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Polya's Problem Solving Approach (PPSA): A Study on Improving Academic Achievement and Attitude Among Struggling Learner

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Abstract

This study investigated the effectiveness of Polya's Problem-Solving Approach (PPSA) in enhancing the academic achievement and attitudes of struggling learners in mathematics. Conducted among 90 first-year BS Criminology students enrolled in Mathematics in the Modern World at North Eastern Mindanao State University – Cantilan Campus, the research employed a quasi-experimental design using pretest and posttest assessments, along with attitude surveys, were used to measure academic achievement and attitude towards mathematics. The experimental group was taught using PPSA integrated with cognitive heuristic strategies, while the control group received a traditional, teacher-centered method. Results revealed that students exposed to PPSA showed significantly greater academic performance improvement than the control group. Although both groups displayed generally positive attitudes toward mathematics, the experimental group demonstrated slightly higher levels of engagement and persistence. Statistical analysis confirmed that the teaching method significantly influenced academic performance, while students' initial mathematical ability levels had no significant effect. The findings underscore the potential of PPSA as an inclusive and effective instructional strategy to support struggling learners and improve their mathematical skills and attitudes.

Keywords: Polya's Problem-Solving Approach, Struggling learners, Cognitive heuristics, Conventional method

Introduction

Problem-solving is essential for students' academic performance and general cognitive development. Effective problem-solving techniques are difficult for many students to use, especially those who have challenges with mathematical and other analytical courses. Polya's Problem-Solving Approach, developed by mathematician George Polya, consists of four key steps: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. This structured method provides learners with a clear framework for tackling complex issues, encouraging logical thinking and persistence. By guiding students through a systematic approach to problem-solving, PPSA aims to improve their ability to solve mathematical problems and foster a more positive attitude toward learning and overcoming challenges. This study evaluates the effectiveness of Polya's Problem-Solving Approach (PPSA) in enhancing the academic performance and attitudes of struggling learners in mathematics.

Targeting students with low achievement and negative perceptions toward the subject, the study aims to determine whether a structured, four-step problem-solving framework can significantly improve their understanding and confidence. Ultimately, the study seeks to provide empirical evidence on the value of PPSA as an instructional tool that supports cognitive development and affective growth among learners facing academic challenges.

Several researchers show that Polya's Problem-Solving Approach (PPSA) effectively improves students' problem-solving skills, critical thinking, and overall mathematics performance. Studies have demonstrated its benefits in statistics and College Algebra, enhancing comprehension and fostering positive attitudes [4, 46]. Additionally, Sosa et al. (2024) found a strong link between critical analysis skills and success in trigonometry. These findings suggest that PPSA can enhance academic performance and student attitudes in college-level mathematics.

Limited research addresses precisely the mathematical problem-solving skills and attitude of struggling students using Polya's 4-step problem-solving approach. Many Filipino students struggle with mathematics, with over 50% scoring below Level 1 in the 2018 PISA exam [8]. These challenges stem from anxiety, learning inequalities, and competency gaps (Dagaylo & Tancinco, 2016). In NEMSU Cantilan, among 893 students enrolled in "Mathematics in the Modern World" for the First Semester A.Y. 2023-2024 in the Criminology program, approximately 47% (424 students) were identified as struggling based on their final grades taken from the secondary data from the respective Instructors. This situation presents a challenge in determining effective intervention strategies to reduce the number of struggling students.

This study aimed to assess the effectiveness of Polya's Problem-Solving Approach (PPSA) in enhancing academic achievement and attitudes among struggling learners. By incorporating PPSA into the classroom, the researcher aims to assist students in improving their problem-solving skills, positive attitude, and overall academic performance toward mathematics. Based on the findings of this study, an intervention strategy was proposed to help improve the overall academic performance of struggling students in mathematics.

LITERATURE REVIEW

Problem-solving in mathematics fosters critical, creative, and logical thinking, enhances organizational skills, promotes intellectual engagement, and helps learners make sense of the world [20]. Polya's (1945) four-step approach—understanding the problem, devising a plan, carrying out the plan, and looking back—remains a cornerstone in teaching problem-solving. This framework has been validated in recent studies: Jahudin and Siew (2024) found it improved seventh graders' algebraic thinking when paired with digital tools; Dayo et al. (2024) showed its effectiveness in gamified lessons; and Nguyen et al. (2023) noted its success in high school physics. Banawi et al. (2024) also confirmed a strong positive correlation between problem-solving skills and academic achievement. Despite these findings, challenges persist: McLoughlin et al. (2022) highlighted curricular discontinuities in math education, while Deieso and Fraser (2019) and Klee and Miller (2019) emphasized the negative impact of mathematics anxiety on cognitive performance. Similarly, Jiang et al. (2020) noted that anxiety leads to rigid problem-solving strategies. Ukobizaba et al. (2021) pointed out gaps in applying math knowledge across contexts and the lack of effective evaluation methods. Their review of literature supported using various assessment strategies—such as performance-based, dynamic, and game-based assessments—alongside active learning approaches to enhance problem-solving skills. Zakariya (2022) stressed the

role of self-efficacy and emotional stability in students' mathematical success. According to DepEd Order No. 021, s. 2019, math and problem-solving are crucial for scientific literacy and daily life. Although countries like Japan, Korea, and Estonia excel in this area, Filipino students continue to underperform in application tasks, as reflected in the 2018 PISA results [35, 36, 37]. Skovsmose et al. (2023) emphasized the teacher's role in nurturing critical thinkers who can use mathematics for societal participation.

Several recent studies emphasize the critical role of students' attitudes and instructional strategies in enhancing mathematical problem-solving skills. Wakhata et al. (2024) revealed a significant link between students' attitudes and their performance in mathematical word problems, while Abdullah et al. (2022) highlighted how self-concept and emotional intelligence influence problem-solving approaches in algebra. Wakhata et al. (2023) further stressed that active learning strategies improve attitudes toward mathematics, enhancing achievement.

However, Makwakwa et al. (2023) found that students often fail to fully engage in Polya's problem-solving stages, particularly in the later steps, indicating a need for persistence and deeper engagement. This aligns with Polya's (1973) assertion that successful problem-solving involves understanding the problem, devising a plan, executing it, and reflecting on the process. Zakariah (2022) added that mathematics anxiety, often mistaken as a lack of ability, poses both emotional and cognitive challenges.

In the Philippines, Garzon (2023) observed that many Filipino junior high students under-performed in problem-solving due to weak conceptual understanding and external influences such as teacher and school factors. Similarly, Samosir et al. (2023) and Siniguian identified student difficulties in applying relational understanding to statistical problems, especially during the execution and review stages of Polya's method. Bernardo et al. (2022) found that external factors like family support and school resources had more impact on performance than innate ability. Albay (2020) demonstrated the effectiveness of collaborative problem-solving strategies in improving college students' performance and attitudes toward algebra. Supporting this, studies by Sauro (2024), Moneva et al. (2020), and Macaso & Dagohoy (2022) confirmed that a positive attitude significantly enhances problem-solving and critical thinking. Obiano and Parangat (2023) also validated the effectiveness of Polya's theory across various student demographics, while Amilin and Arriola (2023) confirmed that students exposed to Polya's Problem Solving Strategy (PPSS) significantly improved their competence in solving worded problems compared to those using traditional methods. Collectively, these studies advocate for integrating attitude-building, structured strategies, and contextual awareness into mathematics education.

METHODOLOGY

The research employed a quasi-experimental design incorporating both descriptive and inferential statistics to determine the impact of PPSA on academic achievement and attitudes. The subject of the study consisted of 90 first-year BS Criminology students who were purposively and randomly assigned into experimental and control groups. Instruction for the experimental group was conducted using PPSA embedded with cognitive heuristic techniques, while the control group received traditional lecture-based teaching. Participants completed a pretest and posttest consisting of 50 multiple-choice items related to the midterm topics in Mathematics in the Modern World. Additionally, students' attitudes toward mathematics were assessed using a 5-point Likert-scale questionnaire grounded in the ABC Model of Attitude (Affective, Behavioral, Cognitive). Data analysis involved using mean scores, standard

deviation, t-tests, ANOVA, and ANCOVA to assess differences in performance and interactions between variables.

RESULTS

Table 1. Distribution of Respondents' Mathematical Ability Level based on Senior High School Grade

SHS Grading Scale	EXPERIMENTAL	CONTROLLED	Mathematical Ability (Description)
80-84	12	12	Satisfactory
85-89	21	20	Very Satisfactory
90-100	12	13	Outstanding
Total	45	45	

The findings showed that the mathematical abilities of the Experimental and Controlled groups are closely aligned, with similar distributions across the Satisfactory, Very Satisfactory, and Outstanding categories. Both groups demonstrate comparable academic performance based on their Senior High School grades.

Table 2. Pretest and Post-test Mean Scores of the Students using the Two Methods of Teaching

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	18.49	5.27697	32.64	4.14046
Control	17.38	4.04120	22.20	3.55221

Based on the table above, results revealed that while both the experimental and control groups started with similar levels of prior knowledge, the students taught using Polya's Problem-Solving Approach (PPSA) demonstrated significantly greater improvement in their academic performance. The experimental group showed higher posttest scores and larger mean scores than the control group, indicating that PPSA was more effective in enhancing learning outcomes. This result suggests that student-centered and problem-solving-based strategies like PPSA can lead to deeper understanding and increased academic achievement.

Table 3. Significant Values on Difference of the Pretest and Posttest Mean Scores of the Students using the Two Methods of Teaching

Pretest	Mean	SD	t-value	p-value	Decision
Experimental	18.49	5.27697	1.121	0.265	Failed to reject H_0
Control	17.38	4.04120			
Posttest	Mean	SD	t-value	p-value	Decision
Experimental	32.64	4.14046	12.843	0.000	Reject H_0
Control	22.20	3.55221			

Results from Table 3 indicate that students in both the experimental and control groups began with comparable levels of academic performance, as shown by the non-significant difference in their pretest

scores. However, following instruction, the experimental group significantly outperformed the control group in both posttest and mean scores. This result demonstrates that the experimental teaching method enhanced student learning and academic achievement more than the traditional approach.

Table 4. Extent of Attitude of the Students Towards Mathematics in terms of Cognitive, Behavior and Affective Learning Domains

Dimensions	Mean (Experimental)	Verbal Description	Mean (Control)	Verbal Description
Cognitive Learning Domain	3.72	Agree	3.74	Agree
Behavior Learning Domain	3.69	Agree	3.60	Agree
Affective Learning Domain	3.70	Agree	3.73	Agree
Mean	3.70	Agree	3.69	Agree

Table 4 revealed that the experimental and control groups demonstrated generally positive attitudes toward mathematics across cognitive, behavioral, and affective domains, with mean scores interpreted as "Agree" in all areas. Students from both groups recognized the real-world value of mathematics and showed reasonable engagement in math-related behaviors, though the experimental group exhibited slightly higher involvement and persistence. Despite this, both groups expressed uncertainty or anxiety in certain cognitive and affective aspects, particularly regarding their confidence in solving mathematical problems and feeling at ease in class. These results suggest that while the intervention had a modest positive effect on behavior and engagement, further support may be needed to build students' confidence and reduce math-related anxiety.

Table 5. Significant Values on Difference of the Students' Mean Scores when Grouped According to their Mathematical Ability

Mathematical Ability	Group	Mean	SD	t-value	p-value	Decision
Outstanding	**Experimental**	34.5000	5.21362	6.638	0.000	Reject H_0
	Control	22.6154	3.66375			
Very Satisfactory	**Experimental**	33.0476	3.81413	9.257	0.000	Reject H_0
	Control	22.3500	3.57292			
Satisfactory	**Experimental**	30.0833	1.92865	7.272	0.000	Reject H_0
	Control	21.5000	3.60555			

In addition, Table 5 shows that although students with different initial levels of mathematical ability (Outstanding, Very Satisfactory, and Satisfactory) had varying mean scores, the differences were not statistically significant. This result suggests that all groups benefited similarly from the instructional intervention, highlighting the effectiveness of the teaching method used. The results support that teaching strategies are more crucial in student improvement than initial ability alone.

Table 6. Significant Values on Difference Between the Academic Performance and the Level of Attitude of the Students using the Two Methods of Teaching

Source of Variance			t-value	p-value	Decision	Conclusion
Academic Performance	Cognitive Domain	Learning	17.63	0.003	Reject H_0	Sig.
	Behavior Domain	Learning	13.95	0.041	Reject H_0	Sig.
	Affective Domain	Learning	3.32	0.076	Failed to Reject H_0	No Sig.

Table 6 analysis showed that the two teaching methods significantly affected students' academic performance in the cognitive and behavioral domains but not in the affective domain. Specifically, there was a significant improvement in understanding, analytical thinking, and learning behaviors such as engagement and participation, supporting findings by Albay (2020) and Jahudin & Siew (2024) on the effectiveness of structured approaches like Polya's Problem-Solving Approach (PPSA). However, students' attitudes and emotional responses toward learning remained essentially unchanged, aligning with Zakariya (2022) and Klee & Miller (2019), who noted that emotional aspects of learning, such as anxiety or motivation, are more resistant to change and often require long-term interventions beyond classroom instruction. These results suggest complementing cognitive-focused strategies with affective or motivational supports to achieve well-rounded student development.

Table 7. Interaction Effect on the Performance of the Students when will be Exposed using the Two Methods of Teaching and when will be Grouped According to their Mathematical Ability

	f- value	p-value	Decision
Level	0.991	0.441	Failed to Reject
Method	93.227	0.003	Reject
Level*Method	69.118	0.227	Failed to Reject

Results in Table 7 revealed that there is no significant interaction effect between students' level of mathematical ability and the teaching method used, indicating that the effectiveness of a teaching method on performance does not vary based on students' mathematical ability ($p = 0.227$). However, the teaching method alone has a significant impact on student performance ($p = 0.003$), while mathematical ability does not ($p = 0.441$). This suggests that effective instructional strategies are more influential than innate ability in enhancing student performance. These findings align with those of Bernardo et al. (2022), Ukobizaba et al. (2021), and Zakariya (2022), who emphasized that teaching strategies and educational resources often outweigh aptitude in influencing outcomes.

DISCUSSION

The study revealed that Polya's Problem-Solving Approach (PPSA) significantly improved the academic performance of struggling learners, as shown by the higher mean scores in the experimental group compared to those taught with conventional methods. The result suggests that PPSA's structured, student-centered strategy enhances cognitive understanding and encourages more persistent and engaged learning behaviors. However, while both groups exhibited generally positive attitudes toward

mathematics, lingering issues with confidence and anxiety remained, particularly in the affective domain, indicating that short-term instructional changes may not fully address emotional barriers. These findings are significant as they demonstrate that effective teaching strategies like PPSA can benefit learners across different ability levels, making them valuable tools for inclusive education. Still, the study's limited duration and focus on a specific group of first-year criminology students constrain the generalizability of the results. Future research is recommended to explore the long-term effects of PPSA, its impact on affective attitudes over time, and its application across diverse student populations and subject areas.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE STUDIES

This study concludes that Polya's Problem-Solving Approach (PPSA) is an effective instructional strategy for improving academic achievement and attitudes toward mathematics among struggling learners. Despite beginning with comparable levels of mathematical ability and prior knowledge, students exposed to PPSA with cognitive heuristics demonstrated significant improvement in academic performance compared to those taught through traditional methods. These findings highlight the power of student-centered, problem-solving approaches in promoting more profound understanding and meaningful learning, particularly for learners who struggle with conventional instruction. Regarding attitude, while both groups generally expressed positive perceptions of mathematics, the experimental group showed slightly higher levels of engagement and persistence, suggesting that PPSA enhances achievement and fosters greater motivation and interest. However, some students continued to experience challenges related to confidence and anxiety, indicating the need for further interventions to support the development of the affective learning domain. This study underscores the critical role of problem-solving-based instruction like PPSA integrated with the cognitive heuristic method in creating more inclusive and effective mathematics classrooms, especially for struggling learners. Future research is encouraged to investigate the long-term effects of Polya's Problem-Solving Approach (PPSA) across diverse student populations, including learners with specific learning difficulties and those situated in varied educational contexts. Such studies would contribute to a more comprehensive understanding of the impact and broader applicability of PPSA, thereby strengthening the validity of its effectiveness as an instructional strategy for improving academic achievement and attitudes in mathematics..

REFERENCES CITED

1. Abdullah, A. H., Julius, E., Suhairom, N., Ali, M., Abdul Talib, C., Mohamad Ashari, Z., & Abd Rahman, S. N. S. (2022), “Relationship between Self-Concept, Emotional Intelligence and Problem-Solving Skills on Secondary School Students’ Attitude towards Solving Algebraic Problems” Sustainability, 14(21), 14402.
2. Abdullah and Suhairom, (2018). Attitude of Students towards Solving Problems in Algebra: A Review of Nigeria Secondary Schools. Journal of Research & Method in Education (IOSR-JRME). https://rb.gy/1a0egt
3. Ajzen, I. (1993). Attitude Theory and the Attitude-Behavior Relation. New directions in attitude measurement, 41-57. https://files.eric.ed.gov/fulltext/EJ1227188.pdf
4. Albay, E.M. (2020). Towards a 21st Century Mathematics Classroom: Investigating the Effects of the Problem-Solving Approach Among Tertiary Education Students. Asia-Pacific Social Science Review 20(2) 2020, pp. 69–86. https://shorturl.at/dvQV3

5. Albay, E.M. (2019). Analyzing the Effects of the Problem Solving Approach to the Performance and Attitude to the First Year University Students. Social Sciences and Humanities Open. Elsevier. 10.1016/j.ssaho.2019.100006
6. Amilin, N. & Arriola, S. (2023). Improving Students' Competence in Solving Mathematics Worded Problem Using Polya's Problem Solving Strategy. International Journal of Management Studies and Social Science Research. DOI: https://doi.org/10.56293/IJMSSSR.2022.4624
7. Banawi , A. ., Rumasoreng, M. I. ., Hasanah , N. ., Rahawarin, D. A. ., & Basta, I. . (2024). The Relationship between Problem-Solving Skills and Student Academic Achievement: A Meta-Analysis in Education. Journal of Ecohumanism, 3(3), 1287–1299. https://doi.org/10.62754/joe.v3i3.3413
8. Bernardo, A. et al. (2022). Contrasting Profiles of Low-Performing Mathematics Students in Public and Private Schools in the Philippines: Insights from Machine Learning. Journal of Intelligence. https://doi.org/10.3390/jintelligence10030061
9. Caliso, N. (2022). Set and Set Operations. Scribd. https://www.scribd.com/document/555317231/SETS-AND-SET-OPERATION
10. Cabral, C. (2022). Modular Development in Mathematics in the Modern World. American Journal of Multidisciplinary Research and Innovation. 1. 11-17. 10.54536/ajmri.v1i4.502.
11. Cornell, D. & Drew, C. (2024). 18 Descriptive Research Examples. https://helpfulprofessor.com/descriptive-research-examples/
12. Culatta, R. (2024). Constructivist Theory (Jerome Bruner). https://www.instructionaldesign.org/theories/constructivist/
13. Dagaylo M. & Tancinco, N. (2016). Mathematics Anxiety and the Academic Performance of Freshmen College Students of the Naval State University. International Journal of Engineering Sciences & Research Technology. https://tinyurl.com/4by4xtxh
14. Dayo, N., Mujataba, M., Mangi, F. H., Bhellar, N. U. A., & Alvi, U. (2024). Enhancement of Polya's Problem-Solving Skills by Gamifying Mathematics Lessons. Innovative Pedagogical Practices for Higher Education 4.0 DOI:10.1201/9781003400691-4
15. Deieso, D. & Fraser, B. (2019). Learning environment, attitudes and anxiety across the transition from primary to secondary school mathematics. Learning Environments Research 22(11):10.1007/s10984-018-9261-5
16. Department of Education Order no. 021 s. 2019. Policy Guidelines on the K to 12 Basic Education Program. https://www.deped.gov.ph/wp-content/uploads/2019/08/DO_s2019_021.pdf
17. DepEd Order No. 8, s. 2015. Policy Guidelines on Classroom Assessment for the K to 12 Basic Education Program. https://www.deped.gov.ph/wp-content/uploads/2015/04/DO_s2015_08.pdf
18. Dominowski, R.L. (2002). Teaching Undergraduates. New Jersey: Lawrence Erlbaum Assosiates Publishers".
https://www.noveltyjournals.com/upload/paper/Analysis%20Mathematical%20Problem%20Solving%20Skills-970.pdf
19. 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
20. Hervey, S., Klerlein, J. (2021). Mathematics as a Complex Problem-Solving Activity: Promoting Students' Thinking through Problem-Solving. Generation Ready White Paper. 2021.

https://36kf1rfh5v23ru41h2gm84pz-wpengine.netdna-ssl.com/wp-content/uploads/2019/02/Mathematics-as-a-Complex-Problem-Solving-Activity.pdf

21. Jahudin, J. & Siew, N. (2024). The Effects of Polya's Problem Solving with Digital Bar Model on the Algebraic Thinking Skills of Seventh Graders. Problems of Education in the 21st Century. https://oaji.net/articles/2023/457-1718792421.pdf
22. Jiang, R., Liu, R., Star, J., Zhen, R., Wang, J., Hong, W., Jiang, S., Sun, Y. & Fu, X. (2020). How Mathematics Anxiety Affects Students' Inflexible Perseverance in Mathematics Problem-Solving: Examining the Mediating Role of Cognitive Reflection. British Journal of Educational Psychology Volume 91, Issue 1 e12364 p. 237-260. https://doi.org/10.1111/bjep.12364
23. Kendra, C. (2022). What are Heuristics? Psychology Journal. https://rb.gy/9p226l
24. Klee, H. L., & Miller, A. D. (2019). Moving up! Or down? Mathematics Anxiety in the Transition from Elementary School to Junior High. The Journal of Early Adolescence, 39(9), 1311–1336.
25. Macaso, K. M. J., & Dagohoy, R. G. (2022). Predictors of Performance in Mathematics of Science, Technology, and Engineering Students of a Public Secondary School in the Philippines. Journal of Studies in Humanities and Education, 3(2), 1–15. DOI:10.35912/jshe.v2i4.990
26. Makwakwa, E., Mogari, D., & Ogbonnaya, U., (2023). First-year undergraduate students' statistical problem-solving skills. An International Journal For Statistics and Data Science Teaching. https://doi.org/10.1111/test.12359
27. Matatag Curriculum. Mathematics Grades 1, 4 and 7. Department of Education. https://www.deped.gov.ph/wp-content/uploads/MATATAG-Mathematics-CG-Grades1-4-and-7.pdf
28. McLoughlin, E. & Grimes, P., Kaur, T. (2022). Mathematics and science across the transition from primary to secondary school: a systematic literature review. IJ STEM Ed 9, 13 (2022). https://doi.org/10.1186/s40594-022-00328-0
29. McLoughlin, E., Kaur, T., Grimes, P. (2022). Mathematics and Science Across the Transition from Primary to Secondary School: A Systematic Literature Review. International Journal of STEM Education. https://stemeducationjournal.springeropen.com/articles/10.1186/s40594-022-00328-0
30. Mcleod, S. (2024). Vygotsky's Theory of Cognitive Development. Simply Psychology. https://www.simplypsychology.org/vygotsky.html
31. Moneva, J. C., Miralles, R. G., & Rosell, J. Z. (2020). Problem Solving Attitude and Critical Thinking Ability of Students. International Journal of Research - Granthaalayah, 8(1), 138–149.https://pdfs.semanticscholar.org/a98e/040acc6592c4cc8ecb839d3c89e0deccfcb1.pdf
32. Ndlovu, V. (2017). Grade 10 -12 learners' attitudes towards mathematics and how the attitudes affect performance https://core.ac.uk/download/pdf/188776028.pdf
33. Nguyen, L. C., Thuan, H. T., & Giang, T. T. H. (2023). A Application of G. Polya's Problem-Solving Process in Teaching High-School Physics. Journal La Sociale, 4(1), 26-33. https://doi.org/10.37899/journal-la-sociale.v4i1.761
34. Obiano, J. & Parangat, K. (2023). Assessing The Effect of Polya's Theory In Improving Problem-Solving Ability Of Grade 11 Students In San Marcelino District. American Journal of Humanities and Social Sciences Research (AJHSSR) e- ISSN :2378-703X Volume-07, Issue-08, pp-110-119. https://www.ajhssr.com/wp-content/uploads/2023/08/L23708110119.pdf
35. OECD (2019). PISA 2018 Results (Volume I): What Students Know and Can Do. PISA, OECD Publishing, Paris, https://doi.org/10.1787/5f07c754-en

36. OECD (2019). PISA 2018 Results (Volume II): Where All Students Can Succeed. PISA, OECD Publishing, Paris, https://doi.org/10.1787/b5fd1b8f-en
37. OECD (2019). PISA 2018 Results (Volume III): What School Life Means for Students' Lives. PISA, OECD Publishing, Paris. https://doi.org/10.1787/acd78851-en
38. Organization for Economic Cooperation and Development (2013). Education at a Glance 2013. http://www.oecd.org/edu/eag2013%20 (eng)--FINAL%2020%20June%202013.pdf
39. Polya, G. (1945). How to solve it. A New Aspect of Mathematical Method. Princeton University Press. https://math.berkeley.edu/~gmelvin/polya.pdf
40. Polya, G. (1973). How to solve it: A new aspect of mathematical method (2nd ed.). Princeton, New Jersey: Princeton University Press.
41. Samosir, C. M., Dahlan, J. A., Herman, T., & Prabawanto, S. (2023). Exploring Students' Mathematical Understanding according to Skemp's Theory in Solving Statistical Problems. Jurnal Didaktik Matematika, 10(2), 219–236. https://doi.org/10.24815/jdm.v10i2.32598
42. Sauro, J. M. (2024). Learning Strategies and Attitudes as Predictors of Problem-Solving Abilities of STEM Students in General Physics. International Journal of Research and Innovation in Social Science, 8(7), 2461–2484. DOI: https://dx.doi.org/10.47772/IJRISS.2024.807194
43. Sosa, C., Ilagan, R.D., Lavarite,L., Polianario, L.A., Santiago, J., & Aplaon, Z. (2024). "Critical Analysis and Problem-Solving Performance in Trigonometry Among College Students", J.Math.Instr.Soc.Res.Opin., vol. 4, no. 1, pp. 33–42, Dec. 2024. https://doi.org/10.58421/misro.v4i1.315
44. Skovsmose, O., Moura, A.Q. & Carrijo, M (2023). Inclusive Citizenship through Mathematics Education: A Conceptual Investigation. ZDM Mathematics Education 55, 941–951 (2023). https://doi.org/10.1007/s11858-023-01470-x
45. Ukobizaba, F., Nizeyimana, G., & Mukuka, A. (2021). Assessment Strategies for Enhancing Students' Mathematical Problem-solving Skills: A Review of Literature. Eurasia Journal of Mathematics, Science and Technology Education, 17(3), em1945. https://doi.org/10.29333/ejmste/9728
46. Valles, J. & Wickramasinghe, I. (2015). Can We Use Polya's Method to Improve Students' Performance in the Statistics Classes? Numeracy 8, Iss. 1 (2015): Article 12. DOI: http://dx.doi.org/10.5038/1936-4660.8.1.12
47. Wakhata, R., Balimuttajjo, S., & Mutarutinya, V. (2024). Relationship between students' attitude towards, and performance in mathematics word problems. Plos one, 19(2), e0278593.
48. Wakhata, R., Mutarutinya, V., & Balimuttajjo, S. (2023). Relationship between active learning heuristic problem-solving approach and students' attitude towards mathematics. Eurasia Journal of Mathematics, Science and Technology Education, 19(2), em2231.
49. Walker, SH. et al., (2020). The ABCs of Math Attitudes: Reliability and Validity of the Three Factor Model. Macrothink Institute/Journal of Studies in Education. https://www.researchgate.net/publication/353545113_The_ABCs_of_Math_Attitudes_Reliability_and_Validity_of_the_Three_Factor_Model
50. Zakariya, YF. (2022). Improving students' mathematics self-efficacy: A systematic review of intervention studies. Front. Psychol. 13:986622. doi: 10.3389/fpsyg.2022.986622