Phenomenon-Based Problem Approach and Problem-Solving Skills Among Grade 8 Students in Geometry

Mary Kris P. Lazo, Rey S. Fuentebilla*

Sultan Kudarat State University, Philippines

***Corresponding author**

DOI: https://doi.org/10.51244/IJRSI.2025.12040105

Received: 21 April 2025; Accepted: 24 April 2025; Published: 16 May 2025

ABSTRACT

This study aimed to determine the effectiveness of a phenomenon-based problem approach in developing the problem-solving skills of Grade 8 students in Geometry. Phenomenon-based learning presents real-life problems and allows learners to discover the skills and knowledge required to solve them. A quasi-experimental design with a non-randomized pre-test and post-test was used. The subjects for this research were two groups, control and experimental, and the data were collected from 80 respondents among these groups. The results showed that the control group's problem-solving skills improved from did not meet expectation to fairly satisfactory, while the experimental group's skills improved from did not meet expectation to very satisfactory. There was a significant difference in problem-solving skills between the two groups. However, there was a minimal increase in the problem-solving performance of the learners using the conventional method. The experimental group showed a significantly higher mean gain score than the control group. The study also found that different phenomena affected students' problem-solving skills. These findings suggest that the phenomenon-based approach is more effective than the conventional method in teaching problem-solving skills in Geometry.

Keywords: Phenomenon-based Approach, Problem Solving Skills, Teaching Methods, Problem-solving Performance in Geometry

INTRODUCTION

It is necessary to build mathematical experience gradually through doing and thinking. Problem-solving among students is important as they use the knowledge and skills acquired to seek solutions to learn and improve their learning in Geometry. Problem-solving requires students to integrate problem information and real-life situations that develop geometric intuition and promote spatial reasoning ability.

Using the phenomenon-based learning approach in teaching problem-solving skills prepares the students to answer problems in actual life. Phenomenon-based learning pushes students to actively find the information and abilities needed to address real-world situations rather than passively acquiring abstract or disjointed notions (Drew, 2021). Students gain information and skills through an experience that is more significant when they actively participate in real-world problem-solving (Zhukov, 2015).

Since geometry constitutes one of the foundational subjects of mathematics, learning how to solve problems is essential. However, pupils' geometric problem-solving abilities are comparatively weak (Zhang, 2017). Issues with geometry learning have impacted the success of mathematics instruction. The curriculum, textbook, physical facilities, instructional and instructional materials, methodologies, and student evaluation strategies all contribute to the ineffectiveness of geometry instruction (Chand et al., 2021).

Studies indicated that many students do not like or do not understand mathematics, probably because they have never been exposed to suitable and meaningful mathematics activities that give them a feeling of understanding and enjoyment (Vale, 2016). Students need to influence their actions in learning Mathematics

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

because of the Mathematical knowledge gap and the lack of innovative and effective teaching strategies (Panthi & Belbase, 2017). However, limited studies have been conducted using the appropriate strategy in teaching Geometry embodied in the new competency.

Students' abilities and skills are impacted when they use problem-solving techniques. According to Oztruk and Guven (2016), problem-solving influences students' aptitude and academic performance, facilitates their ability to tackle challenging situations, and advances their knowledge (Tambunan, 2019). However, because students draw connections between different disciplines and recognize real-world applications, phenomenon-based learning facilitates deeper learning. Students get better at communicating, working in teams, and creating their problems based on the circumstances in their surroundings. However, few studies have been cited that utilize the phenomenon-based approach in teaching Geometry to Grade 8 students.

The researcher has encountered several problems in teaching Geometry. The improvement of students' geometry problem-solving skills is still low based on the latest result of the quarter examination. The absence of face-to-face classes resulted in a low achievement rate of Grade 8 students in Geometry.

Citing the above problems about students' problem-solving skills in geometry, the researcher aims to conduct this study to determine the extent of the phenomenon-based approach in developing the problem-solving skills in the Geometry of Grade 8 students. Thus, this study contributed to the existing literature and filled the gaps in students' Geometry learning.

Statement of the Problem

This study determined the extent of the phenomenon-based approach in developing the problem-solving skills in the Geometry of Grade 8 students at Surallah National High School. It answered the following questions:

1. To what extent are the pre-test and post-test problem-solving skills of Grade 8 students in Geometry exposed to the conventional method?
2. To what extent are the pre-test and post-test problem-solving skills of Grade 8 students in Geometry exposed to the phenomenon-based approach?
3. Is there a significant difference in the problem-solving skills of Grade 8 students in Geometry in the pre-test and post-test using the phenomenon-based approach and conventional method?
4. Which among the phenomena significantly influenced in improving the problem-solving skills in Geometry among Grade 8 students:

    4.1. collapsing bridge;

    4.2 storm;

    4.3 volcanic eruption;

    4.4 drought;

    4.5 typhoon?

5. Is there a significant difference in the mean gain scores in the problem-solving skills of Grade 8 students in Geometry using the phenomenon-based approach and conventional method?

METHODOLOGY

Research Design

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

In this research study, the researcher utilized a quasi-experimental design with nonrandomized or nonequivalent pre-test and post-test to determine the problem-solving performance of Grade 8 students in Geometry using the phenomenon-based approach and conventional method. Two groups served as the research subjects: one was an experimental group that received treatment utilizing a phenomenon-based problem approach, and the other was a control group that received treatment using the traditional way.

The study's most crucial statistics, mean gain scores, were calculated by calculating the absolute difference between each group's pre-test and post-test scores. According to Creswell (2018), quasi-experiments are frequently used in educational research because forming groups intentionally would interfere with classroom instruction.

Respondents of the Study

The researcher selected Grade 8 students as the study's respondents. The respondents were randomly assigned to two different strategies for determining problem-solving skills in Geometry. The first section was assigned as the experimentation group, which was composed of forty (40) students using the phenomenology-based approach. Another section was designated as a control group with forty (40) students using the conventional method. The design of the study is symbolically represented by the table below.

Table 1. Distribution of Respondents

Groups	**Mean of the Two Groups**		**Mean Gain**
	Pre-test	**Post-test**	
Experimental Group			
Phenomenon-based Approach (40 students)	x_1	Y_1	$/x_1-y_1/=d_1$
Control Group			
Conventional Method (40 students)	X_2	Y_2	$/x_2-y_2/=d2$

Research Instruments

The research instrument that answered the data on the problem-solving skills of Grade 8 students was researcher-made. It was based on the MELC of Geometry for Grade 8 students during the third and fourth quarters. The instruments consisted of solving problems involving Geometry competencies.

The researcher prepared the 6-item test questions. The school's adviser and other Math teachers checked the draft teacher-made test. Once it was checked, the researcher underwent a validation process.

A validity test confirmed that the instrument measured what it intended to measure. Content validity was employed to evaluate the formulation of the process. The teacher-made test was validated by Math experts, preferably Master teachers, Master's graduates majoring in Mathematics, and doctorate holders who are experts in test constructions. Abdullah et al... (2017) supported this claim.

Content validation sought to assess item inquiries about the certain construct of an issue by preserving the essential elements while discarding the superfluous items within a defined domain. Lawshe's Methods can

determine the content validation ratio (CVR) (Aithal et al.,2020)

Accordingly, the content verification ratio is an exponential increase of the percentage agreement among experts in a panel regarding the essentiality of an item, determined as follows: The Content Validity Ratio (CVR) is calculated by subtracting the number of professional panel members who indicate "essential" (ne) from half the total number of expert committee members (N/2), and then dividing the result by N/2. The ultimate assessment for retaining the item predicted on the CVR is contingent upon the number of panels. The researcher used the validation tool with an acceptable CVI of 0.83 (Yousoff, 2019).

Data Collection and Analysis

After determining that the data gathering tool was valid and reliable, the Graduate School approved the study. Subsequently, upon securing the request from the College of Graduate School, a letter was forwarded to the Schools Division Superintendent of South Cotabato for approval. With the superintendent's consent, a similar letter was drafted and sent to the School Principal for recommendation. After getting the study's approval, the research instrument was automatically distributed to the respondents.

The initial data collection phase involved administering a pre-test on problem-solving in Geometry to the identified control and experimental groups. In this stage, both groups were given the same test before any instructional intervention. The pre-test aimed to assess the students' prior problem-solving abilities and establish a baseline for comparison before applying the research method.

During the treatment phase, the experimental group differed from the control group regarding the teaching method. During the study, the experimental group was exposed to a phenomenon-based approach.

Consequently, the treatment stage began by using teaching methods to teach the two groups of respondents the same set of topics. The researcher handled the two sections during the experimentation period to avoid bias in the study.

In the treatment, the researcher applied the strategies over two months. The control group was solely taught using the conventional approach. The teacher carefully explained the instructions and mechanics to ensure successful activities.

At the end of the treatment stage, both groups (the Experimental and Control classes) received a post-test. The post-test assessed the students' performance in problem-solving Geometry after learning and implementing two problem-solving strategies. The content of the post-test was the same as that of the pre-test.

The treatment effect was evaluated based on the mean gain scores. The pre-test and post-test results were reviewed, organized, and analyzed. The findings were then presented in tabular form and interpreted using appropriate statistical tools.

RESULTS AND DISCUSSION

This chapter deals with the results, analyses, and interpretations of the data gathered to answer the study's objectives. The results are presented in the succeeding tables with corresponding discussions and explanations.

Table 1. Problem-Solving Skills of the Control Group in the Pre-test and Post-test

Control Group	Mean Score	SD	MPS	Interpretation
Pre-test	4.40	1.82	65. 87	Did Not Meet Expectation
Post-test	14.75	2.27	79.67	Fairly Satisfactory

Table 1 discloses the level of problem-solving skills of the control group in the pre-test and post-test. The result shows that during the pre-test, the mean percentage score of the control was 4.40 (SD=1.82), interpreted as not meeting expectations. On the other hand, during the post-test, the mean percentage score of the control group was 14.75 (SD=2.27), interpreted as fairly satisfactory.

The data implies that the control group had fairly satisfactory problem-solving skills using the conventional method. The result supplementary means that the control group exposed to the Conventional Method have a limited prior knowledge of the concepts of Geometry, as indicated by their mean percentage scores in the pretest, which obtained a fairly satisfactory after series of discussion and different activities were conducted.

Abah's present study (2020) shows that scholars and educators have repeatedly criticized traditional teaching methods as ineffective, inflexible, and outdated in teaching mathematics. As a result, most concerns over traditional education stemmed from particular instances that demonstrated a teacher's ineffectiveness (Abah, 2020). The main characteristics that render traditional teaching an antiquated method of training include drills, rote memorization, and the incapacity to accommodate all students (Boylan et al., 2016).

Moreover, the way the human mind functions is hampered by conventional teaching methods (Haghighi et al., 2015). The students are doing repeated learning. Instructors have their students repeat what they have been taught. Attending to students' interests and considerations is impossible throughout the lengthy traditional teaching times (Riley et al., 2017).

Table 2. Problem-Solving Skills of the Experimental Group in the Pre-test and Post-test

Experimental Group	Mean Score	SD	MPS	Interpretation
Pre-test	4.68	2.07	66.23	Did Not Meet Expectation
Post-test	18.78	2.34	85.03	Very Satisfactory

Table 2 displays the problem-solving skills level in the experiment group's pre-test and post-test using the phenomenon-based approach. The result shows that during the pre-test, the mean percentage score of the experimental group was 4.68 (SD=2.07) and interpreted as not meeting expectations. On the other hand, during the post-test, the mean percentage score of the experimental group was 18.78 (SD=2.34) and interpreted as very satisfactory.

The data implies that the experimental group did not meet the expectations of passing the test as manifested in the mean. However, a very satisfactory performance in problem-solving of Geometry was posted after the post-test was administered.

The result also means that the phenomenon-based approach effectively develops the problem-solving skills of Grade 8 students in Geometry. The data also implies that the students limited prior knowledge of the concepts of Geometry, as indicated by their mean percentage scores in the pretest, which was developed using the phenomenon-based approach.

In support of the other studies, a phenomenon-based learning project connects teachers and students to explore a phenomenon through a multidisciplinary approach. In phenomenon-based teaching, knowledge is viewed as the result of the interplay between circumstances and knowledge, and the learner is viewed as an active maker of knowledge (Symeonidis & Schwarz, 2016). According to Vygotsky, the learner must actively participate in this interaction for learning to occur. However, a genuinely engaged learner does not always emerge from a well-organized and safe learning environment (Mazzola, 2020).

The ability to change emotional, cognitive, and behavioral patterns while consciously containing changes and gaining new abilities and viewpoints is known as phenomenon-based learning. Furthermore, learning can be a dynamic process involving performance on an individual and/or group level (Taylor, 2022). Learning is always gaining information about anything from someone with a certain objective. According to phenomenology, learning as an experience means that students must have experiences; they cannot make them. As a result, instructors need to be prepared to cope with a certain level of ambivalence and ambiguity (Symeonidis & Schwartz, 2016).

Table 3. The Z-test Result of the Mean Scores of the Control Group in the Pre-test and Post-test

Control Group	N	Mean Score	SD	df	z–computed value	p-value

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Pre - test Post test	40 40	4.40 14.75	1.82 2.27	39	22.47*	0.00
Mean Difference		**10.35**				

*****Significant at 0.05 level of significance

Table 3 presents the conducted z-test to determine the significant difference in the mean gain scores between the pre-test and post-test of the control group. Based on the analyzed result, there is a significant difference between the pre-test (M=4.40, SD=1.82) and post-test (M=14.75, SD=2.27) in the problem-solving skills of the control group, [z(39)=22.47, p<0.05]. Thus, the null hypothesis is rejected.

This implies that the problem-solving skills of Grade 8 students in Geometry improved using the conventional method, as reflected in their increase from a mean score of 4.40 in the pre-test to 14.75 in the post-test, with a mean difference of 10.35. There is a significant difference in the pre-test and post-test problem-solving skills of Grade 8 students. The result further implies that using the conventional method has increased the problem-solving skills of Grade 8 students in Geometry.

Table 4. The z-test Result of the Mean Scores of the Experimental Group in the Pre-test and Post-test.

Experimental Group	N	Mean Score	SD	df	z– computed value	p-value
Pre - test Post test	40 40	4.68 18.78	2.07 2.34	39	28.57*	0.000
Mean Difference		**14.10**				

*****Significant at 0.05 level of significance

Table 4 reveals the z-test result to determine the significant difference between the pre-test and post-test scores of the experimental group. Based on the analyzed result, there is a significant difference between the pre-test (M=4.68, SD=2.07) and post-test (M=18.78, SD=2.34) problem-solving skills of the experimental group, [z(39)=28.57, p<0.05]. Thus, the null hypothesis is rejected.

This result indicates that the phenomenon-based approach significantly improved the scores of Grade 8 students in problem-solving skills. This implies that the performance of Grade 8 students in Geometry greatly improved with the intervention of the phenomenon-based approach. The result further implies that the phenomenon-based approach as an intervention in teaching Geometry is proven effective in enhancing the students' problem-solving skills, as reflected in the significant increase of their mean score of 14.10 from pre-test to post-test.

Furthermore, Funfuengfu (2022) emphasizes the importance of teaching mathematics based on phenomena. Start by encouraging children to learn through a range of events. Students can build their knowledge through proactively learning management, which uses methodologies and various instruments to enable them to learn from real-world occurrences or authentic phenomena, which are phenomena that happen in the past or present or are likely to occur (Unal, 2017).

In phenomenon-based learning, new skills and information are added to existing mental models to create a more coherent mental model. This process is called collaborative creation (Lonka & Westling, 2018). Phenomenon-based learning can be emotionally draining for the students. A key element of phenomenon-based learning is developing the ability to bear difficult emotions, such as ambiguity, uncertainty, confusion, and anxiety (Heikkila, 2022).

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

Table 5. Analysis of Variance on the Significant Difference of Phenomenon-Based Mathematics Problems

Source of Variation	SS	df	MS	F	F crit	P-value	Remarks
Between Groups	27.12	5	5.424	6.550	2.253	0.000	Significant
Within Groups	193.8	234	0.828				
Total	220.9	239					

***Significant at 0.05 level of significance**

Table 5 presents the analysis of variance in the significant difference in phenomenon-based mathematics problems. Based on the results, the phenomenon–based mathematics problems possessed a significant difference [F(6.550)=2.253, p<0.05]. Thus, the null hypothesis is rejected.

The result implies a significant difference in grade 8 students' problem-solving skills scores when categorized by phenomena. The students' scores differ, and each phenomenon has a distinct effect on their problem-solving skills.

Muangchan and Kijkiakul (2022) state that teachers choose phenomena relevant to their town or school, use questions to help students connect what they have learned, engage with students constructively, and assess their abilities using a range of techniques. Furthermore, according to Ayuwanti and Siswoyo (2021), participants' mathematical connection skills have increased in all domains, including connections with everyday life, connections with others, and connections within mathematics.

Table 6. Post Hoc Test on Significant Difference of Phenomenon Based Mathematics Problems

Math Problem	Math Problem	Mean Difference	Significant Value	Inference
1 Collapsing Bridge	2	.37500	.440	Not Significant
	3	-.20000	.923	Not Significant
	4	.50000	.141	Not Significant
	5	.10000	.996	Not Significant
	6	-.50000	.141	Not Significant
2 Storm	1	-.37500	.440	Not Significant
	3	-.57500	.057	Not Significant
	4	.12500	.990	Not Significant
	5	-.27500	.756	Not Significant
	6	-.87500*	<.001	Significant
3 Volcanic Eruption	1	.20000	.923	Not Significant
	2	.57500	.057	Not Significant
	4	.70000*	.009	Significant
	5	.30000	.681	Not Significant
	6	-.30000	.681	Not Significant

4 Volcanic Eruption	1	-.50000	.141	Not Significant
	2	-.12500	.990	Not Significant
	3	-.70000*	.009	Significant
	5	-.40000	.365	Not Significant
	6	-1.00000*	<.001	Significant
5 Drought	1	-.10000	.996	Not Significant
	2	.27500	.756	Not Significant
	3	-.30000	.681	Not Significant
	4	.40000	.365	Not Significant
	6	-.60000*	.041	Significant
6 Typhoon	1	.50000	.141	Not Significant
	2	.87500*	<.001	Significant
	3	.30000	.681	Not Significant
	4	1.00000*	<.001	Significant
	5	.60000*	.041	Significant

*. The mean difference is significant at the 0.05 level.

Table 6 shows the post hoc test on significant differences in phenomenon-based mathematics problems. The findings indicate that most math problems did not exhibit statistically significant differences, suggesting that students demonstrated a relatively consistent level of understanding and problem-solving ability across these tasks.

However, a few problems, particularly Math Problem 6, showed significant differences compared to Problems 2, 4, and 5. Either this suggests that Math Problem 6 may have been more challenging due to its complexity, the cognitive skills required, or the nature of the mathematical concepts involved. Similarly, the significant difference observed between Math Problems 3 and 4 highlights potential variations in difficulty or the strategies students used to approach these problems. Moreover, significant differences in certain problems suggest that while Phenomenon-Based Mathematics Problems can effectively support student learning, variations in problem difficulty were considered when designing instructional activities.

Table 7. The z-test Result of the Mean Gain Scores of the Control Group and Experimental Group.

Groups	N	Mean Gain	SD	df	z – computed value	p-value
Control Experimental	40 40	10.35 14.10	1. 97 1.85	78	8.78*	0.000
Mean Difference		**3. 75**				

*****Significant at 0.05 level of significance

Table 7 reveals the z-test result that was conducted to determine the significant difference between the mean gain scores of the control and experimental groups. Based on the analyzed result, a significant difference was found between the mean gain scores of the control group (M=10.35, SD=1.97) and experimental group (M=14.10, SD=1.85), [z(78)=8.78, p<0.05]. Thus, the null hypothesis is rejected.

The result implies that the experimental group's mean gain score is significantly higher than the control group's mean gain score. This further implies that using phenomenon-based intervention approaches in teaching problem-solving skills in Geometry is more effective than the conventional method. This can be proven by a significantly higher mean gain score of 14.10 for the experimental group compared to a mean gain score of 10.35 for the control group, with a significant mean difference of 3.75.

Using a phenomenological approach, students actively participate in practical activities designed to solve issues and provide answers, thus increasing their ability. Students did the best in fluency and the worst in originality among the components of mathematical creativity with the phenomenon method. This suggests that getting many right answers is the easiest, and creating unique solutions is the hardest. Additionally, a greater focus on student autonomy and experience learning in phenomenon-based learning enables students to learn more deeply (Kroesbergen & Schoevers, 2017). In light of this, Borja (2018) emphasized that students will be better equipped to bridge the gap between various subject areas the more deeply they study.

CONCLUSION

The following conclusions were drawn from the findings and the tested hypothesis.

The control group demonstrated satisfactory problem-solving skills using the conventional method, indicating limited knowledge of geometry concepts. However, their mean percentage scores improved after discussions and various activities, indicating a satisfactory level of understanding in the conventional method.

In so doing, the experimental group did not meet the expectations but demonstrated satisfactory performance in the geometry problem-solving post-test. The study suggests that the phenomenon-based approach effectively develops problem-solving skills in Grade 8 students despite their limited prior knowledge of Geometry concepts. The data indicates that the study's effectiveness is attributed to the students' performance in the pre-test. Further, this concludes that despite learning Geometry, the conventional method showed minimal improvement, indicating its effectiveness. The performance of Grade 8 students in Geometry greatly improved with the intervention of the phenomenon-based approach.

Grade 8 students' problem-solving skills vary significantly based on various phenomena, each having a distinct effect on their scores.

The experimental group showed a significantly higher mean gain score than the control group, indicating that a phenomenon-based intervention approach to teaching problem-solving skills in Geometry is more effective than conventional methods.

RECOMMENDATIONS

Upon a thorough study of the findings, the following actions are recommended:

1. Mathematics teachers are encouraged to utilize the phenomenon-based approach not only in problem-solving skills but also in other competencies in Mathematics.
2. Mathematics teachers may develop other strategies to enhance students' problem-solving understanding of Geometry.
3. It is also recommended to the mathematics teachers that by considering the length of use or duration of the approach, problem-solving skills may improve from very satisfactory to outstanding performance through a phenomenon-based approach.
4. School principals believe a phenomenon-based approach may be replicated or introduced to other schools for utilization.
5. Education program supervisors may develop lesson guides using the phenomenon-based approach, which serves as teaching material for mathematics teachers.
6. The study was limited to using a phenomenon-based approach in developing problem-solving skills in the Geometry of Grade 8 students. Thus, another study may be conducted by other researchers looking into other strategies that may be utilized to improve the problem-solving skills of the Grade 8 students.

INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

REFERENCES

1. Abah, J.A. (2016). Recency bias in the era of big data: The need to strengthen the status of history of mathematics in Nigerian schools. Advances in Multidisciplinary Research Journal, 2(4), 241-248 http://media.wix.com/ugd/
2. Abah, J. (2020). An appeal in the case involving conventional teaching: emphasizing the transformation to enhanced conventional teaching in mathematics education. VillageMath Educational Review (VER), 2020, 1 (1), 1-10. ff10.5281/zenodo.3860320ff. ffhal-02771716f
3. Abdullah, A. H., Mokhtar, M., Halim, N. D. A., Ali, D. F., Tahir, L. M., & Kohar, U. H. A. (2017). Mathematics teachers' level of knowledge and practice on the implementation of higher-order thinking skills (HOTS). Eurasia Journal of Mathematics, Science and Technology Education, 13(1), 3–17. https://doi.org/10.12973/eurasia.2017.00601a
4. Abdul Gafoor, K., & Kurukkan, A. (2015). Learner and teacher perception on difficulties in learning and teaching mathematics: Some implications. Online Submission. https://files.eric.ed.gov/
5. Akkas, E., & Eker, C. (2021). The Effect of Phenomenon-Based Learning Approach on Students' Metacognitive Awareness. Educational Research and Reviews, 16(5), 181-188. https://files.eric.ed.gov/fulltext/EJ1296934.pdf
6. Alghadari, Fiki, Herman, Tatng & Prabawanto, Sufyani. (2021). Factors affecting senior high school students to solve three-dimensional geometry problems. International Electronic Journal of Mathematics Education, 15 (3), 1-13. https://doi.org/10.29333/iejme/8234
7. Alimuddin, Ruslan, & Nasrullah, (2018). Do scientific learning and problem- solving develop mathematics students' creativity? Advances in Social Science, Education, and Humanities Research (ASSEHR), 227(1), 10-12. https://www.atlantis-press.com/proceedings/icamr-18/55916842
8. Asahid, R. L. & Lomibao, L.S. (2020). Embedding proof-writing in phenomenon-based learning to promote students' mathematical creativity. American Journal of Educational Research, 8(9), 676-684. https://www.researchgate.net/
9. Ayuwanti, I., & Siswoyo, D. (2021). Teacher-student interaction in mathematics learning. International Journal of Evaluation and Research in Education, 10(2), 660-667. https://files.eric.ed.gov/fulltext/
10. Azmidar, A., Darhim, D., & Dahlan, J. A. (2017, September). Enhancing Students' Interest through Mathematics Learning. In Journal of Physics: Conference Series, 895 (1), 012072. IOP Publishing
11. Bhardwaj P. (2019). Types of sampling in research. Journal of the Practice of Cardiovascular Sciences, 5(3), 157. DOI: 10.4103/jpcs.jpcs_62_19
12. Birgili, B. (2015). Creative and critical thinking skills in problem-based learning environments. Journal of Gifted education and creativity, 2(2),71-80. https://files.eric.ed.gov/fulltext/ED563985.pdf
13. Boonen, A. J. H., de Koning, B. 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, 1-10. https://doi.org/10.3389/fpsyg.2016.00191
14. Borja, M. (2018). Mathematical creativity on students' solutions to open-ended problems. [Unpublished Masters™ Thesis. Philippine Normal University]
15. Boylan, M., Wolstenholme, C., Maxwell, B., Jay, T., Stevens, A. & Demack, S. (2016). Longitudinal evaluation of the mathematics teacher exchange: China – England. London: Department of Education. 1-55. https://shura.shu.ac.uk/
16. Buckley, J., Seery, N., & Canty, D. (2019). Investigating the use of spatial reasoning strategies in geometric problem solving. International Journal of Technology and Design Education, 29(2), 341-362. https://doi.org/10.1007/s10798-018-9446-3
17. Cahyono, Adi Nur & Ludwig, Matthias. (2019). Teaching and learning mathematics around the city supported by the use of digital technology. EURASIA Journal of Mathematics, Science and Technology Education, 15(1), 1-8. https://doi.org/10.29333/ejmste/99514
18. Canpolat, A. M., Kazak Çetinkalp, Z. & OzkaĢer, M. (2013). Problem solving skills and classroom climate in a physical education lesson: A study on secondary school students. SPORMETRE. Beden Eğitimi ve Spor Bilimleri Dergisi (3), 89-94. https://files.eric.ed.gov/fulltext/ EJ1068620.pdf

19. Chand S, Chaudhary K, Prasad A and Chand V.(2021). Perceived causes of students' poor performance in mathematics: a case study at Ba and Tavua Secondary Schools. Front. Appl. Math. Stat. 7, 614408. doi: 10.3389/fams.2021.614408
20. Chaudhary, Ranjita. (2019). A study on difficulties in learning geometry at secondary level students. [Master's Thesis], University Campus Kathmandu, Tribhuvan University, Kantipur, Nepal.
21. Chaudhary, A. (2014). A study on causes of low achievement of dalit students. An unpublished Master' thesis. In Mathematics education. T.U. Kirtipur.
22. Cherry, K. (February 2022). What is sociocultural theory? Very well mind. https://www.verywellmind.com/what-is-sociocultural-theory-2795088
23. Cohen, L., Manion, L., & Morrison, K. (2018). Research methods in education. Routledge.
24. Davadas, S.D. & Lay, Y.F. (2018). Factors affecting students' attitude toward mathematics: A structural equation modeling approach. Eurasia J. Math. Sci. Technol. Education,14 (1), 517-529. www./ejmste/80356
25. Dendane, A. (2009, April 3). Skills needed for mathematical problem solving. http://www.analyzemath.com/ math_problems/paper_7.html
26. DepEd. (2023, July 3). National learning camp (NLC). deped.gov.ph
27. Donnelly, K. (2014, November 6). 'Chalk and Talk' teaching might be the best way after all. http://theconversation.com/talk-and-chalk-teaching-might- be-the-best-way-after-all-34478
28. Drew, Chris. (2021, March 3). What is Finland's phenomenon-based Learning approach? https://www.teachermagazine.com/au_en/articles/what-is- finlands-phenomenon-based-learning-approach
29. Dewey, J. (1933). How we think, Boston: D. https. wordpress. com/2015/09/dewey-how-we-think.pdf
30. Effiom,W. A. (2015). Improving the Teaching and learning of mathematics education through a systematic generative model. Kusugu Journal of Education 4(1). 226-230. https://www.sfjesgs. com/index. php/SFJESGS/article/download/196/191
31. Effiom, William Anietimfon. (2021). Effect of polya's problem-solving strategy on senior secondary school students' performance in algebraic word problem in Katsina Metropolis, Katsina State, Nigeria. Sapientia Foundation Journal of Education, Sciences and Gender Studies (SFJESGS), 3, (2), 344 – 351. https://www.sfjesgs. com/index. php/SFJESGS/article/download/196/191
32. Ferreira da Silva Santos, J., Lopes-Silva, J. P., Loturco, I., & Franchini, E. (2020). Test-retest reliability, sensibility and construct validity of the frequency speed of kick test in male black-belt taekwondo athletes. Ido Movement for Culture. Journal of Martial Arts Anthropology, 20(3), 38-46. https://www.researchgate.net/
33. Finnish National Board of Education. (2017). National core curriculum for early childhood education and care. Helsinki.
34. Fortes, E. C., & Andrade, R. R. (2019). Mathematical creativity in solving non-routine problems. The Normal Lights, 13(1). https://www.researchgate.net/publication/
35. Franke, M., & Reinhold, S. (2016). Didaktik der Geometrie in der Grundschule [Didactics of geometry in primary school] (3rd ed.). Springer Spektrum
36. Funfuengfu, V. (2022). The development of phenomenon-based learning model for enhancing active learning competencies of teacher students. Journal of Positive School Psychology, 6(7), 1366-1377.
37. Gagnon, G. W., & Collay, M. (2001). Designing for learning: six elements in constructivist classrooms. Thousand Oaks, CA: Corwin Press Inc.
38. Germain-Williams, T. L. (2017). Teaching children to love problem-solving: a reference from birth through adulthood. World Scientific Publishing Co. Pte. Ltd. https://doi.org/10.1142/10415
39. Gecici, M. E., & Aydın, M. (2020). Determining the geometry problem posing performances of eighth grade students in different problem posing situations. International Journal of Contemporary Educational Research, 7(1), 1-17. DOI: https://doi.org/10.33200/ijcer.575063
40. Gurat, M. and Medula, C. Jr. (2016). Metacognitive strategy knowledge use through mathematical problem solving amongst student teachers', American Journal of Educational Research, 4 (2), 170-189. https://doi.org/10.12691/ education-4-2-5
41. Guzman Gurat M. (2018). Mathematical problem-solving strategies among student teachers. Journal on Efficiency and Responsibility in Education and Science, 11(3), 53-64. https://files.eric.ed.gov/

42. Habib, M., & Bibi, N. (2020). Assessment of Mathematical Problem-Solving Skills of Class VIII Students. Ilkogretim Online, 19(2), 1316-1326.
43. Haghighi, A. M., Vakil, R. & Weitba, J. K. (2015). Reverse-traditional/hands-on: An alternative method of teaching statistics. Application and applied mathematics (AAM.). 1. https://digitalcommons.pvamu.edu/aam/
44. Heikkila, E. (2022). Sustainability through a Phenomenon-based learning approach: A study of student reflections.
45. Hiltrimartin, Cecil. (2018, Septemebr 7). Mathematics teachers' perception about problem solving task: Case Study in SMA 4 Lahat. https://dx.doi.org/10.2991/ice-17.2018.58
46. Hobri, Ummah, I. K., Yuliati, N., & Dafik. (2020). The effect of jumping task based on creative problem solving on students' problem-solving ability. International Journal of Instruction, 13(1), 387–406. https://doi.org/10.29333/iji.2020.13126
47. Hsiao, H., Lin, C., Chen, J., & Peng, Y. (2018). The influence of a Mathematics problem – solving training system on first – year middle school students. EURASIA Journal of Mathematics, Science and Technology, Education, 14(1), 77 – 98.
48. Hu, Y., Wu, B., & Gu, X. (2017). An eye tracking study of high-and low-performing students in solving interactive and analytical problems. Journal of Educational Technology & Society, 20 (4), 300-311. https://www.jets.net/collection/published-issues/20_4
49. Juman, Z. A. M. S., Mathavan, M., Ambegedara, A. S., & Udagedara, I. G. (2022). Difficulties in learning geometry component in mathematics and active-based learning methods to overcome the difficulties. Shanlax International Journal of Education, 10(2), 41-58. http://www.shanlaxjournals.com/
50. Kangas, M., & Rasi, P. (2021). Phenomenon-based learning of multiliteracy in a Finnish upper secondary school. Media Practice and Education, 22(4), 342-359.
51. Kroesbergen, E. H., & Schoevers, E. M. (2017). Creativity as predictor of mathematical abilities in fourth graders in addition to number sense and working memory. Journal of Numerical Cognition, 3, 417–440. https://doi.org/10.5964/jnc.v3i2.63
52. Kumar, M. (2020). A study of problem-solving ability and creativity among the higher secondary students. Shanlax International Journal of Education, 8(2), 30-34. https://eric.ed.gov/?id=EJ1256061
53. Kuzle, Ana & Gracin Dubraska. (2020). Making sense of geometry education through the lens of fundamental ideas: An Analysis of Children's Drawings. The Mathematics Educator, 29(1),7–52. https://etd.uwc.ac.za/ xmlui/bitstream /handle/11394/7511/ shonhiwa _m_edu_2019.pdf?sequence=1&isAllowed=y
54. Leikin, R. (2018). Openness and constraints associated with creativity directed activities in mathematics for all students. In N. Amado, S. Carreira, & K. Jones (Eds.), Broadening the scope of research on mathematical problem solving (387–397). Springer.
55. Hickendorff M. (2021). The demands of simple and complex arithmetic word problems on language and cognitive resources. Front Psychol, 18(12),727761. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8558208/
56. Lessani, A., Yunus, A. S., Bakar, K. A., & Khameneh, Z. (2016). Comparison of learning theories in mathematics teaching methods. In Fourth 21st CAF Conference in Harvard, Boston, Massachusetts, USA,9,(1),10.https://www.21caf.org/uploads/1/3/5/2/13527682/14hrd4111_lessani.pdf
57. Liljedahl, P., Santos–Trigo, M., Malaspina, U., & Bruder, R. (2016). Problem solving in Mathematics Education. Springer. Com/content/pdf/ 10.1008% 2F97 8 -3-319-40730-2pdf
58. Lonka, K., Makkonen, J., Berg, M., Talvio, M., Maksniemi, E., Kruskopf, M., ... Westling, S. K. (2018). Phenomenal Learning from Finland. Helsinki, Edita.
59. Mahulae, P. S., Sirait, M., & Sirait, M. (2017). The effect of inquiry training learning model using PhET media and scientific attitude on students' science process skills. IOSR Journal of Research & Method in Education, 7(5), 24-29. https://www.iosrjournals.org/iosr-jrme/ papers/Vol-7%20Issue-5/Version-1/E0705012429.pdf
60. Malci. (2019). Examining 10th grade students' problem-solving processes in geometry using eye tracking technology. [Master's Thesis], Middle East Technical University

61. Martínez-Jiménez, E.; Nolla de Celis, Á.; Fernández-Ahumada, E. (2022). The city as a tool for steam education: problem-posing in the context of math trails.10,2995.https://doi.org/ 10.3390/math10162995
62. Margaret T. (2015). Teaching values through a problem-solving approach to mathematics. http://www.mathgoodies.com/articles/teaching_values.html
63. Mazzola, G. (2020). Meeting Phenomenon-Based Learning: Insights from Art Education.
64. McLeod, S. (2020. March 8). Vygotsky's sociocultural theory of cognitive development. Simply Psychology. https://www. simply psychology .org/ vygotsky.html
65. Muangchan, Warisara & Kijkuakul, Sirinapa. (2022). Using phenomenon – based learning approach to develop grade 5 students' mathematical connection skills in geometry. https://so02.tcithaijo.org/index.php/JournalGradVRU/article/view/242102
66. NoprianiLubis, J., Panjaitan, A., Surya, E., & Syahputra, E. (2017). Analysis mathematical problem-solving skills of student of the grade VIII-2 junior high school Bilah Hulu Labuhan Batu. International Journal of Novel Research in Education and Learning, 4(2), 131-137.
67. Noreen, R., & Rana, A. M. K. (2019). Activity-Based Teaching versus Traditional Method of Teaching in Mathematics at Elementary Level. Bulletin of Education and Research, 41(2), 145-159. https://files.eric.ed.gov/fulltext/EJ1229426.pdf
68. Noushad, P.P. (2017, February 20). Cognitions about Cognitions: The theory of metacognition, online submission. https://eric.ed.gov/
69. Novotna, J., Eisenmann, P., Přibyl, J., Ondrusova, J. and Břehovský, J. (2014). Problem solving in school mathematics based on heuristic strategies', Journal on Efficiency and Responsibility in Education and Science, (7), 1,16.https://doi.org/10.7160/eriesj.2013.070101
70. Ocak, G., Doğruel, A. B., & Tepe, M. E. (2021). An analysis of the relationship between problem solving skills and scientific attitudes of secondary school students. International Journal of Contemporary Educational Research, 8(1), 72-83. DOI: https://doi.org/10.33200/ijcer.780710
71. Ojimba, D. P., Gogo, Z. I., & Anderson, O. M. (2022). Effect of Mayer's problem- solving strategy on senior secondary students' retention in geometry. Int. J. Adv. Res. Innov. Ideas Educ., 8, 546. https://ijariie.com/
72. Ojose, B. (2008). Applying Piaget's theory of cognitive development to mathematics instruction. The mathematics educator, 18(1). https://files.eric.ed.gov/fulltext/EJ841568.pdf
73. Ozturk, T., & Guven, B. (2016). Evaluating students' beliefs in problem solving process: A Case Study. Eurasia Journal of Mathematics, Science & Technology Education, 12(2), 411-429. https://doi.org/10.12973/eurasia.2016.1208a
74. Panthi, R. K., & Belbase, S. (2017, May 28). Teaching and learning issues in mathematics in the context of Nepal. https://files.eric.ed. gov/fulltext /ED573754.pdf
75. 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
76. Piaget, J. (1936). Origins of intelligence in the child. London: Routledge & Kegan Paul. https://www.scirp.org
77. Powell, S. R., Stevens, E. A., & Berry, K. A. (2019). Effects of a word-problem intervention on word-problem language features for third-grade students with mathematics difficulty. Grantee Submission. https://files.eric.ed.gov/fulltext/EJ1230022.pdf
78. Putri, AL, Lukito, A and Wijayanti, P. (2020). Students' specializing in mathematics problem solving. Journal of Physics: Conf. Series 1470. https://iopscience.iop.org/article/10.1088/1742-6596/1470/1/012075
79. Rao, D. (2018). Science education in developing countries. New Delhi; Discovery Publishing House (124-126). https://files.eric.ed.gov/fulltext/EJ1229426.pdf
80. Rejeki, S. (2021, June). Analysis of students' problem-solving ability in solving geometry problem. In Journal of Physics: Conference Series, 1918, (4), 042075). IOP Publishing. https://www.researchgate.net/publication/
81. Reyadi, Rejeki, S. & Siswanto. (2020). Analysis of students' problem-solving ability in solving geometry problem. Journal of Physics: Conference Series, 1918. https://www.researchgate.net/

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

82. Riley, N., Luban, D., Holmes, K., Gore, J., & Morgan, P. (2017). Movement-based mathematics: Enjoyment and engagement without compromising learning through the easy minds program. EURASIA Journal of Mathematics Science and Technology Education, 13(6),1653-1673. https://www.ejmste.com/
83. Rivas, S. F., Saiz, C., & Ossa, C. (2022). Metacognitive strategies and development of critical thinking in higher education. Frontiers in Psychology, 13, 913219. https://www.ncbi.nlm.nih.gov/pmc/articles/
84. Riyadi, Syarifah, T. J., & Nikmaturrohmah, P. (2021). Profile of students' problem-solving skills viewed from Polya's four-steps approach and elementary school students. European Journal of Educational Research, 10(4), 1625-1638. https://doi.org/10.12973/eu-jer.10.4.1625
85. Rizo, S. M. W. (2016). The effect of using Van Hiele's instructional model in the teaching of congruent triangles in grade 10 in Gauteng high schools. Master of science. University of south Africa.
86. Safrina, Y., Ikhsan, M., & Zubainur, C. M. (2022, January). Improving student geometry problem-solving skills through spatial training. In Eighth Southeast Asia Design Research (SEA-DR) & the Second Science, Technology, Education, Arts, Culture, and Humanity (STEACH) International Conference (SEADR-STEACH), 30-37. Atlantis Press. http://creativecommons.org/licenses/by-nc/4.0/
87. Sari, N. M., Pasundan, U., & Yaniawati, P. (2019). The effect of different ways in presenting teaching materials on students mathematical problem-solving abilities. International Journal of Instruction, 12(4), 495–512. https://doi.org/10.29333/iji.2019.12432a
88. Shonhiwa, William. (2019). The impact of using technology through cooperative learning on learners' performance on grade 11 circle geometry. [Master's Thesis]. The University of the Western Cape, Republic of South Africa.
89. Schoevers, E. M., Leseman, P. P. M., & Kroesbergen, E. H. (2020). Enriching mathematics education with visual arts: Efects on elementary school students' ability in geometry and visual arts. International Journal of Science and Mathematics Education, 18, 1613–1634. https://doi.org/10.1007/s10763-019-10018-z
90. Silander P. (2015). Rubric for phenomenon-based learning. http://nebula.wsimg.com/c
91. Simamora, R. E., Sidabutar, D. R., & Surya, E. (2017). Improving learning activity and students' problem-solving skill through problem-based learning (PBL) In Junior High School. International Journal of Sciences: Basic and Applied Research (IJSBAR), 33(2), 321–331.
92. Simamora, R. E., & Saragih, S. (2019). Improving Students' Mathematical Problem-Solving Ability and Self-Efficacy through Guided Discovery Learning in Local Culture Context. International Electronic Journal of Mathematics Education, 14(1), 61-72.
93. Singh, S. (2003). Simple random sampling. In advanced sampling theory with applications, 71-136. Springer, Dordrecht. https://link.springer.com /chapter/ 10.1007/978-94-007-0789-4_2
94. Siswono, T. Y. E., Kohar, A. W., Hartono, S., Rosyidi, A. H., Kurniasari, I., & Karim, K. (2019). Examining teacher mathematics-related beliefs and problem-solving knowledge for teaching: Evidence from Indonesian primary and secondary teachers. International Electronic Journal of Elementary Education, 11(5), 493506.https://www.iejee.com/index.php/
95. Sri Adi Wiidodo, Pardimin. (2016). Increasing skills of student in junior high school to problem solving in geometry with guided. Journal of Education and Learning. 0 (4), 390-395.
96. Sunghwan, Hwang. (2019). The relationship between students' perception toward mathematics teachers' instructional practices and attitude toward mathematics: a mediation role of self-efficacy beliefs. Journal of Elementary Mathematics Education in Korea 23 (4), 383-403. https://www.koreascience.or.kr/article/JAKO201921040062042.pdf
97. Symeonidis, V., & Schwarz, J. F. (2016). Phenomenon-based teaching and learning through the pedagogical lenses of phenomenology: the recent curriculum reform in Finland. Forum O? wiatowe, 28 (2), 3147. https://www.researchgate.net/
98. Tambunan, H. (2019). The effectiveness of the problem-solving strategy and the scientific approach to students' mathematical capabilities in high order thinking skills. International electronic journal of mathematics education, 14(2), 293-302. https://doi.org/10.29333/iejme/5715
99. Taylor, C. (2022). Phenomenon-based instruction in the elementary classroom: impact on student engagement and achievement in science content learning. [Thesis, Boise State University]. https://scholarworks.boisestate.edu/cgi/

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue IV April 2025

100. Torres, J., Leal, O. R., & Ortega, M. V. (2021, July). The rubric as an assessment tool for solving problem situations in the physics and mathematics teaching context. In Journal of Physics: Conference Series, 1981, (1), 012018. IOP Publishing.
101. Ulandari,L. (2019). Development of learning materials based on realistic mathematics education approach to improve students' mathematical problem-solving skills and self-efficacy. International Electronic Journal of Mathematics Education. 14(2), 375-383. https://doi.org/10.29333/iejme/5721
102. Unal, M. (2017). Preferences of teaching methods and techniques in Mathematics with reasons. Universal Journal of Educational Research, 5(2), 194-202. http://www.hrpub.org/
103. Vula, E., Avdyli, R., Berisha, V., Saqipi, B., & Elezi, S. (2017). The impact of metacognitive strategies and self-regulating processes of solving math word problems. International Electronic Journal of Elementary Education, 10(1), 49–59. https://doi.org/10.26822/iejee.2017131886
104. Wang, L., Cao, C., Zhou, X., & Qi, C. (2022). Spatial abilities associated with open math problem solving. Applied Cognitive Psychology, 36(2), 306-317.
105. Yavuz, Gunes, Deringol, Yasemin, Arslan, Cigdem. (2017). Elementary school students' perception levels of problem-solving skills. Universal Journal of Educational Research 5(11), 1896-1901. http://www.hrpub.org/
106. Yeh, C. Y., Cheng, H. N., Chen, Z. H., Liao, C. C., & Chan, T. W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. Research and Practice in Technology Enhanced Learning, 14(1), 1-19.
107. Zalmon, I. G. (2021). Effects of Polya's and Schoenfeld's problem solving strategy on secondary students' performance and retention in Mathematics in Obio- Akpor, Rivers State. [Unpublished Ph.D. Thesis], University of Port Harcourt
108. Zalmon, I. G. & Wonu, N. (2019). Comparative analysis of student Mathematics achievement in West African senior secondary certificate examination in Nigeria. European Journal of Research and Reflection in Educational Sciences, 5(1), 24-31
109. Zhang, D. (2017). Effects of visual working memory training and direct instruction on geometry problem solving in students with geometry difficulties. A Contemporary Journal. 15(1), 117-138. https://files.eric.ed. gov/fulltext/EJ1141989.pdf
110. Zhukov T (2015, June 8). Phenomenon-based learning: What is PBL? https://www.noodle.com/articles/phenomenon-basedlearning-what-is-pb