

Research Article

Cite this article: Rio, R. M. D., & Protacio, J. V. (2025). Explanatory Sequential Study on Word Problem-Solving and Mathematical Cognitive Skills of College Students: Implications for STEM Competencies Development. *Educational Process: International Journal*, 18, e2025506.
<https://doi.org/10.22521/edupij.2025.18.506>

Received July 22, 2025

Accepted October 2, 2025

Keywords: College mathematics education, higher order thinking, mathematics learning impediments, key sustainability competencies, mixed methods research

Author for correspondence:

Judel V. Protacio

✉ jvprotacio@capsu.edu.ph

✉ College of Education, Arts and Sciences
Capiz State University, Capiz, Philippines



OPEN ACCESS

© The Author(s), 2025. This is an Open Access article, distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted re-use, distribution, and reproduction, provided the original article is properly cited.

Explanatory Sequential Study on Word Problem-Solving and Mathematical Cognitive Skills of College Students: Implications for STEM Competencies Development

Rica Mae D. Rio^{ID}, Judel V. Protacio^{ID}

Abstract

Background/purpose. The strategic goal of science, technology, engineering, and mathematics (STEM) literacy is to develop scientifically and technologically equipped global citizens who are innovators and problem-solvers in a rapidly changing world. The study contributes to this goal by drawing pedagogical implications from examining college students' word problem-solving skills, their perceptions of the role of mathematical cognitive skills, and the factors that hinder successful word problem-solving.

Materials/methods. An explanatory sequential design was used, with the quantitative phase assessing college students' word problem-solving skills and the qualitative phase examining their perceptions of mathematical cognitive skills and hindering factors to explain variations in word problem-solving performance.

Results. College students demonstrated fundamental-level word problem-solving ability, highlighting the inherent difficulty in navigating complex cognitive tasks. The variations in problem-solving proficiency, shaped by nuanced differences in cognitive development, instructional practices experienced, and available learning opportunities, influence the problem-solving approaches undertaken, the perception of problem-solving complexity, and the use of strategies in overcoming problem-solving barriers.

Conclusion. College students recognize the crucial role of mathematical cognitive skills in solving word problems. However, the prevalence of hindering factors underscores that cognitive skills alone do not decisively translate into successful problem-solving. Enhancing word problem-solving competencies in the context of STEM education requires the adoption of a systemic approach that integrates the enhancement of cognitive skills, the implementation of strategic and differentiated interventions responsive to varying levels of problem-solving ability, and the creation of supportive learning environments fostered by technology-based, collaborative, reflective, and integrative teaching practices.

1. Introduction

Science, technology, engineering, and mathematics (STEM) education is a framework that provides the context and mechanism for integrating 21st-century skills into the curriculum by fostering the development of critical, innovative, and interdisciplinary thinking, collaboration and communication, technological fluency, and creative problem-solving. STEM skills also contribute to key sustainability competencies (KSCs), which enable individuals and organizations to be better equipped to navigate uncertainty, adapt to change, and build a resilient future (Eberz et al., 2023). The 2022 Programme for International Student Assessment (PISA) results indicate a general decline in STEM skills among secondary learners. In 2022, 30% of students were found to lack proficiency in basic mathematics, a significant increase from 23% in 2018. Similarly, students who have difficulties in fundamental science increased from 22% in 2018 to 24% in 2022 (OECD, 2019, 2023). The results suggest the need for urgent action to enhance STEM skills at the primary education level and sustained curricular integration in higher education. Although STEM education is a well-established curricular framework in upper secondary schools and specialized college programs, there remains a scarcity of documented studies examining how STEM integration has been pedagogically translated into general education mathematics and science courses for early college students in developing countries such as the Philippines. This gap necessitates closer investigations and, more importantly, curricular reforms that align mathematics education with the broader goal of sustaining STEM in higher education—chiefly through the cultivation of mathematical literacy among college students.

Mathematical literacy is essential for academic success as it promotes cognitive development, critical thinking, and problem-solving skills. It also empowers individuals to make reasoned decisions and sound judgments (OECD, 2019), thereby equipping them to contribute meaningfully in an increasingly complex and rapidly changing world. Success in mathematics may reveal a learner's potential for mental abilities in logical reasoning, pattern recognition, and critical analysis (Dowker et al., 2016; Szabo et al., 2020), as well as executive functions that include inhibition, shifting, and updating (Emslander & Scherer, 2022). Mathematically literate students are expected to be better equipped to evaluate risks, interpret information, and solve complex problems—skills essential for responsible citizenship and future employment. Moreover, students' mathematical abilities are underscored as a foundational contribution to national development and growth, as well as participation in the modern knowledge economy (Chinn, 2021; OECD, 2019; Simamora & Saragih, 2019). Hence, the pivotal role of mathematics literacy in both academic and real-life problem-solving contexts implies a well-grounded mathematics learning experience that builds mathematical proficiency.

Despite increasing efforts to advance mathematical literacy through initiatives such as STEM/STEAM education (Eberz et al., 2023), evidence continues to highlight persistent underachievement across all educational levels. Large-scale assessments—including TIMSS for elementary and middle school learners (von Davier, 2024), PISA for high school students (Gamazo & Martinez-Abad, 2020; OECD, 2019, 2023), and TEDS-M for prospective mathematics teachers (Tatto, 2013)—consistently reveal these gaps. Likewise, studies on specific dimensions of mathematical proficiency indicate that students frequently struggle with problem-solving and the associated complex cognitive abilities such as mathematical reasoning, conceptual understanding, mathematical representations, and mathematical communication (Aljura et al., 2025; Novak & Tassell, 2017; Verschaffel et al., 2020; Yusoff et al., 2022), rendering problem-solving—the ultimate indicator of mathematical competence—a particularly 'bad weather' learning experience.

Given the declining mathematical proficiency and the significant role of mathematics literacy in both individual and societal contexts, this study addresses the identified gaps in the limited studies investigating the integration of STEM competencies, such as problem-solving ability and the underlying mathematical cognitive skills, in general education mathematics courses among early

college students. Specifically, it investigates the extent of word problem-solving skills of college students and examines how their perceptions of mathematical cognitive ability, along with the factors hindering its development, provide explanation for varying levels of problem-solving skills to draw pedagogical implications towards STEM integration sustainability in higher education. Hence, the study addresses the following research questions:

1. What is the extent of word-problem-solving proficiency of college students?
2. How do college students' perceptions of mathematical cognitive skills characterize their varying levels of problem-solving proficiency?
3. How do college students of varying levels of problem-solving ability navigate through word problem-solving?
4. What hinder college students from successful word problem-solving?

1.1. Theoretical Framework

As a mixed-methods study, the overall research framework operates within the pragmatic research paradigm (Weaver, 2018). This research philosophy emphasizes practical outcomes by underscoring what works individually or collectively, rather than adhering to a single general worldview. Informed by the quantitative phase, which assessed word problem-solving proficiency, the study advances by incorporating multiple perspectives from college students, capturing their individual problem-solving experiences to provide a more nuanced understanding of the dynamics of mathematical cognition and word problem-solving ability. Consequently, the study paradigm recognizes what works based on individual experience and what is collectively effective in real-world contexts, such as established problem-solving heuristics. At the specific aspects of investigation, the study is grounded in constructivism (Ernest, 2010), which emphasizes active engagement and real-world application, enabling students to construct mathematical understanding through meaningful learning experiences. This study examines how students perceive mathematical cognition and how they apply these skills in word problem-solving, as well as the available instructional support and learning resources. By dwelling on mathematical cognition, the study drew insights from Piaget's cognitive theory (Greenfield & Moorman, 2019; Miller, 2011; Piaget, 1950) which provided the direction for choice of the target population and development of research instruments, with the assumption that early college students should be proximately at the formal operational stage of cognitive development. Finally, the study is also grounded in cognitivism (Bandura, 1997), which views learning as an internal process involving memory and schema — generally identified factors essential for developing mathematical cognitive skills used in solving complex problems. These theoretical underpinnings collectively provide a framework for exploring and better understanding college students' perceptions of mathematical cognition, as well as the hindering factors that impede successful word problem-solving.

2. Literature Review

2.1. Mathematical Proficiency and Cognitive Skills

Mathematical proficiency is a multifaceted competence in mathematics education involving conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition, each contributing uniquely and holistically to learners' ability to grasp mathematical concepts, solve problems, and apply knowledge effectively (National Research Council, 2001; Spencer et al., 2020). These interwoven strands emphasize not only a learner's ability to solve mathematical problems but also their inclination to view mathematics as a meaningful and worthwhile pursuit. Kilpatrick and colleagues argued that to achieve true proficiency, a student must develop all five strands, each of which plays a critical role in different mathematical contexts (National

Research Council, 2001). Notably, interest in the first two dimensions has been well-documented (Ngu & Phan, 2016; Rittle-Johnson et al., 2017; Tchoshanov & Monarrez, 2024), implying the need to investigate how the other dimensions impact learning and applying mathematics.

Cognitive skills are the foundational blocks of mathematical proficiency as they are indispensable in mathematics learning by influencing how students understand concepts, apply procedures, and approach novel problem situations (Cragg & Gilmore, 2018; Emslander & Scherer, 2022; Snowling & Hulme, 2021; Spiegel et al., 2021; Xie et al., 2020). According to Hannell (2005), language facility, visual-spatial skills and memory are strongly associated with mathematical proficiency. More specifically, Butterworth (2019) and Shaw (2022) consider number sense, working and short-term memory, reasoning ability, attention, and language ability as essential cognitive abilities in learning mathematics; hence, these are referred to as mathematical cognitive skills in this paper.

Results of international large-scale assessments (ILSAs) such as the PISA and TIMSS attribute underachievement in mathematical proficiency to factors such as outdated instructional strategies, lack of access to quality materials, and a low level of teacher content knowledge, and low socioeconomic status (Karakolidis et al., 2016; Gamazo & Martinez-Abad, 2020; Wang et al., 2023; Lazarevic & Orlic, 2018; Tuoron et al., 2018). Accordingly, this suggests that mathematical proficiency development is better approached as a dynamic interplay of conceptual understanding, cognitive function, student-related factors, and an instructional support system. While ILSAs are focused on the foundational dimensions of mathematics achievement among secondary students (Gamazo & Martinez-Abad, 2020; OECD, 2019, 2023; Wang et al., 2023), there is a limited number of studies examining how cognitive skills factor into mathematical proficiency including problem-solving abilities of young adults in higher education settings (Gilmore et al., 2022; Xie et al., 2020) where college students are expected to have reached the formal operational stage of Piaget's cognitive development theory.

2.2. Word Problem-Solving

Problem-solving is both a teaching and learning tool for building mathematical proficiency. In particular, word problems are designed to contextualize instruction, making the learning process more relevant and meaningful. Accordingly, word problem-solving—a complex cognitive task that integrates reading comprehension and mathematical representation skills (Boonen et al., 2016)—is widely regarded as a vital indicator of students' overall mathematical proficiency and cognitive capabilities. Employing word problems in instruction gauges students' ability to translate real-life situations into mathematical models (Ogut et al., 2024), which in turn requires high-level reasoning and flexible cognitive and problem-solving strategies. By allowing them to focus on understanding rather than non-contextual repetitions of procedures (Rocha et al., 2024), it also serves as a medium for students to bridge real-world contexts and abstract mathematical operations, thereby reinforcing their reasoning and judgment abilities (Nguyen et al., 2020). Consequently, problem-solving has become an essential component of most student-centered approaches in mathematics education such as inquiry-based and problem-based learning (Tepla & Distler, 2025; Tursynkulova et al., 2023). While there is a general agreement on the essential role of problem-solving in learning, it remains one of the inherently complex tasks for most learners, as noted earlier (Aljura et al., 2025; Novak & Tassell, 2017; Verschaffel et al., 2020; Yusoff et al., 2022).

Current literature presents mixed views on what constitute successful problem-solving (Achmetli et al., 2019; Cirillo & Hummer, 2021; Mills, 2021; Rocha & Babo, 2024). On the other hand, difficulties in mathematical problem-solving are not solely due to a lack of procedural knowledge but also stem from linguistic and cognitive barriers (Fatmanissa & Novianti, 2022; Lee et al., 2019). In addition to cognitive and proficiency-related factors, problem-solving ability is influenced by external variables, such as mindset, the use of digital tools, parental support, and quality teacher-student interactions.

Conversely, poor comprehension, limited vocabulary, and misapplied operations often hinder achievement (Zhu et al., 2024). While prior research has established the interrelated roles of problem-solving skills, cognitive abilities, and environmental factors in the learning outcomes of basic education students, limited attention has been given to how these dimensions shape variations in word problem-solving performance among early college students. This gap underscores the need for further investigation in the present study.

3. Methodology

3.1. Research Design

This study employed a mixed-methods explanatory sequential design beginning with a quantitative phase followed by a qualitative phase to explain quantitative findings (Creswell & Plano Clark, 2018). The quantitative phase, intended to answer Research Question 1, employed a descriptive quantitative approach through a cross-sectional survey to describe and summarize the characteristics of the population or its sample, without manipulating variables or making inferences about population characteristics (Fraenkel et al., 2012). In this study, the word problem-solving ability of college students was assessed and the data gathered underwent descriptive analysis to allow individual and group classification of proficiency levels in terms of problem-solving topics. The distribution of participants in terms of varying levels of problem-solving proficiency provided the sample frame for the qualitative phase of the study, in which a certain number of participants were taken from each level of problem-solving performance. Subsequently, a descriptive qualitative research design was employed to address Research Questions 2, 3, and 4, providing a straightforward description of participants' perspectives and experiences in a language that is accessible and understandable (Colorafi & Evans, 2016). It was particularly aimed at drawing out an in-depth understanding of students' perception of mathematical cognitive skills and their roles in the word problem-solving experience of students. It also identified and explained factors hindering the development of these skills. This qualitative information was intended to explain the variations in students' word problem-solving proficiency obtained from the quantitative phase.

3.2. Participants, Sampling, and Setting

The study was conducted at a state university in Capiz, Philippines, during the second semester of the 2024-2025 academic year. The setting was chosen for its accessibility, relevance, and typical characteristics of public tertiary institutions in the country. The sample size for the quantitative phase consisted of 265 college students who had completed the Mathematics in the Modern World course, selected from a population of 813 students using Cochran's formula (Cochran, 1977). Proportional cluster sampling was applied based on degree programs, followed by simple random sampling with proportional allocation by gender within each cluster. Presented in Table 1 is the cross-tabulation of the distribution of college students by gender and degree programs. Among the respondents, 40% were males and 60% were females. Likewise, about 25% of the participants were involved in mathematics-based programs, such as agricultural engineering and computer science. Approximately 15% were in agricultural sciences, another 15% in education, and the remainder in business-oriented programs.

In the qualitative phase, nine participants were purposively selected through a nested sampling approach. In this sampling technique, the inclusion criteria involved purposive selection of participants from each of the problem-solving ability levels. Accordingly, the nine participants were identified based on exhibiting high (advanced and proficient levels, P1 – P3), average (approaching proficiency level, P4 – P6), and low (beginning and developing levels, P7 – P9) problem-solving performance with three participants from each performance level to ensure representative sampling and draw reliable insights in explaining the quantitative results. The age range of the participants was 18 to 20 years, as they were from early-year levels of college education.

Table 1. Cross-Tabulation of Distribution of Participants by Gender and Degree Programs

Degree Program	Gender		N	%
	Male	Female		
Agricultural engineering	9	10	19	7.17
Agriculture	7	10	17	6.42
Fisheries	9	14	23	8.68
Secondary teacher education	9	18	27	10.19
Physical teacher education	3	4	7	2.64
Elementary teacher education	3	7	10	3.77
Computer science	25	21	46	17.36
Business administration	16	45	61	23.02
Hospitality management	25	30	55	20.75
Total	106	159	265	100

3.3. Research Instruments, Data Gathering, and Analysis Procedures

In the quantitative phase, the research instrument used was a researcher-developed 24-item word problem-solving proficiency test covering targeted topics in the general education course Mathematics in the Modern World, as prescribed by the Commission on Higher Education (CHED) (CHED, 2013). Six items were constructed for each of the main topics as shown in Table 2 below.

Table 2. Table of Specifications for Word Problem-Solving Proficiency Test

Problem-solving topics	Number of items	%
Nature of mathematics	6	25.00
Logic pattern	2	8.33
Number pattern	2	8.33
Fibonacci sequence	2	8.33
Mathematical language and symbols	6	25.00
Order of operations	2	8.33
Sets	2	8.33
Relations and functions	2	8.68
Recreational problem solving	6	25.00
Mathematics as a tool	6	25.00

Measures of central tendency	1	4.17
Simple and compound interest	3	12.50
Measures of relative position	1	4.17
Measures of dispersion	1	4.17
Total	24	100.00

In scoring the responses, a rubric was used where each item was evaluated in terms of four criteria equally contributing to the total score of 10 points: problem-solving strategy, reasoning and proof, communication, and representation. Response under each criterion was rated as proficient (10), adequate (7), developing (4), or not present (1). Individual performance was expressed in terms of percentage rating (PR) and interpretation of overall PR was based on the following scale: 87.5 - 100.00 (Advanced), 75.01 - 87.50 (Proficient), 62.51 - 75.00 (Approaching Proficiency), 50.00 - 62.50 (Developing), and below 50 (Beginning).

In the qualitative phase, an interview guide was developed based on the characterization of mathematical cognitive skills by Butterworth (2009) and Shaw (2022) that includes number sense, working and short-term memory, reasoning ability, abstraction, attention, and language ability. Guiding questions were formulated to explore students' perceptions of the role of mathematical cognitive skills in word problem-solving and the factors that hinder problem-solving. Sample guide questions for Research question 2 are presented below.

- *Main question:*

What is your understanding of mathematical cognitive skills (i.e., number sense, working and short-term memory, reasoning, abstraction, attention, and language ability)?

- *Follow-up question:*

Do you employ other thinking skills while doing mental tasks? If there is, can you describe it?

- *Main question:*

What do you think of these skills when you do mental tasks like problem-solving?

- *Follow-up question:*

How do you employ these skills when you solve word problems in mathematics?

The two sets of instruments were subjected to content validation by five mathematics educators who had at least three years of experience teaching the course Mathematics in the Modern World, held relevant doctoral degrees, and had substantial research experience in mathematics education. Content validation through qualitative assessment by the validators encompasses the following parameters: clarity of instructions, test items, and guide questions, as well as the sufficiency of the items or questions in answering the research questions. The suggestions of the validators were incorporated into the final draft of the instruments and were presented to the validators for further validation. The final draft of the word problem-solving test was pilot-tested on thirty college students from the same cohort as the study participants, using the test-retest method—a reliability procedure suitable for open-ended tests. The two sets of scores were then correlated and the obtained reliability coefficient was $r = .734$. Test-retest reliability coefficients of correlations $\geq .70$ are considered favorable (Terwee et al., 2007); thus, the instrument demonstrated acceptable reliability.

The college research panel, tasked with reviewing and approving research protocols, provided clearance to conduct the study. The participants were informed of the voluntary nature of their

participation and asked to provide informed consent prior to their participation, ensuring adherence to ethical standards during data collection. The researchers personally coordinated instrument administration. Online in-depth interviews were conducted via Google Meet with responses transcribed and translated for thematic analysis. Data analysis for the quantitative phase utilized the Statistical Package for the Social Sciences (SPSS). The qualitative data were analyzed using the six-phase Braun and Clark (2013) thematic analysis model, which includes familiarizing oneself with the texts, generating initial codes, searching for themes, reviewing the themes, defining and naming the themes, and producing a report. The trustworthiness of the findings was ensured through triangulation, dependability, and confirmability criteria. In the triangulation process, the researchers referred to the results from the quantitative phase and consulted with expert opinion from mathematics educators to verify the research findings. The interview transcripts and findings were also presented to the participants for confirmation.

4. Results

4.1. Quantitative Findings

4.1.1. Word Problem-Solving Proficiency

The assessment of word problem proficiency among college students covered four key topics from the course Mathematics in the Modern World: the nature of mathematics, mathematical language and symbols, recreational problem-solving, and mathematics as a tool. Data in Table 3 show that college students were at the beginning level of proficiency ($M = 101.92$, $SD = 48.03$, $PR = 42.27$), suggesting that students' difficulty in navigating word problems was due to inadequately acquired prerequisite knowledge and skills. Students achieved developing level of proficiency in nature of mathematics which deals with patterns and sequences ($PR = 52.87$), beginning level in mathematical language which contains operations, sets, relations and functions ($PR = 49.17$), beginning level in recreational problem solving which dwells on logical reasoning and general mathematical knowledge ($PR = 38.87$), and also beginning level in mathematics as a tool which deals with basic statistics and rates ($PR = 28.97$). The results underscore the consistent underperformance of college students in solving word problems, particularly in relation to relations and functions, recreational problem-solving, and applications of mathematics in statistics and rate problems.

Table 3. Word Problem-Solving Proficiency of College Students

Problem solving topics ($N = 265$)	Total Points	M	SD	Percentage Rating (PR)
Nature of mathematics	60	31.72	9.61	52.87
Logic pattern	20	13.33	4.51	66.65
Number pattern	20	9.38	4.14	46.90
Fibonacci sequence	20	9.01	5.04	45.05
Mathematical language and symbols	60	29.50	13.46	49.17
Order of operations	20	11.00	6.54	55.00
Sets	20	9.82	5.98	49.10
Relations and functions	20	8.68	5.30	43.40
Recreational problem solving	60	23.32	14.03	38.87

Mathematics as a tool	60	17.38	10.93	28.97
Measures of central tendency	10	4.87	3.34	48.70
Simple and compound interest	30	13.28	6.90	44.27
Measures of relative position	10	2.73	2.73	27.30
Measures of dispersion	10	2.36	2.36	23.60
Overall word problem-solving proficiency	240	101.92	48.03	42.47

Note. Interpretation of PR is based on the following scale: 87.51-100.00(Advanced), 75.01-87.50 (Proficient), 62.51-75.00(Approaching Proficiency), 50.00-62.50(Developing), and below 50 (Beginning)

Presented in Table 4 are the percentage distributions of participants in terms of word problem-solving proficiency levels by main problem-solving topics. In Figure 1, the whole-group levels of word problem-solving, categorized by main topics and specific problem-solving topics, are also presented. In terms of overall performance, approximately 95% of college students have achieved beginning (61.50%) to developing (34.00%) levels of proficiency, reflecting an achievement of a fundamental level of problem-solving ability that requires further assistance to effectively apply and transfer knowledge in new and different contexts. Among the main topics covered, about 27% have achieved proficient and advanced levels, such as mathematics and mathematical language and symbols, indicating that a greater majority lags behind the expected level of problem-solving competence. Similarly, for recreational problem solving, about 20% have achieved the expected proficiency level, while in mathematics as a tool, about 97% were still at the beginning and developing levels. The results indicate that the college students' learning experience from the Mathematics in the Modern World course may not have yielded significant learning outcomes, particularly in recreational problem-solving and applying mathematics as a tool in practical applications. Likewise, this may also suggest the inherently complex nature of word problems that impedes successful problem-solving among young adult learners most of whom were enrolled in non-mathematics-based programs.

Table 4. Percentage Distribution of Participants in Terms of Word Problem-Solving Proficiency Levels by Main Topics

Topics covered	Proficiency level percentage distribution				
	Beginning	Developing	Approaching proficiency	Proficient	Advanced
Nature of mathematics	40.80	31.30	21.10	6.00	0.80
Mathematical language and symbols	41.10	27.90	21.50	6.80	2.60
Recreational problem solving	64.50	15.10	17.40	2.30	0.80
Mathematics as a tool	81.90	14.70	3.40		
Overall word problem-solving proficiency	61.5	34.0	4.2	0.40	

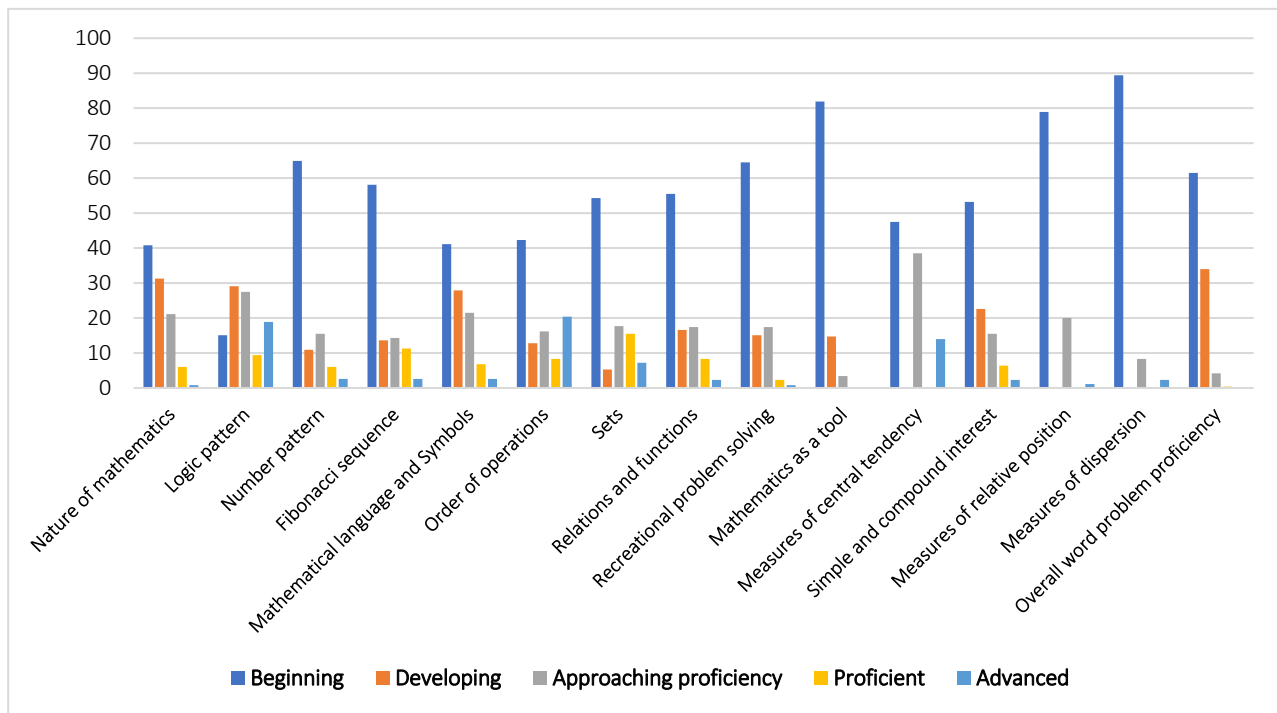


Figure 1. Whole-Group Levels of Word Problem-Solving Proficiency by Main and Specific Topics (Authors' Own Work)

4.2. Qualitative Findings

4.2.1. Perceptions of Mathematical Cognitive Skills and Word Problem-Solving

Thematic analysis of college students' responses revealed insights into how they perceived the crucial role mathematical cognitive skills in word problem-solving. The overarching themes guiding the conversation with students on their perceptions of mathematical cognitive skills include number sense, logical reasoning, abstract thinking, memory and prior knowledge, attention and focus, and language facility (Butterworth, 2009; Shaw, 2022). Students described number sense as understanding how numbers behave and their role in estimating and checking solutions, while logical reasoning was viewed as the ability to think procedurally, make connections, analyze information, identify patterns, and arrive at valid conclusions, making it a critical skill for problem-solving. Students saw abstract thinking as a mental ability to work with concepts beyond concrete realities and deemed it crucial for analyzing complex situations and developing creative solutions. Participants also emphasized the importance of memory and domain-specific prior knowledge on mathematical rules and formulas for efficient problem-solving. They also considered the skills previously learned from other mathematics areas and problem-solving experience as handy tools in reducing analysis time.

Attention and focus were highlighted as playing a crucial role in understanding problems, avoiding careless mistakes, and maintaining organization. Furthermore, text comprehension and overall language facility were repeatedly identified as essential skills for effective problem-solving. The following are excerpts from an interview transcript on students' views of mathematical cognitive abilities in problem-solving.

4.2.1.1. Number Sense

P1 with high-level problem-solving competence has clear understanding of number sense and its importance in making estimates and solution verification.

P1: "So, for me, number sense is kind of like understanding how numbers behave, like knowing when the number is too small or too big for the problem. And it really helps when I'm estimating or checking my work."

4.2.1.2. Logical Reasoning

These participants, who demonstrate high-level problem-solving competence, highlight how logical reasoning is applied in problem-solving.

P2: "Logical reasoning is somewhat an ability to think step-by-step procedure and make connections between different pieces of information."

P3: "Logical reasoning is a form of thinking that involves using logic and reason to analyze information, identify patterns, and arrive at valid conclusions. It's a critical skill for problem-solving, decision-making, and understanding the world around us."

4.2.1.3. Abstract Thinking

P3 explains how abstract thinking matters in problem-solving as it enables one to operate from the actual to the hypothetical situations.

P3: "Abstract thinking, the ability to understand and work with concepts beyond concrete realities, is crucial for solving word problems as it allows you to analyze complex situations, identify patterns, and develop creative solutions."

4.2.1.4. Working Memory and Domain Specific Prior Knowledge

P4 and P6, participants with average and low-level problem-solving abilities, recognize the value of recalling prior knowledge, particularly in the domain of mathematics, such as mathematical formulas, in problem-solving. Their views however are fixated on formulas as the gateway to solving problems. P8, however, is unclear about which skills are actually utilized.

P4: "For me, the more areas of math you know, the more tools you have to solve different types of problems. If you can remember lots of formulas, then you can answer lots of problems."

P6: "Memory is important because if I can remember or recall relevant formulas or rules, I can apply them to problems instead of searching for them. If I forget a formula, it slows me down and sometimes leads to mistakes, or I can't understand the problem properly."

P8: "Problem-solving skills really help, ma'am, in different areas of mathematics. If you don't have those skills, you won't be able to answer math questions, but if you do, you can answer them quickly."

4.2.1.5. Attention and Focus

P2 and P8 perceive attention and focus differently. P2 understands attention and focus as a cognitive ability necessary in problem solving while P8 sees it as a classroom behavior towards teaching-learning process.

P2: "I think attention and focus play a huge role in solving word problems because they help me fully understand what the problem is asking and avoid making careless mistakes. If I'm not paying attention, I may misread the problem, struggle to understand it, or forget a step or process in the solution. Focus, on the other hand, helps me stay organized, especially when I am confronted with word problems that involve multiple steps or procedures to follow."

P8: “You really need attention and focus, ma’am. For example, if you don’t listen in your math class and the teacher asks you to answer something, you won’t be able to respond because you weren’t paying attention. You really need to focus to answer the problem correctly.”

4.2.1.6. Text Comprehension

P4 explains the significance of understanding the problem from comprehension of the problem structure to be on the right track in problem-solving.

P4: “For me, the crucial cognitive skills are reading and comprehension skills. We should read and understand the problem. We really need to comprehend or understand the question first because we cannot answer the question if at first, we do not understand it.”

4.3. Navigating Word Problem-Solving

Exploring college students’ experiences in navigating word problem-solving revealed their thoughts on the problem-solving approaches they used, perceived ease and difficulties, and strategies they adapted for overcoming problem-solving barriers. Students generally employed structured thinking processes with some specifying Polya’s four-step problem-solving heuristics. These approaches typically start with reading and understanding the problem, followed by identifying and extracting relevant information. After the initial phase, students execute the solution plan and conclude by reviewing and checking their answers. In designing and executing solution plans, students considered breaking down complex problems into more manageable parts, keeping in mind the underlying mathematical concepts and structures.

Despite the systematic approaches undertaken, students claimed to have encountered problem solving stumbling blocks such as difficulties in translating words into mathematical form, grappling with problem complexity, struggling with specific problem types, and experiencing language and comprehension issues. Memory issues and difficulty in retrieving prior knowledge were noted as detrimental to problem-solving efficiency, along with the inherent difficulty in verifying the accuracy of solutions. To navigate these difficulties, students utilized external resources such as multimedia aids, sought help from peers and educators, and emphasized critical role of consistent practice. The following are the participants' exact statements supporting the identified emerging themes.

4.3.1. Structured Approaches in Solving Word Problems

Participants P2 and P4, who possess proficient problem-solving skills, demonstrate an understanding of what a structured approach entails, specifying what to do in each step, whereas P6 has a somewhat generic notion.

P2: “I approach it by applying George Polya’s four steps in problem solving. These steps were taught to us by our instructor during the first semester wherein there are four steps to consider.”

P4: “And the last step is I double-checked it because if I committed a mistake in one aspect, then apparently all of my solution is considered wrong also.”

P6: “In typical word problems, I use a step-by-step process. First, I read and understand what is being asked.”

4.3.2. Perceived Ease and Difficulties

Coming from participants with average and low-level problem-solving competence, P4 identifies mathematical representation as a stumbling block in word problem solving, while P6 and P7 grapple with cognitive load, language, and problem structure.

P4: "I find it hard when dealing with word problems because it is quite hard to convert it into mathematical equations."

P6: "The most challenging part is probably the abundance of unnecessary information, and it's hard to filter out what is most important for the problem. Also, problems with many steps and formulas to memorize are difficult. It's challenging because it's hard to keep track, and it's easy to make mistakes."

P7: "For me, ma'am, in dealing with word problems, what I find difficult is the complex words used or terminologies used in mathematics. For example, the complicated terms used in naming figures. Also, the structure of the word problem and the formulas ma'am are quite difficult for me."

4.3.3. Strategies for Overcoming Problem-Solving Barriers

The strategies employed by students in overcoming problem-solving barriers include being organized, consulting knowledgeable individuals such as teacher and peers and utilizing ICT resources.

P1: "And then since I cannot understand the formula given to us, I approached our professor to ask her for clarifications and I ended up following through her instructions after drawing the diagram."

P2: "If it is a multi-step problem, I often write a plan before planning or solving to keep everything organized."

P3: "I browse on YouTube the concepts/topics that I don't understand and I want to get more information about it because there are several tutorial lessons on YouTube that gives an in-depth detail on how to solve. And after I watch the videos (with quizzes in the end), I try to answer so that if during examination time comes, it would be easier for me and I could manage my time."

P6: "If I really try to practice a lot, and if I get stuck in a part, I ask others for help or try to break it down. I break down the complicated parts until they become simple and no longer overwhelming."

4.4. Factors Hindering Word Problem-Solving Skills Development

Analysis of students' responses revealed factors that contribute to the perceived complexity of word problem-solving, as manifested by students across high to low levels of proficiency. Student-related hindering factors were attributed to inadequate achievement in mathematical proficiency, specifically in terms of conceptual understanding, procedural fluency, and strategic competence, as well as difficulties with mathematics language and the language of instruction. Students grappled with text comprehension where they have to navigate through the technical mathematics language embedded in the English language—the medium of instruction and their second language. Consequently, language barriers hinder the students' making sense of word problems, the words-into-equation process in translating concepts into mathematical expressions and statements during crucial stages of problem-solving process, and the choice of appropriate solution plan and formulas, resulting in students getting stuck and thereby losing interest in completing the task effectively.

External factors include problem structure and novelty, especially of non-routine problems, insufficient instructional time allotted for problem solving, inadequate teacher support due to teachers' uncooperative behavior, which results in less productive student-teacher interaction, and the lack of a supportive environment and resources from immediate learning spaces and home, due to socio-economic conditions. These encompassing factors underscore that word problem

proficiency is not solely determined by mathematical aptitude but is also considerably influenced by students' emotional states, past learning experiences, and broader environmental contexts.

The following are excerpts from students' responses reflecting their views on different factors hindering the development of their word problem proficiency.

4.4.1. Poor Conceptual Understanding and Procedural Fluency

Students across all levels of problem-solving proficiency identify their inability to mathematically make sense of the problem situation and make corresponding representations as one of the hindering factors in successful word problem solving.

P1: "I often get stuck when I try to turn the words into equations which I have mentioned before because it's really the part where I feel unsure if I'm interpreting the question correctly."

P4: "I really find it difficult ma'am if the problem is in sentence form. It's quite hard for me to understand because I felt like it's a very complicated problem."

P6: "The hardest part is probably understanding what exactly the problem is asking (...) The difficulty is more related to understanding the problem and translating it into mathematical expressions or representations."

4.4.2. Inadequate Strategic Competence

Strategic competence, one of the dimensions of mathematical proficiency after conceptual understanding and procedural fluency, plays a crucial role in problem-solving. Here, P5 and P7 trace the cause of difficulties from being confused or indecisive on what formula to use.

P5: One of the challenges I always encountered when I'm trying to decide what formula to use in a certain problem.

P7: "Yes, I understand the question or the given situation but when it comes to the part of planning on what formula to use or apply in solving the problem, it is where I often get stuck."

4.4.3. Language Difficulties

The persistent difficulty in problem solving emanates from language barrier. Students are hindered in trying to comprehend both the mathematics and English language

P4: "For me, the factors that hinder my ability to solve are the language and literacy skills, ma'am. In mathematics, there are times that I encounter some English words that are not familiar to me."

4.4.4. Problem Structure and Novelty

P4 considers problem structure and novelty, such as the case of routine and non-routine problems, which present obstacles in problem-solving.

P4: "And the other one is the cognitive load and problem structure because there are problems that are really difficult or hard to answer especially if it is not familiar to me or I haven't encountered or learned it before."

4.4.5. Insufficient Instructional Time

P3 is referring to insufficient time allotted to problem-solving in a typical mathematics class where getting a correct answer is all that matters rather than reflecting on the solution process.

P3: “Time constraints and testing pressure. Personally, I find word problems time-consuming since they require good reading comprehension, so limited time to solve the problem could really affect my ability to solve a word problem.”

4.4.6. Inadequate Teacher Support

For P8, teacher behavior and affective support can either make or break students' enthusiasm and confidence in problem-solving. For P2, teaching quality and student-teacher interaction are crucial in problem-solving.

P2: “Aside from these, I also consider the teacher-student interaction factors as a hindrance since it includes the quality of feedback (...) Without proper feedback, it's difficult to build confidence or fix misunderstanding before they affect future lessons.”

P8: “The last one is instructional factors (...) And when face-to-face classes resumed, I struggled more. For me, it felt like the teaching wasn't effective, because when I asked how to solve something, they gave me a different answer. And there was favoritism—teachers would only help the smart ones. Those of us who struggled weren't helped at all.”

4.4.7. Lack of Supportive Environment

Participants also recognize the role of available resources at home and the general supportive environment in the development of problem-solving skills.

P6: “And probably, the socioeconomic and environmental factors, because if your surroundings are not supportive, you lose confidence.”

5. Discussion

The study aimed to determine the extent of college students' achievement in word problem solving and to generate empirical insights on the varying levels of their problem-solving skills from their perceptions of the role of mathematical cognitive skills, adaptations made in problem-solving experience, and external factors influencing their problem-solving performance. By characterizing these variations in problem-solving ability levels in relation to mathematical cognition, the study highlights pedagogical implications that emphasize differentiated and targeted strategies to address the observed problem-solving deficits among low, average, and high-achieving problem solvers.

5.1. Discussion of Quantitative Results

College students generally achieved a fundamental level of word problem-solving proficiency in the context of targeted topics in the Mathematics in the Modern World course, confirming results of underperformance in some settings in ILSAs (OECD, 2023) and in field-specific studies (Aljura, 2025; Masjudin, 2020; Pentang, 2024). Specifically, college students demonstrated a developing level of proficiency in word problems involving patterns and sequences, indicating a transition stage approaching proficiency level but still requiring teacher assistance and external support for the transfer of understanding to new contexts. The students, however, showed considerable learning struggle with their beginning level of problem-solving ability in cases involving sets, relations and functions; recreational problems, and basic statistical applications. These results are consistent with the findings of Masjudin et al. (2020) placing the ability of students in explaining relations and functions, determining function value, and generating function equations in low category. Testa and Catena (2022) also noted that students have considerable difficulty in interpreting mathematical representations of algebraic relations. In a more proximate and familiar context, Pentang et al. (2024) reported that preservice teachers experienced moderate difficulty with problem-solving yet performed poorly in measurement, geometry, algebra, statistics, and probability. The underachievement in word problem-solving among college students is contrary to the generally

expected more advanced reasoning skills and learning habits among higher education students (Schneider & Preckel, 2017). It may indicate insufficient cognitive development on conceptual understanding and procedural fluency revealed by their inability to explain key concepts, interpret mathematical representations and apply them into targeted problem-solving contexts like statistics, recreational problems involving other fields of knowledge. Unlike intramathematical problem solving, word problem-solving requires students to apply mathematical concepts and procedures to specific situations, translating real-world scenarios into mathematical forms (Ogut et al., 2024).

Studies have also shown that association between cognitive abilities and mathematical proficiency tends to weaken with age from children to adolescents and adults (Molnar et al., 2013; Kievit et al., 2019) shedding light on the findings of the present and previous studies. The reason is that mathematics is taught systematically and practiced intensively at the elementary and lower secondary levels, but less so at the upper secondary and tertiary levels (Peng et al., 2019; Vandenbroucke, 2018). The study findings together with that of Cirillo and Hummer (2021) pointing out evident difference between the utilized and inherent mathematical knowledge stand between two opposing thoughts. One claims that previous knowledge and mathematical competence are directly associated (Achmetli et al., 2019; Mills, 2021; Süß & Kretzschmar, 2018) while the other contends on the lack of direct association between mastery of mathematical knowledge and competence in navigating through mathematical problems (Rocha & Babo, 2024).

On the other hand, problem-solving performance may also reflect past and recent learning experiences, student-teacher interactions, and environmental conditions such as educational technology, socioeconomic status, and parents' educational attainment contributing to the overall problem-solving performance (Amalina & Vidákovich, 2023; Loes & Pascarella, 2015; Lu & Xie, 2024; Soto-Ardila et al., 2022). Hence, to strategically enhance problem-solving skills among higher education students, institutions may integrate active, inquiry and context-based approaches; develop cognitive skills through reflective practice and explicit instruction on analyzing complex word problem structures; and establish a learning culture that cultivates a growth mindset, promotes collaborative learning, and leverages technology to create supportive environments that facilitate practice, feedback, and reflection on learning experiences.

5.2. Discussion of Qualitative Results and Meta-Inferences

Taking into account the students' specific perspectives provides meta-inferences for the varying levels of their word problem-solving skills and the interplay of factors shaping the development of these skills, positively or otherwise. College students across varying levels of problem-solving ability recognized mathematical cognitive skills as vital in problem-solving through the meaningful utilization of numerical ability such as number sense and logical reasoning, abstract thinking, working memory and domain specific prior knowledge; attention and focus; and text comprehension and general language facility.

College students with advanced problem-solving abilities are typically confident, organized, and focused. Their well-developed mathematical cognitive ability allows them to make estimates and verify results, perform mental calculations, identify relationships and patterns, translate concepts into mathematical models, and analyze and generate solutions by drawing on prior knowledge. These findings align with earlier studies indicating that strong mathematical skills, particularly problem-solving, are closely linked to higher working memory capacity—the ability to temporarily store and manipulate information during cognitive tasks and attentional abilities form the foundation of mathematical skills (Geary et al., 2017). Accordingly, high-performing problem-solvers are able to effectively integrate a range of cognitive skills in tackling mathematical tasks. Similarly, Barroso et al. (2021) and Hiltrimartin et al. (2025) demonstrated that higher levels of mathematical performance are associated with positive emotions or lower levels of anxiety, a relationship reflected in the

confident, stable, and focused behaviors observed among college students with strong problem-solving skills.

In navigating word problem-solving, high-achieving students have made meaningful use of what Schoenfeld (2016) identified as mathematics tools during problem-solving process: abstraction, symbolic representation, and symbolic manipulation. Consequently, they have proficient grasp of structured problem-solving approaches such as Polya's heuristics (Polya, 1945). They are mostly self-directed learners, seeking assistance only in comprehending challenging non-routine problems where a complex problem structure obstructs the solution process. This provides further evidence that successful problem-solvers follow structured strategies (Ahmed Khan et al., 2023; Pongsakdi et al., 2020; Ogut et al., 2024) in navigating through problem-solving tasks. Accordingly, students with high-level problem-solving abilities would benefit from learning activities that foster intellectual growth, motivation, and self-directed learning, with a pedagogical emphasis on strategic thinking, deep conceptual understanding, and precise and creative applications of knowledge and skills. They may further enhance their proficiency by leveraging systematic problem-solving and metacognitive awareness through developmental exploration of increasingly complex and varied contextualized word problems that require multi-stage applications of integrated concepts.

Students with an average level of problem-solving ability are also concerned with being organized and place an emphasis on understanding and procedural fluency in performing mathematical tasks. They apply estimations in calculations, check results, make connections and deductions, translate concepts into mathematical statements, and retrieve and apply prior knowledge. Unlike students with high-level cognitive and problem-solving proficiency, they sometimes rely on visualization for understanding and are hindered by past mistakes and general academic weaknesses, conveying diminished confidence and efficacy. They demonstrate functional but less organized grasp of Polya's heuristics by employing intermediate problem-solving approaches. They have facility in solving routine problems but struggle with non-routine problems involving unfamiliar abstract contexts and language structures; thus, seek peer assistance to arrive at solutions.

These findings highlighting on the awareness of college students on how to carry out mathematical tasks the way high-level problem-solvers do confirm what Özkubat and Özmenb (2021) point out that average-achieving mathematics learners leverage on metacognitive strategies—techniques that explain how students attempt to perform an assigned learning task (Schudmak, 2014)—during problem-solving activity. In most problem-solving practices, however, the metacognitive aspect is often overlooked, leaving average and low-achieving students to work independently (Özkubat & Karabulut, 2021). Özkubat and Özmenb (2021) further explain that this reliance on metacognition among average-achieving problem-solvers is because problem-solving is a metacognitive process founded on students' ability to manage their thoughts. Consequently, those with an average level of problem-solving skills may gain conceptual understanding and procedural fluency through diverse and systematic problem-solving experiences, as well as targeted support to address cognitive weaknesses through technology integration and metacognitive, reflective, and collaborative learning approaches. Consistent emphasis on problem-solving heuristics may strengthen their choice and use of approaches in dealing with contextualized word problems in a learning environment that promotes technology integration, cooperative, and integrative learning.

Students with low-level problem-solving proficiency have developing procedural fluency, and possess definition-based understanding of concepts. While they can make connections and deductions, they often resort to verbalizing their thoughts to arrive at an understanding due to difficulties in retrieving and transferring foundational knowledge. These learning inadequacies exacerbated by past mistakes diminish confidence and thus hinder realization of problem-solving abilities. This finding validates what Özkubat and Özmenb (2021) earlier pointed that low-achieving students rely on metacognitive knowledge and experience in dealing with mathematical cognitive

tasks. Mathematical knowledge constitutes what students know about what they know, while metacognitive experience depicts the internal and external conditions that influence students' actions (Akama, 2006; Sweeney, 2010). Hence, fostering the development of mathematical skills among low-achieving students entails assisting students in transitioning their metacognitive functioning from metacognitive knowledge and experience to metacognitive strategies.

Furthermore, low-achieving students manifested vague notion of problem-solving heuristics, mostly employing elementary problem-solving approaches. While they indicate ease in solving routine problems, dealing with non-routine, abstract, and unfamiliar problems require them to seek peer assistance and teacher confirmation. According to Butterworth (2019), low mathematics performance is related to low IQ as students struggle with mathematical tasks that require complex concepts and strategies such as word problem-solving. Consequently, these students struggle to identify relevant information, interpret problem statements, and design appropriate strategies in solving word problems (Aljura et al., 2025). Hence, for low-achieving students, the complexity of word problems obstructs the comprehension and solution process (Daroczy et al., 2015).

As conceptual understanding and related cognitive abilities are critical to successful problem-solving (Booth & Davenport, 2013; Goos & Kaya, 2020; Ji & Guo, 2023; Peng & Kievet, 2020; Peng et al., 2019), students with lower levels of problem-solving competence may benefit from strengthening their foundational conceptual understanding and procedural fluency through incremental contextualized and guided or structured inquiry-based learning activities that foster efficient recall and application of concepts and processes. Complementary targeted affective support, facilitated through metacognitive and reflective learning approaches, can further enhance students' confidence and problem-solving efficacy. Given the well-documented influence of memory and mathematics domain-specific prior knowledge (DPSK) on problem-solving (Amalina & Vidakovich, 2023; Mills, 2021; Molnar et al., 2013; Peng et al., 2016; Süß & Kretschmar, 2018), addressing the needs of students with limited proficiency requires prioritizing learning support to improve memory and information retrieval. Additionally, formalized and structured problem-solving exercises that strengthen their command of heuristics, language facility, and comprehension, while strategically integrating educational technologies within cooperative and integrative learning contexts, may further promote the development of foundational problem-solving skills.

Finally, the external factors hindering problem-solving abilities identified by students across varying levels of problem proficiency are attributed to incompatible teaching delivery and instructional practices with learning needs, a lack of affective teacher support and teaching quality, and a lack of learning opportunities and resources from the immediate environment outside the teaching-learning contexts. To offset the difficulties, the student resorted to accessing available online learning resources, peer learning, and consultations with teachers. Studies have shown the significance of teacher expectations (Soto-Ardilla et al., 2022), use of technological tools, teachers' scaffolding and guidance techniques, and peer collaboration (Filiz & Gur, 2025; Lu & Xie, 2024; Ngu & Phan, 2023) and overall quality of instruction (Vessonen et al., 2025) to have positive influence on problem-solving skills development. These interacting factors underscore that word problem proficiency is not solely determined by mathematical aptitude or cognitive capabilities but is also considerably influenced by students' emotional states, past learning experiences, and broader environmental contexts. Thus, within higher education, where cognitive development is closely tied to intellectual capital and sustainable development (Pedro et al., 2020), fostering environments that support intellectual growth (Zhoc et al., 2019) through problem-solving and other complex cognitive tasks stresses the need to strengthen educational technology integration, ensure access to sufficient learning materials, and promote collaborative learning spaces.

6. Further Implications to STEM Education and Limitations of the Study

The intersection of mathematical cognition and problem-solving, STEM education, and KSCs suggests that pedagogical integration of these competencies may find its grounding in instructional strategies, outcomes-based assessment, and professional development. Current literature identifies holistic or cross-curricular, holistic-pluralistic-action-oriented teaching, problem-based approach, real world exploration or experiential learning, place-based or community-based learning, role playing, inquiry-based learning, collaborative learning, and experiential learning (Di Biase et al., 2022; Sinakou et al., 2019; Sposab & Rieckmann, 2024) as relevant STEM education approaches. In the context of mathematics education, these approaches can be translated through guided and independent inquiry such as mathematical investigations, researches, and projects in real world settings where students take the opportunity to practice cognitive and problem-solving skills in an outcomes-based, collaborative, and authentic scenarios. Outcomes-based assessment, in both formative and summative forms, can be emphasized as a complementary strategy to sustainability teaching, providing feedback and enabling students to track and reflect on their learning progress. Moreover, fostering STEM oriented instruction can only begin systemic curricular reforms and innovations such as the inclusion of contextualized STEM skills as learning outcomes in courses. As teachers are key implementers of curricula, promoting the sustainable integration of STEM skills entails investing in professional development that focuses on developing their own STEM competencies through training and the provision of resources to effectively integrate these skills into their teaching.

The study acknowledges certain limitations regarding sampling coverage and representation in terms of other student characteristics such as academic achievement and learning experiences. Although restricting the sample to a single institution reduces potential confounding cultural factors and thereby allows for a more coherent and contextually proximate representation of the current situation, this design choice, while providing an in-depth explanation of the research results, constrains the generalizability of the major study findings. Limiting the investigation to one geographical setting also precludes broader representation, as students from other programs and institutions may hold different perspectives shaped by varied their academic practices, learning trajectories, and environmental influences. Future research should address these limitations by incorporating more diverse samples and by examining the influence of metacognitive and reflective approaches on mathematical problem-solving through large-scale predictive analyses or multivariate experimental designs.

7. Conclusion

The study underscores the investigation of cognitive and external factors that explain the varying levels of problem-solving ability of college students. College students generally demonstrated fundamental level of word problem-solving skills, highlighting the inherent difficulty in navigating the complex cognitive process of mathematical problem-solving. Findings show that variations in students' problem-solving abilities are shaped by differences in cognitive development, the degree to which instructional practices address their learning needs, the quality of teaching and affective support provided, and the accessibility of external learning opportunities and resources. These varying levels in ability likewise influence the problem-solving approaches undertaken, the perception of the nature of difficulties encountered, and the practical, cognitive and metacognitive strategies employed to surmount problem-solving barriers. While students recognize the crucial role of number sense, logical reasoning, abstract thinking, attention, mathematical domain-specific prior knowledge, and language facility, the prevalence of hindering factors suggests that mathematical cognitive skills alone do not decisively translate into successful word problem-solving. The varying levels of word problem-solving skills require strategic and differentiated pedagogical interventions

that leverage existing cognitive and problem-solving proficiencies to optimize instruction. In higher education, where academic growth is expected to align with intellectual capital and sustainable development, fostering problem-solving skills and STEM competencies can be better approached through a systemic interplay of cognitive skills enhancement, effective learning practices, and the provision of supportive learning spaces via the strategic use of technology-based, collaborative, reflective, and integrative teaching approaches.

Declarations

Author Contributions. RMR: Conceptualization, instrumentation, data gathering and analysis procedures; original manuscript preparation; JVP: Conceptualization, review of literature, validation, supervision, review-editing and writing. All authors have read and approved the final version of the article.

Conflicts of Interest. The authors declare no conflict of interest.

Funding. The study received no funding.

Ethical Approval. The research committee of the college approved the study's conduct, giving careful consideration to ethical research standards. Participation was voluntary, and participants provided informed consent prior to data collection.

Data Availability Statement. The data gathered from the study are available upon reasonable request from the authors.

Acknowledgments. The authors acknowledge the suggestions of their colleagues for the improvement of the study. Special thanks are extended to the anonymous peer reviewers who shared generous insights to improve the manuscript.

References

- Achmetli, K., Schukajlow, S., & K. Rakoczy, K. (2019). Multiple solutions for real-world problems, experience of competence and students' procedural and conceptual knowledge. *International Journal of Science and Mathematics Education*, 17, 1605-1625, <https://doi.org/10.1007/s10763-018-9936-5>
- Ahmed Khan, Z., Adnan, J., & Adnan Raza, S. (2023). Cognitive learning theory and development: Higher education case study. *IntechOpen*. <https://doi.org/10.5772/intechopen.110629>
- Akama, K. (2006). Relations among self-efficacy, goal setting, and metacognitive experiences in problem-solving. *Psychological Reports*, 98, 895-907. <https://doi.org/10.2466/PRO.98.3.895-907>
- Aljura, A. N., Retnawati, H., Dewanti, S. R., Kassymova, G. K., Sotlikova, R., & Septiana, A. R. (2025). Mathematical reasoning and communication word problems with mathematical problem-solving orientation: A relation between the skills. *Journal on Mathematics Education*, 16(2), 529–558. <https://doi.org/10.22342/jme.v16i2.pp529-558>
- Amalina, I., & Vidakovich, T. (2023). Cognitive and socioeconomic factors that influence the mathematical problem-solving skills of students. *Heliyon*, 9(9). <https://doi.org/10.1016/j.heliyon.2023.e19539>
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. W.H. Freeman & Co.
- Barroso, C., Ganley, C., McGraw, A., Geer, E., Hart, S., & Daucourt, M. (2021). A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin*, 147, 134–68. <https://doi.org/10.1037/bul0000307>

- Boonen, A., de Koning, B., Jolles, J., & Van der Schoot, M. (2016). Word problem solving in contemporary math education: a plea for reading comprehension skills training. *Frontiers in Psychology*, 7, 191. <https://doi.org/10.3389/fpsyg.2016.00191>
- Booth, J. L., & Davenport, J. L. (2013). The role of problem representation and feature knowledge in algebraic equation-solving. *Journal of Mathematical Behavior*, 32(3), 415-423, <https://doi.org/10.1016/j.jmathb.2013.04.003>
- Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. Sage Publications.
- Butterworth, B. (2019). *Dyscalculia: From science to education*. Routledge. <https://doi.org/10.4324/9781315538112>
- Chinn, S. (2021). *Mathematics learning difficulties, dyslexia and dyscalculia*. Routledge.
- Cirillo, M., & Hummer, J. (2021). Competencies and behaviors observed when students solve geometry proof problems: An interview study with smartpen technology. *ZDM—Mathematics Education*, 53, 861-875, <https://doi.org/10.1007/s11858-021-01221-w>
- Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons.
- Colorafi, K. J., & Evans, B. (2016). Qualitative descriptive methods in health science research. *Health Environments Research & Design Journal*, 9, 16-25. <https://doi.org/10.1177/1937586715614171>
- Commission on Higher Education (CHED). (2013, June 28). *CHED memorandum order no. 20, series of 2013*. CHED. ched.gov.ph
- Cragg, L., & Gilmore, C. (2018). Skills underlying mathematics: The role of executive function in the development of mathematics proficiency. *Trends in Neuroscience and Education*, 3(2), 63-68. <https://www.sciencedirect.com/science/article/pii/S2211949313000422>
- Creswell, J., & Plano Clark, V. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage.
- Daroczy, G., Meurers, D., Heller, J., Wolska, M., & Nürk, H. C. (2015). The interaction of linguistic and arithmetic factors affects adult performance on arithmetic word problems. *Cognitive Processes*, 21(1), 105-125. <https://doi.org/10.1007/s10339-019-00948-5>
- Di Biase, R., Malatesta, S., & Schmidt di Friedberg, M. (2022). Promoting education for sustainable development in the Maldives: Exploring the link between theory and practice. *Prospects*, 52, 529–544. <https://doi.org/10.1007/s11125-021-09558-6>
- Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology*, 7, 508. <https://doi.org/10.3389/fpsyg.2016.00508>
- Eberz, S., Lang, S., Breitenmoser, P., & Niebert, K. (2023). Taking the lead into sustainability: Decision makers' competencies for a greener future. *Sustainability*, 15, 4986. <https://doi.org/10.3390/su15064986>
- Emslander, V., & Scherer, R. (2022). The relation between executive functions and math intelligence in preschool children: A systematic review and meta-analysis. *Psychological Bulletin*, 148(5-6), 337–369. <https://doi.org/10.1037/bul0000369>
- Ernest, P. (2010). Reflections on theories of learning. In B. Sriraman & L. English (Eds.), *Theories of mathematics education: Seeking new frontiers* (pp. 39-47). Springer. https://doi.org/10.1007/978-3-642-00742-2_4

- Fatmanissa, N., & Novianti, M. N. (2022). Linguistic challenges in solving mathematics word problems: A case of EFL university students. In *Eighth Southeast Asia Design Research (SEA-DR) & the Second Science, Technology, Education, Arts, Culture, and Humanity (STEACH) International Conference (SEADR-STEACH 2021)* (pp. 16-23). Atlantis Press. <https://doi.org/10.2991/assehr.k.211229.003>
- Filiz, A., & Gür, H. (2025). Students' Perceptions and Applications of Metacognitive Awareness Levels in Problem Solving with ChatGPT. *Educational Process: International Journal*, 14, e2025063. <https://doi.org/10.22521/edupij.2025.14.63>
- Fraenkel, J., Wallen, N., & Hyun, H. (2012). *How to design and evaluate research in education* (8th ed.) McGraw-Hill.
- Gamazo, A., & Martinez-Abad, F. (2020). An exploration of factors linked to academic performance in PISA 2018 through data mining techniques. *Frontiers in Psychology*, 11, 575167. <https://doi.org/10.3389/fpsyg.2020.575167>
- Geary, D. C., Nicholas, A., Li, Y., & Sun, J. (2017). Developmental change in the influence of domain-general abilities and domain-specific knowledge on mathematics achievement: An eight-year longitudinal study. *Journal of Educational Psychology*, 109, 680–93. <https://doi.org/10.1037/edu0000159>
- Gilmore, C., Göbel, S. M., & Inglis, M. (2022). *An introduction to mathematical cognition*. Routledge. <https://doi.org/10.4324/9781315684758>
- Goos, M., & Kaya, S. (2020). Understanding and promoting students' mathematical thinking: A review of research published in ESM. *Educational Studies in Mathematics*, 103, 7-25. <https://doi.org/10.1007/s10649-019-09921-7>
- Greenfield, E. A., & Moorman, S. M. (2019). Childhood socioeconomic status and later life cognition: Evidence from the Wisconsin longitudinal study. *Journal of Aging and Health*, 31(9), 1589-1615. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6478570/>
- Hannell, G. (2005). *Dyscalculia*. David Fulton Publishers Ltd.
- Hiltrimartin, C., & Pratiwi, W. (2025). Problem-solving skills among students on the topic of derivatives: Differences in the changes of achievement emotions. *EURASIA Journal of Mathematics, Science and Technology Education*, 21(6), em2645. <https://doi.org/10.29333/ejmste/16504>
- Ji, Z., & Guo, K. (2023). The association between working memory and mathematical problem solving: A three-level meta-analysis. *Frontiers in Psychology*, 14, 1091126. <https://doi.org/10.3389/fpsyg.2023.1091126>
- Karakolidis, A., Pitsia, V., & Emvalotis, A. (2016). Examining students' achievement in mathematics: a multilevel analysis of the programme for international student assessment (PISA) 2012 data for Greece. *International Journal of Educational Research* 79, 106–115. <https://doi.org/10.1016/j.ijer.2016.05.013>
- Kievit, R. A., Hofman, A. D., & Nation, K. (2019). Mutualistic coupling between vocabulary and reasoning in young children: A Replication and extension of the study by Kievit et al. (2017). *Psychological Science*, 30(8), 1245–1252. <https://doi.org/10.1177/0956797619841265>
- Lazarevic, L. B., & Orlic, A. (2018). PISA 2012 mathematics literacy in Serbia: A multilevel analysis of students and schools. *Psihologija*, 51, 413–432. <https://doi.org/10.2298/PSI170817017L>

- Lee, K., Ng, E. L., & Ng, S. F. (2019). The contributions of working memory and executive functioning to problem representation and solution generation in algebraic word problems. *Journal of Educational Psychology, 101*(2), 373–387. <https://doi.org/10.1037/a0013843>
- Loes, C. N., & Pascarella, E. T. (2015). The benefits of good teaching extend beyond course achievement. *Journal of the Scholarship of Teaching and Learning, 15*(2), 1-13. <https://doi.org/10.14434/josotl.v15i2.13167>
- Lu, D., & Xie, Y. (2024). The application of educational technology to develop problem-solving skills: A systematic review. *Thinking Skills and Creativity, 51*, 101454. <https://doi.org/10.1016/j.tsc.2023.101454>
- Masjudin, M., Muzaki, A., Abidin, Z., & Ariyanti, A. (2020). *Journal of Physics: Conference Series, 1521*, 032063. <https://doi.org/10.1088/1742-6596/1521/3/032063>
- Miller, P. H. (2011). Piaget's theory: Past, present, and future. In U. Goswami (Ed.), *The Wiley-Blackwell handbook of childhood cognitive development* (2nd ed.). Wiley Blackwell. <https://psycnet.apa.org/record/2010-22950-025>
- Mills, N. J. D. (2021). ALEKS constructs as predictors of high school mathematics achievement for struggling students. *Heliyon, 7*(6). <https://doi.org/10.1016/j.heliyon.2021.e07345>
- Molnár, G., Greiff, S., & B. Csapó, B. (2013). Inductive reasoning, domain specific and complex problem solving: Relations and development. *Thinking Skills and Creativity, 9*, 35-45, <https://doi.org/10.1016/j.tsc.2013.03.002>
- National Research Council. (2001). *Adding it up: Helping children learn mathematics*. The National Academies Press. <https://doi.org/10.17226/9822>
- Ngu, B. H., & Phan, H. P. (2023). Differential instructional effectiveness: Overcoming the challenge of learning to solve trigonometry problems that involved algebraic transformation skills. *European Journal of Psychology of Education, 38*(4), 1505–1525. <https://doi.org/10.1007/s10212-022-00670-5>
- Ngu, B. H., & Phan, H. P. (2016). Comparing balance and inverse methods on learning conceptual and procedural knowledge in equation solving: A cognitive load perspective. *Pedagogies: An International Journal, 11*(1), 63–83. <https://doi.org/10.1080/1554480X.2015.1047836>
- Nguyen, H. A., Guo, Y., Stamper, J., & McLaren, B. M. (2020). Enhancing Students' Problem-Solving Flexibility in Non-Routine Mathematics In I. Bittencourt, M. Cukurova, K. Muldner, R. Luckin, & E. Millán (Eds), *Artificial Intelligence in Education* (409-413). Springer. https://doi.org/10.1007/978-3-030-52240-7_74
- Novak, E., & Tassell, J. L. (2017). Studying preservice teacher math anxiety and mathematics performance in geometry, word, and non-word problem solving. *Learning and Individual Differences, 54*, 20–29. <https://doi.org/10.1016/j.lindif.2017.01.005>
- OECD. (2023). *PISA 2022 results (Volume 1): The state of learning and equity in education*. OECD Publishing.
- OECD. (2019). *Country note: PISA result 2018(Philippines)*. OECD Publishing.
- Ogut, B., Webb, B., Hicks, J., Circi, R., & Yin, M. (2024). Exploring mathematical problem-solving through process mining: Insights from large-scale assessment log data. *Computers in the Schools, 1*–31. <https://doi.org/10.1080/07380569.2024.2416422>

- Özkubat, U., & Karabulut, A. (2021). Cognitive strategy instruction for mathematical problem solving. In Kargin, T. Güldenöğlü, B. İ. (Eds), *Teaching Mathematics in Special Education* (pp. 142–171). Pegem Academy Publishing.
- Özkubat, U., & Özmenb, E. R. (2021). Investigation of effects of cognitive strategies and metacognitive functions on mathematical problem solving performance of students with or without learning disabilities. *International Electronic Journal of Elementary Education*, 13(4), 443-456. <https://doi.org/10.26822/iejee.2021.203>
- Pedro, E., Leitão, J., & Alves, H. (2020). Stakeholders' Perceptions of Sustainable Development in Higher Education Institutions: An Intellectual Capital Approach. *International Journal of Sustainability in Higher Education*, 21(5), 911-942. <https://doi.org/10.1108/IJSHE-01-2020-0030>
- Peng, P., & Kievit, R. (2020). The development of academic achievement and cognitive abilities: A bidirectional perspective. *Child Development Perspectives*, 14(1). <https://doi.org/10.1111/cdep.12352>
- Peng, P., Namkung, J., Barnes, M., & Sun, C. (2016). A meta-analysis of mathematics and working memory: Moderating effects of working memory domain, type of mathematics skill, and sample characteristics. *Journal of Educational Psychology*, 108(4), 455–473. <https://doi.org/10.1037/edu0000079>
- Peng, P., Wang, T., Wang, C., & Lin, X. (2019). A meta-analysis on the relation between fluid intelligence and reading/mathematics: Effects of tasks, age, and social economics status. *Psychological Bulletin*, 145, 189–236. <https://doi.org/10.1037/bul0000182>
- Pentang, J. T., Andrade, L. J. T., Golben, J. C., Talua, J. P., Bautista, R. M., Sercenia, J. C., Permatasari, D., Bucad, Jr., M. L., & Viernes, M. D. D. (2024). Problem-solving difficulties, performance, and differences among preservice teachers in Western Philippines University. *The Palawan Scientist*, 16(1), 58-68. <https://doi.org/10.69721/TPS.J.2024.16.1.07>
- Piaget, J. (1950). *The psychology of intelligence*. Routledge. <https://doi.org/10.4324/9780203981528>
- Polya, G. (1945). *How to solve it: A new aspect of mathematical method*. Princeton University Press. <https://doi.org/10.2307/j.ctvc773pk>
- Pongsakdi, N., Kajamies, A., Veermans, K., Lertola, K., Vauras, M., & Lehtinen, E. (2020). What makes mathematical word problem solving challenging? Exploring the roles of word problem characteristics, text comprehension, and arithmetic skills. *ZDM–Mathematics Education*, 52, 33–44. <https://doi.org/10.1007/s11858-019-01118-9>
- Rittle-Johnson, B., Star, J. R., & Durkin, K. (2017). The power of comparison in mathematics instruction: Experimental evidence from classrooms. In D. C. Geary, D. B. Berch, & K. M. Koepke (Eds.), *Ngu and Phan Mathematical cognition and learning: Acquisition of complex arithmetic skills and higher-order mathematics concepts* (pp. 273–295). Elsevier. <https://doi.org/10.1016/B978-0-12-805086-6.00012-6>
- Rocha, H., & Babo, A. (2024). Problem-solving and mathematical competence: A look to the relation during the study of linear programming. *Thinking Skills and Creativity*, 51, 101461. <https://doi.org/10.1016/j.tsc.2023.101461>
- Rocha, H., Viseu, F., & Matos, S. (2024). Problem-solving in a real-life context: An approach during the learning of inequalities. *European Journal of Science and Mathematics Education*, 12(1), 21-37. <https://doi.org/10.30935/scimath/13828>

- 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>
- Schoenfeld, A. H. (2016). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics (Reprint). *Journal of Education*, 196, 1-38. <https://doi.org/10.1177/002205741619600202>
- Schudmak, W. (2014). Metacognitive strategies employed during mathematical problem solving: a comparative case study of fifth graders who are gifted and have ADHD. [Doctoral dissertation, George Mason University].
- Shaw, S. R. (2022). *Reaching and teaching students who don't qualify for special education: Strategies for the inclusive education of diverse learners* (1st ed). Routledge. <https://doi.org/10.4324/9781003133896>
- Simamora, R. E., & Saragih, S. (2019). Improving students' mathematical problem-solving abilities and self-efficacy through guided discovery learning in a local cultural context. *International Electronic Journal of Mathematics Education*, 14(1), 61-72. <https://doi.org/10.12973/iejme/3966>
- Sinakou, E., Donche, V., Boeve-de Pauw, J., & Van Petegem, P. (2019). Designing powerful learning environments in education for sustainable development: A conceptual framework. *Sustainability*, 11, 5994. <https://doi.org/10.3390/su11215994>
- Snowling, M., & Hulme, C. (2021). *The Science of reading: A handbook* (2nd ed.). Wiley-Blackwell.
- Soto-Ardila, L. M., Caballero-Carrasco, A., & Casas-García, L. M. (2022). Teacher expectations and students' achievement in solving elementary arithmetic problems. *Heliyon*, 8(5). <https://doi.org/10.1016/j.heliyon.2022.e09447>
- Spencer, M., Fuchs, L. S., & Fuchs, D. (2020). Language-related longitudinal predictors of arithmetic word problem solving: A structural equation modeling approach. *Contemporary Educational Psychology*, 60. <https://doi.org/10.1016/j.cedpsych.2019.101825>
- Spiegel, J. A., Goodrich, J. M., Morris, B. M., Osborne, C. M., & Lonigan, C. J. (2021). Relations between executive functions and academic outcomes in elementary school children: A meta-analysis. *Psychological Bulletin*, 147(4), 329–351. <https://doi.org/10.1037/bul0000322>
- Sposab, K., & Rieckmann, M. (2024). Development of sustainability competencies in secondary school education: A scoping literature review. *Sustainability*, 16(23), 10228. <https://doi.org/10.3390/su162310228>
- Süß, H. M., & Kretzschmar, A. (2018). The Impact of Cognitive Abilities and Prior Knowledge on Complex Problem-Solving Performance: Empirical Results and a Plea for Ecologically Valid Microworlds. *Frontiers in Psychology*, 9, 1-22. <https://doi.org/10.3389/fpsyg.2018.00626>
- Sweeney, C. M. (2010). The metacognitive functioning of middle school students with and without learning disabilities during mathematical problem solving. [Doctoral dissertation, University of Miami].
- Szabo, Z. K., Körtesi, P., Guncaga, J., Szabo, D., & Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability*, 12(23), 10113. <https://doi.org/10.3390/su122310113>

- Tatto, M. T. (2013). *Teacher education and development study in mathematics (TEDS-M): Policy, practice, and readiness to teach primary and secondary mathematics. Technical Report*. International Association for the Evaluation of Educational Achievement.
- Teplá, M., & Distler, P. (2025). The impact of long-term inquiry-based science education on students' motivation and knowledge acquisition: The role of gender, subject, and level of inquiry. *Palgrave Communications*, 12(1), 1-12, <https://doi.org/10.1057/s41599-025-04437-3>
- Terwee, C., Bot, S., de Boer, M., van der Windt, D., Knol, D., Dekker, J., Bouter, L., & de Vet, H. (2007). Quality criteria were proposed for measurement properties of health status questionnaires. *Journal of Clinical Epidemiology*, 60(1), 34 – 42. <https://doi.org/10.1016/j.jclinepi.2006.03.012>
- Testa, I., & Catena, D. (2022). High school students' performances in transitions between different representations of linear relationships in mathematics and physics. *Education Sciences*, 12(11), 776. <https://doi.org/10.3390/educsci12110776>
- Tchoshanov, M., & Monarrez, A. (2024). Analyzing teacher-designed tasks through the lens of procedural and conceptual knowledge. *Canadian Journal of Science, Mathematics and Technology Education*, 24, 23–38. <https://doi.org/10.1007/s42330-024-00319-z>
- Tourón, J., López-González, E., Lizasoain-Hernández, L., García-San Pedro, M. J., & Navarro-Asencio, E. (2018). Spanish high and low achievers in science in PISA 2015: Impact analysis of some contextual variables. *Revista de Educacion*, 380, 156–184. <https://doi.org/10.4438/1988-592X-RE-2017-380-376>
- Tursynkulova, E., Madiyarov, N., Sultanbek, T., & Duysebayeva, P. (2023). The effect of problem-based learning on cognitive skills in solving geometric construction problems: A case study in Kazakhstan. *Frontiers in Education*, 8. <https://doi.org/10.3389/feduc.2023.1284305>
- Vandenbroucke, L., Spilt, J., Verschueren, K., Piccinin, C., & Baeyens, D. (2018). The classroom as a developmental context for cognitive development: A meta-analysis on the importance of teacher–student interactions for children's executive functions. *Review of Educational Research*, 88, 125–164. <https://doi.org/10.3102/0034654317743200>
- Verschaffel, L., Schukajlow, S., Star, J., & Van Dooren, W. (2020). Word problems in mathematics education: A survey. *ZDM-Mathematics Education*, 52(1), 1–16. <https://doi.org/10.1007/s11858-020-01130-4>
- Vessonen, T., Hellstrand, H., Kurkela, M., Aunio, P., & Laine, A. (2025). The effectiveness of mathematical word problem-solving interventions among elementary schoolers: A systematic review and meta-analysis. *International Journal of Educational Research*, 132, 102642. <https://doi.org/10.1016/j.ijer.2025.102642>
- von Davier, M., Kennedy, A., Reynolds, K., Fishbein, B., Khorramdel, L., Aldrich, C., 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, X., Perry, L., Malpique, A., & Ide, T. (2023). Factors predicting mathematics achievement in PISA: A systematic review. *Large-scale Assessments in Education*, 11, 24. <https://doi.org/10.1186/s40536-023-00174-8>
- Weaver, K. (2018). Pragmatic paradigm. In *The SAGE encyclopedia of educational research, measurement, and evaluation* (Vol. 4, pp. 1287-1288). SAGE Publications, Inc., <https://doi.org/10.4135/9781506326139.n534>

- Xie, F., Zhang, L., Chen, X., & Xin, Z. (2020). Is spatial ability related to mathematical ability: A meta-analysis. *Educational Psychology Review*, 32(1), 113–155. <https://doi.org/10.1007/s10648-019-09496-y>
- Yusoff, A. S. M., Durairaj, K., Mohamed, R., Peng, F. S., Abdullah, N., Ismail, H., Salleh, S. M., & Wahid, Z. (2022). Communication in mathematics among school children: A systematic review. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 28(2), 275–290. <https://doi.org/10.37934/araset.28.2.275290>
- Zhoc, K. C., Webster, B. J., King, R. B., Li, J. C., & Chung, T. S. (2019). Higher education student engagement scale (HESES): Development and psychometric evidence. *Research in Higher Education*, 60, 219–244. <https://doi.org/10.1007/s11162-018-9510-6>
- Zhu, H., Zhang, J., Li, H., Huang, B., Feng, H., Liu, C., & Si, J. (2024). Independent and joint effects of perceived teacher support and math self-efficacy on math achievement in primary school student: Variable-oriented and person-oriented analyses. *Learning and Individual Differences*, 112, 102445. <https://doi.org/10.1016/j.lindif.2024.102445>

About the Contributor(s)

Rica Mae D. Rio, MA Mathematics, is a lecturer at the Computer Science Department of the College of Education, Arts and Sciences at Capiz State University-Pontevedra, Philippines.

Email: rmdrio@capsu.edu.ph

ORCID: <https://orcid.org/0009-0004-9482-0698>

Judel V. Protacio, PhD, is a professor and presently the dean of the College of Education, Arts and Sciences at Capiz State University-Pontevedra, Philippines. His research interest is in mathematics and teacher education.

Email: jyprotacio@capsu.edu.ph

ORCID: <https://orcid.org/0000-0003-0468-4166>

Publisher's Note: The opinions, statements, and data presented in all publications are solely those of the individual author(s) and contributors and do not reflect the views of Universitepark, EDUPIJ, and/or the editor(s). Universitepark, the Journal, and/or the editor(s) accept no responsibility for any harm or damage to persons or property arising from the use of ideas, methods, instructions, or products mentioned in the content.
