary mathematics and statistics education: A scoping review. In S. Cook, B. Katz, & D. Moore-Russo (Eds.), *Proceedings of the 27th Annual Conference on Research in Undergraduate Mathematics Education* (pp. 258–268). SIGMAA on RUME. https://doi.org/10.17608/k6.auckland.29925140

Garzon, J. R. (2023). Correlates of problem-solving difficulties among Ibarra NHS learners: Towards an evidence-based Project IMPACT. *Psychology and Education: A Multidisciplinary Journal, 15*(6), 588–596. https://doi.org/10.5281/zenodo.10255604

Jasmin, D. R., & Buan, A. (2025). A systematic review on instructional strategies promoting K–12 students' creative thinking in mathematics. *Journal of Innovation, Advancement, and Methodology in STEM Education, 2*(3). https://so13.tci-thaijo.org/index.php/J_IAMSTEM/article/view/2026

Ji, Z., & Guo, K. (2023). The association between working memory and mathematical problem solving: A three-level meta-analysis. *Frontiers in Psychology, 14*, Article 1091126. https://doi.org/10.3389/fpsyg.2023.1091126

Khasanah, A. K., Wiryanto, & Siswono, T. Y. E. (2025). The effectiveness of realistic mathematics education to improve students' problem-solving skills in elementary schools: Literature review. *Jurnal Cakrawala Pendas, 11*(1), 188–199. https://doi.org/10.31949/jcp.v11i1.12186

Masingila, J. O., Caviness, S. L., Simiyu, C. W., Agbozo, C. T., & Nartey, F. (2025). Preparing prospective mathematics teacher educators to teach mathematics through problem solving. *Education Sciences, 15*(9), Article 1131. https://doi.org/10.3390/educsci15091131

Myers, J. A., Witzel, B. S., Powell, S. R., Li, H., Pigott, T. D., Xin, Y. P., & Hughes, E. M. (2022). A meta-analysis of mathematics word-problem solving interventions for elementary students who evidence mathematics difficulties. *Review of Educational Research, 92*(5), 695–742. https://doi.org/10.3102/00346543211070049

Paldi, P., & Khuzaini, N. (2024). A systematics literature review of the problem-solving approach in mathematics learning: Fostering creativity and reducing math anxiety. *Journal of Educational Technology and Mathematics, 1*(2), 16–22. https://edutechnusantara.org/index.php/jetm/article/view/22

PBLWorks. (n.d.). *What is project based learning?* Retrieved October 4, 2025, from https://www.pblworks.org/what-is-pbl

Pew Research Center. (2024, January 25). *Key milestones for young adults today versus 30 years ago*. https://www.pewresearch.org/social-trends/2024/01/25/key-milestones-for-young-adults-today-versus-30-years-ago/

Pólya, G. (1957). *How to solve it: A new aspect of mathematical method* (2nd ed.). Princeton University Press. (Original work published 1945)

Säfström, A. I., Lithner, J., Palm, T., Palmberg, B., Sidenvall, J., Andersson, C., Boström, E., & Granberg, C. (2024). Developing a diagnostic framework for primary and secondary students' reasoning difficulties during mathematical problem solving. *Educational Studies in Mathematics, 115*(2), 125–149. https://doi.org/10.1007/s10649-023-10278-1

Sanditan, R. O., Jr., & Roble, D. B. (2026). Enhancing students' mathematical problem-solving skills using Math Workshop Model (MWM): A quasi-experimental study. *Journal of Innovations in Teaching and Learning, 6*(1), 26–30. https://doi.org/10.12691/jitl-6-1-4

Santos-Trigo, M. (2024). Problem solving in mathematics education: Tracing its foundations and current research–practice trends. *ZDM–Mathematics Education, 56*, 211–222. https://doi.org/10.1007/s11858-024-01578-8

Schneider, M., & Preckel, F. (2017). Variables associated with achievement in higher education: A systematic review of meta-analyses. *Psychological Bulletin, 143*(6), 565–600. https://doi.org/10.1037/bul0000098

Sinaga, B., Sitorus, J., & Situmeang, T. (2023). The influence of students' problem-solving understanding and results of students' mathematics learning. *Frontiers in Education, 8*, Article 1088556. https://doi.org/10.3389/feduc.2023.1088556

Sugiharti, A., Rahmawati, D., & Anwar, R. (2026). Trends in mathematical problem-solving skills in mathematics learning. *International Journal of Studies in Education and Science, 7*(2), 188–201. https://doi.org/10.46328/ijses.6725

Svane, R. P., Willemsen, M. M., Bleses, D., Krøjgaard, P., Verner, M., & Nielsen, H. S. (2023). A systematic literature review of math interventions across educational settings from early childhood education to high school. *Frontiers in Education, 8*, Article 1229849. https://doi.org/10.3389/feduc.2023.1229849

von Davier, M., Kennedy, A. M., Reynolds, K. A., Fishbein, B., Khorramdel, L., Aldrich, C. E. A., Bookbinder, A., Bezirhan, U., & Yin, L. (2024). *TIMSS 2023 international results in mathematics and science*. Boston College, TIMSS & PIRLS International Study Center. https://doi.org/10.6017/lse.tpisc.timss.rs6460

Wang, W., Ma'rof, A. M., & Burhanuddin, N. A. N. (2025). A scoping review on social problem-solving interventions for college students. *Frontiers in Education, 10*, Article 1509641. https://doi.org/10.3389/feduc.2025.1509641

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology, 14*, Article 1202728. https://doi.org/10.3389/fpsyg.2023.1202728

Zuhaida, N., Pujiastuti, E., Zaenuri, & Walid. (2025). Trends in students' mathematical problem-solving skills: A systematic review and bibliometric analysis of GeoGebra-assisted problem-based learning research (2021–2025). *Media Pendidikan Matematika, 13*(2), 1118–1133. https://doi.org/10.33394/mpm.v13i2.18489