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Effects of Teaching Students through Problem-Solving on Students' Academic Performance in Problem-Solving

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Abstract
The study aimed to determine how teaching students problem-solving techniques affected their academic problem-solving performance. A quasi-experimental research design was used for this study. The BIA Lamplighter College of Education's level 400 students make up the population for the 2022–2023 academic year. However, all upper primary students were chosen for the study because Problem-solving was a subject taught in that grade. There were three groups of 126 upper primary students in total. Intact groups were used in the study. The problem-solving technique was used in conjunction with the whole class, cooperative, and think-pair-share teaching methods while teaching Groups 1, 2, and 3 (G1, G2, and G3). Scores from the pre-and post-tests were used to gather information. The data were analyzed using ANOVA, Wilcoxon Signed Ranks, Kruskal-Wallis Test, both Wilcoxon W and Mann-Whitney U. The study's conclusions suggest that teaching through Problem-solving may enhance students' problem-solving abilities. The study also discovered that both students taught using whole-class teaching strategies and students led using cooperative learning and think pair teaching strategies benefit from the techniques. After using the "teaching through" problem-solving approach, there was no discernible difference in performance between male and female students.

Keywords: problem-solving; academic performance; cooperative learning; critical thinking

I. Introduction

Every aspect of human life, including daily activities, the workplace, and other subject areas, depends on mathematics (Joaquin, 2022). One of the skills that students are expected to learn is Problem-solving. This is because today's rapidly evolving information-based society has impacted mathematics programs at various educational levels. Today's employers look for thoughtful employees who can solve problems regardless of their culture, gender, or socioeconomic status (Joaquin, 2022). Students should be able to reason, analyze, think critically, synthesize information, gain confidence in their reasoning, and strengthen their mental faculties through problem-solving activities. All collegiate study areas benefit from problem-solving and critical thinking skills, which also hold long-term value in the workplace and daily life (McCormick, Clark, & Raines, 2015).

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It is also acknowledged that problem-solving is a crucial life skill that involves many procedures, including analyzing, interpreting, reasoning, predicting, evaluating, and reflecting (Anderson, 2014). According to curriculum developers, the creation of problem-solving activities is a requirement for students to use and apply their mathematical knowledge in meaningful ways. Through problem-solving, students can better understand mathematical ideas, become more involved and enthusiastic in their studies, and recognize the value and relevance of mathematics (Anderson, 2014). Students benefit from problem-solving because it enhances their mathematical knowledge and skills, in addition to helping them solve real-world problems. In a sample of Bangladeshi schools, Hossain and Ahmad (2013) found that cooperative learning positively affects students' academic performance and attitude toward mathematics. Additionally, according to Intaros, Inprasitha, and Srisawadi (2014), when students engage in problem-solving, they work together to create their problem-solving approaches.

According to Fard, Bahador, Moghadam, Rajabi, and Moradi (2014), problem-solving instruction fosters students' creativity, develops their abstract thinking, and draws attention to their creative and original solutions. King (2019) researched to identify more useful problem-solving techniques with a scientific approach to students' mathematical aptitudes in higher-order thinking abilities. The study's conclusions showed that problem-solving learning was superior to the scientific method for enhancing students' mathematical reasoning, problem-solving, and communication skills. In other words, problem-solving methods of teaching enhance mathematical skills more so than scientific methods. The current problem is how to effectively teach problem-solving in the mathematics classroom and what teaching methods should be used to enhance efficient problem-solving.

As evidenced by the assertion that, as a result of this, teaching strategies in mathematics classrooms have shifted to an insight-based problem-solving process in the twenty-first century (Intaros et al., 2014). For example, Klang, Karlsson, Kilborn, Eriksson, Karlberg, and Holmes (2021) found that cooperative problem-solving significantly impacts students' academic performance more than the lecture method. This implies that teaching students Problem-solving through collaboration has a more significant impact than teaching the entire class. Small-group collaborative learning and Problem-solving effectively increase student involvement, interest, and perceptions of the value of mathematics and other subject content (McCormick et al., 2015). Even in large classes, where facilitating small groups can be a daunting prospect for teachers, evidence shows that collaborative learning effectively increases student-to-teacher interaction, student-to-student interaction, and students' critical thinking skills (McCormick et al., 2015).

According to the literature, there are three main approaches to teaching Problem-solving. In problem-solving, the teacher presents the mathematics, then the students practice the skills, and finally, solve story problems that require using the skill. Walking students through a procedure or demonstrating a step-by-step method for solving a specific problem was deemed the most beneficial approach to learning. Second, when we teach students different problem-solving strategies, we teach them about Problem-solving. Finally, according to Van de Walle et al. (2010), teaching through Problem-solving "might be described as an upside down from teaching for Problem-solving - with the problem or task presented at the beginning of a lesson and related knowledge or skills emerging from exploring the problem." It has been demonstrated that teaching Problem-solving through Problem-solving is the most effective of the three strategies.

As a result, the current study investigated the impact of problem-solving teaching on students' academic performance. This was evaluated using the think-pair-share method, cooperative learning, and whole-class teaching. The findings of this study will help teachers, particularly pre-service teachers, to combine problem-solving strategies with teaching strategies that will have the most significant impact on student's academic performance.

II. Research Method

The research design adopted for the study is a Quasi-experimental design. The study aimed to ascertain the effects of teaching through Problem-solving on students' performance in mathematics Problem-solving. The population consists of all level 400 students in BIA Lamplighter College of education for the 2022/2023 academic year. However, because Problem-solving was an upper-primary course, all the upper-primary students were chosen for the study. The total number of upper primary students was 126 in three groups. The groups were retained for the current study since the school's culture does not permit the distortion of the original groups. As a result of that, intact groups were used for the study. Group one (G1), Group two (G2), and Group three (G3) were taught using the think pair, cooperative, and whole class teaching methods, respectively. However, all the groups were taught using the "teaching through problem" solving approach for twelve weeks (12). Before the intervention, students were given ten questions on Problem-solving as a pretest. This ensured that the students were at the same level before the intervention. After the twelve weeks, the students were made to take a posttest to ascertain the technique's effects. The same examination questions used for the pretest were also used for the posttest. The data collected were analyzed using ANOVA, Wilcoxon Signed Ranks, Kruskal-Wallis Test, both Wilcoxon W and Mann-Whitney U.

The research hypothesis was used to analyze the data. However, before performing the analysis, the data were subjected to a normality test to determine the type of test statistics appropriate for a specific hypothesis. The first section examines the normality test of the pretest scores.

III. Results and Discussion

Normality Test of the Pretest scores

The normality of the pretest scores was ascertained using both Kolmogorov-Smirnov and Shapiro-Wilk tests. The results are shown in Table 1.

Table 1.
Normality test of the pretest

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest (G1)	.105	40	.200*	.943	40	.055
Pretest (G2)	.130	40	.086	.954	40	.103
Pretest (G3)	.130	40	.084	.961	40	.178

*. This is a lower bound of the true significance. a. Lilliefors Significance Correction

The normality test of the pretest scores of the three groups is shown in Table 1. The results of both the Kolmogorov-Smirnov and the Shapiro-Wilk tests were significant at P = 0.05 in all three groups. This indicated that the pretest scores of groups G1, G2, and G3 were usually distributed. As a result, ANOVA was used to compare the scores of the three groups (G1, G2, and G3), as shown in Table 2.

Table 2.
Comparison of the pretest scores of the three groups (G1, G2, G3)

	N	Mean	Std. Deviation	F	Sig
Pretest (G1)	44	9.364	2.393		
Pretest (G2)	40	9.600	2.251	2.750	.068
Pretest (G3)	42	8.476	2.255		

The One-way ANOVA in Table 2 compares the pretest scores of the three groups taught using different teaching approaches. Table 2 results show that there is no significant difference in the mean scores of G1 (Mean = 9.364, SD = 2.393), G2 (Mean = 9.600, SD = 2.251), and G3 (Mean = 8.476, SD = 2.255) at the P = 0.05 significant level. This demonstrates that all three groups' pretest scores are statistically

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equal. That is, all of the groups are similar. The effect of any treatment given to these groups can thus be compared at the post-test level.

Research Hypothesis One:

H_0: *There is no statistical difference between students' pretest scores and posttest scores across the three teaching Methods*.

To determine whether there was a significant difference between the pretest and post-test scores of the three groups, the data was first subjected to a normality test, which guided the researcher in selecting appropriate test statistics. Table 3 displays the normality test results for the three groups' post-test scores (G1, G2, and G3).

Table 3.
Normality test of the posttest scores of the three groups

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	df	Sig.	Statistic	df	Sig.
Posttest (G1)	.151	40	.022	.916	40	.006
Posttest (G2)	.175	40	.003	.876	40	.000
Posttest (G3)	.155	40	.017	.936	40	.025

The Kolmogorov-Smirnov and Shapiro-Wilk tests' P-values are significant at P = 0.05 in all three groups. This indicated that all three groups' post-test results were not normally distributed. As a result, only the Wilcoxon signed ranks test, the non-parametric equivalent of the paired sample t-test can be used to analyze research hypothesis one. This was used because the researcher wanted to know if students' performance in Problem-solving improved after going through the Problem-solving strategies with all three groups. Table 4 displays the results.

Table 4.
Wilcoxon signed ranks test comparing the pretest and the posttest scores of the three groups

		N	**Mean Rank**	**Sum of Ranks**	**Z**	**Asymp. Sig. (2-tailed)**
Posttest G1 –	Negative Ranks	0[a]	.00	.00		
Pretest G1	Positive Ranks	44[b]	22.50	990.00	-6.334[b]	0.000
	Ties	0[c]				
	Total	44				
Posttest G2 –	Negative Ranks	0[d]	.00	.00		
Pretest G2	Positive Ranks	40[e]	20.50	820.00	-5.849[b]	0.000
	Ties	0[f]				
	Total	40				
Posttest G3 –	Negative Ranks	2[g]	1.50	3.00		
Pretest G3	Positive Ranks	40[h]	22.50	900.00	-6.136[b]	0.000
	Ties	0[i]				
	Total	42				

The positive mean ranks of the various groups (post-pretest) = 22.50, (Posttest G2-Pre-test G2) = 20.50, and (Posttest G3-Pre-test G3) = 22.50 are all significant at the P = 0.05 significant level, according to the results in Table 4. This indicated that students' posttest scores were higher than their pretest scores in all three groups. This meant that the intervention was a success. Regardless of the teaching strategies used, students' performance in all three groups (G1, G2, G3) improved after teaching through Problem-solving. This means that problem-solving-based teaching can improve students' mathematics problem-solving performance. This finding is not surprising given that teaching through Problem-solving engages students throughout the instructional process. Moreover, because the students are fully immersed in the learning environment, learning becomes a part of them. This is consistent with the findings of the subsequent studies. According to Fard, Bahador, Moghadam, Rajabi, and Moradi (2014), problem-solving instruction improves students' abstract thinking, increases their creativity, and highlights their unusual solutions and innovative skills. King (2019) researched to discover more effective problem-solving strategies for students' mathematical abilities in higher-order thinking skills using a scientific approach. The findings are also supported by studies (Syafii & Yasin, 2013; Fidan, M., & Tuncel, 2019; Huang, Kuo, & Chen, 2020) that show that teaching students through Problem-solving improves their academic achievement.

Research Hypothesis Two

H_0: *There is no significant difference between the students taught using the three teaching techniques*.

This hypothesis seeks to determine whether there are differences in the posttest scores of the three groups of students (G1, G2, and G3) after taking Problem-solving strategies. The Kruskal-Wallis test, the non-parametric test of One-way ANOVA, was used to ascertain this. The results of the Kruskal-Wallis test are shown in Table 5.

Table 5.
Kruskal-Wallis test comparison of students' posttest scores based on groups

	Group	N	Mean Rank	Chi-Square	df	Asymp. Sig.
Scores	G 1	44	66.55	16.715	2	.000
	G 2	40	78.39			
	G 3	42	46.13			

At the P = 0.05 significance level, the Kruskal-Wallis Test reveals a significant difference between the mean rank of G1 (66.55), G2 (78.39), and G3 (46.13). This demonstrates that the mean ranks of the three groups' post-test scores differ. As a result, null hypothesis two is rejected at the 0.05 alpha level. Table 5 also shows that the mean rank of G2 appears to be the highest, followed by the mean rank of G1, and the mean rank of G1 appears to be the lowest. However, if the data is subjected to a pairwise comparison, the research may be able to pinpoint the location of the actual difference. Table 6 displays the results of the pairwise Comparison.

Table 6.
Pairwise comparison of the three groups posttest scores

Sample1-sample2	Test Statistics	Std. Error	Sig
G3-G1	20.415	7.816	0.009
G3-G2	-11.842	7.916	0.000
G2-G1	32.257	8.005	0.135

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displaced. The significance level is 0.05

The pairwise comparisons revealed that the differences in posttest scores between the three groups are between G3 and G1 (P = 0.009) and G3 and G2 (P = 0.000) at the P = 0.05 significant level. This meant that the mean rank of G2 and G1 were both higher than the mean rank of G3, even though the mean rank of G2 and G1 were statistically equal. This indicated that students taught using the think pair share method and cooperative groups outperformed their counterparts using the whole class discussion method. This demonstrated that teaching students through problem-solving strategies is far more effective in groups. Students sharing ideas about concepts, which enhances a deeper understanding of mathematical concepts, may contribute to group performance. Additionally, some students learn best when their peers surround them. This finding is consistent with the assertion that mall-group collaborative learning and Problem-solving effectively increase student involvement, interest, and perceptions of the worth of mathematics and other subject content (McCormick et al., 2015). Even in large classes where facilitating small groups can be difficult, evidence shows that collaborative learning is an effective measure for increasing student-to-teacher interaction, student-to-student interaction, and students' critical thinking skills (McCormick et al., 2015). In the current study, however, the effect of small-group instruction was greater than that of whole-class instruction. Klang et al. (2021) discovered that collaborative problem-solving teaching impacts students' academic performance more than whole-class instruction or lecture methods.

Research Hypothesis Three

H_0: *There is no significant difference between male and female students' scores after being exposed to teaching through Problem-solving techniques.*

The data was first subjected to a normality test to guide the researcher in choosing appropriate test statistics to determine whether there was a significant difference between the male and female post-test scores. Table 7 shows the results of the normality test of the posttest scores of Male and Female students.

Table 7.
Normality test of the posttest scores male and female students

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Male	.170	60	.000	.900	60	.000
Female	.183	60	.000	.926	60	.001

Both the Kolmogorov-Smirnov and Shapiro-Wilk P-values in both groups are significant at P = 0.05. This indicated that both sexes' post-test results were not normally distributed. As a result, research hypothesis three can only be examined using the non-parametric Mann-Whitney U and Wilcoxon W tests, which are the non-parametric equivalents of the independent sample t-test. This was used because the study wanted to see if there were any differences in the problem-solving abilities of male and female students after teaching them problem-solving techniques, as shown in Table 8.

Table 8.
Comparison of male and female student's performance in posttest

	Sex	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Posttest Scores	Male	63.57	4195.50	1975.500	3805.500	-.022	.982
	Female	63.43	3805.50				

Table 8 compares the posttest scores of male and female students after being exposed to problem-solving techniques. Both Wilcoxon W (3805.500) and Mann-Whitney U (1975.500) test statistics are insignificant at the P = 0.05 significance level. In other words, a Z-value of -0.022 with a P-value of 0.982 is not statistically significant at the 0.05 alpha level. This means that the mean rank of Males (63.57) and Females (63.43) is statistically equal. This means there was no statistically significant difference in the performance of male and female students after problem-solving instruction. This is an intriguing finding because many studies have found disparities in mathematics performance between male and female students. While some argue that men outperform women in mathematics, others dismiss this claim. However, this approach to teaching Problem-solving benefits both male and female students, bridging the gender gap in mathematics performance. The study confirmed the findings of Adeleke (2007), who found that when taught through Problem-solving using procedural and conceptual learning strategies, male and female students perform equally well. The findings also contradict the findings that female students in Physics outperform male students in Problem-solving (Istiyono, Mustakim, Widihastuti, Suranto & Mukti, 2019). The current study also refutes the claim that gender differences in mathematical Problem-solving favor males (Zhu, 2007).

IV. Conclusion

The study intends to examine the impact of problem-solving instruction on various teaching strategies (whole-class teaching, Think pair share, and cooperative teaching). The academic performance of all three groups improved due to cooperative teaching. However, the performance of cooperative groups and students taught using the think pair share method was higher than that of students taught using the whole class method. Furthermore, the study found no statistically significant difference between male and female mean scores in any of the three groups. This demonstrates that teaching through Problem-solving has the potential to improve both male and female students' academic performance. When teaching Problem-solving at all levels of education, it is recommended that teachers, particularly pre-service teachers, use the teaching through the Problem-solving approach. The analysis results on the five types of errors above stated that students experienced the most errors in reading and comprehension. These two types of student errors indicate the low level of students' thinking in understanding problems in mathematical story problems. Next is the type of transformation error and process skill. These two errors show students' cognitive abilities in understanding the concepts for each sample point counting rule found in the problem. Moreover, the type of error that students experience the least is encoding. This shows the students' accuracy in writing the correct mathematical operations according to the mathematical concepts used to solve problems.

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