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Effect of the Problem-Solving Approach on Academic Achievement of Students in Mathematics

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Abstract

The primary focus of this quantitative experimental study was to explore the effect of the problem-solving approach on the academic achievement of students in mathematics at grade IX and to compare the achievement of boys and girls of grade IX taught using this method at Latinath Secondary School Naugad 03, Darchula. This study was based on experimental research method under the quantitative research design. A sample of 60 students was chosen using purposive stratified random sampling, forming equivalent experimental and control groups of 30 students each. Data were collected using two achievement tests (pre-test and post-test) and structured interview tools. Statistical calculations included mean, standard deviation, two-tailed t-test, and coefficient of variation (CV). The post-test results indicated a significant difference in mean achievement between the groups (mean difference of 4.44), significant at the 0.05 level. The coefficient of variation of the achievement of students in the control group (18.14%) was higher than that of the experimental group (12.20%). It was concluded that the experimental group, taught with the problem-solving approach, had better achievement than the control group, which was taught using the traditional approach. Furthermore, while the mean achievement score of boys (30.08) was slightly greater than that of girls (29.68) in the post-test, the difference was not statistically significant at the 0.05 level. Thus, the study concluded that the problem-solving approach minimizes the gender difference in learning mathematics.

Keywords : Problem-solving approach, Experimental group, Control Group, Mathematics achievements, Impact, Gender Differenceattitudes, phenomenology

Introduction

Problem solving in mathematics holds the potential to be an engaging activity for many students, frequently boosting their motivation and enhancing their enjoyment of the subject (Avğın, 2025). However, the opposite effect can occur, particularly when students face challenges related to speed, accuracy, neatness, or difficulty in finding the correct answers (Smith, 2020) .In situations where students struggle, frustration may arise if educators fail to exhibit patience, understanding, and subtle support. Conversely, when teachers cultivate a relaxed and supportive classroom atmosphere, students are more likely to derive satisfaction from discovering creative and original solutions to mathematical problems (Smith, 2020).

The problem-solving method as a pedagogical strategy in mathematics education began gaining traction in the 1940s and has since continued its evolution. Polya (1945) defined problem-solving as the process of identifying a path out of a difficulty when an immediate solution is not apparent. Despite its recognized potential, the use of problem-solving methods has not been extensively adopted or practiced in Nepalese classrooms over a long duration (Poliya, 1945). The National Council of Teachers of Mathematics (NCTM, 1980) advocated for a focus on problem-solving in mathematics education, emphasizing its role in developing essential skills necessary for everyday life and aiding individuals in adapting to unexpected challenges.

In Nepal, the education system operates under a federal structure, where local governments are tasked with managing school education while the federal government retains responsibility for curriculum design. A notable disparity exists in mathematics achievement between private and public schools, with average scores reported as 57% and 26%, respectively (Ministry of Education, 2019). Several identified factors contribute to the lower achievement rates observed in public schools, including delayed distribution of textbooks, irregular student attendance, insufficient parental involvement, low student self-efficacy, and a lack of discipline (Adane, 2013).

Khan (2010) Conducted a study titled "Effect of using problem solving method in teaching mathematics on the achievement of mathematics student". The objective was to investigate the effects of the problem-solving method on students' achievement at the elementary level (Khan, 2010). Employing a pre-test/post-test design, the study sampled 76 8th-grade students in Bannu, Pakistan (Khan, 2010). Using a self-developed test, the results showed a significant difference between the effectiveness of the traditional teaching method and the problem-solving method in elementary mathematics instruction.

The study recommended that teachers be encouraged to utilize the problem-solving method for teaching mathematical concepts (Khan, 2010).

Perveen (2010) Studied the "Effect of the problem-solving Approach on academic achievement of students in mathematics at secondary level". The study's objective was to determine the effect of the problem-solving approach on achievement at the secondary level (Khan, 2010). Forty-eight students were divided equally into an experimental group and a control group based on pre-test results, using a survey type of research design (Khan, 2010). The sample consisted of 10th-class students from a Government Pakistan Girls High School in Rawalpindi. Data analysis utilized a two-tailed t-test (Khan, 2010). The strong suggestion from this study was that presenting mathematical concepts to secondary-level pupils through a problem-solving sequence enables the learner to conceptually integrate the content in a way that promotes retention (Khan, 2010).

Gurat (2018) Researched on "mathematical problem-solving strategies among student teachers". The purpose was to understand these strategies among student teachers, interviewing 23 students (19 females and 4 males) who volunteered. This mixed-methods study gathered data through participant interviews (semi-structured and videotaped) and the analysis of their actual mathematical problem-solving outputs. The study revealed that student teachers employed cognitive, metacognitive, and other strategies in problem-solving. It also indicated a significant influence of these strategies on the student teachers' academic performance.

Kandel (2007) Focused on the "Effectiveness of problem-solving method in arithmetic at lower secondary level". The specific aim was to explore the effectiveness of the problem-solving approach in addressing gender differences in learning arithmetic at grade VII (Kandel, 2007). Out of 130 students, 25 were selected for the experiment and 25 for the control group. Statistical tools included mean, standard deviation, and the t-test (at 0.05 significance level) for comparing achievement (Kandel, 2007). Kandel concluded that the problem-solving approach was superior to the traditional approach of teaching. (Kandel, 2007)

Parajuli (2009) Conducted experimental research to study "a study on the effectiveness of teaching mathematics by using problem solving method at lower secondary level mathematics" (Parajuli, 2009). The goal was the prior use of experimental verification by teaching arithmetic with the problem-solving method (Parajuli, 2009). A total of 60 students were involved, with 30 selected randomly and then divided into 15 students for the experiment and 15 for the control group. Analysis of the final achievement test used the t-test at the 0.05 level of significance, concluding that experimental verification had a significant effect on teaching mathematics (Parajuli, 2009).

The primary purpose of the present study is multifaceted to examine the

effectiveness of the problem-solving method in teaching mathematics; to compare the mathematics achievement of boys and girls taught using this approach; and to compare the outcomes of the problem-solving approach versus traditional methods for teaching grade IX students. Furthermore, the research aims to understand the impact of problem-solving techniques within the Nepalese educational context. Modern teaching methods, such as problem-solving, which emphasize decision-making and critical thinking, are generally considered more effective in developing these specific skills in students. The researcher compares the effectiveness of the expository strategy and the problem-solving approach in secondary-level mathematics education.

The following statistical hypotheses were formulated for this research work:

Null Hypothesis (Pre-test): There is no significant difference in the achievement of mathematics of the experimental group and the controlled group in the pre-test.

Alternative Hypothesis (Pre-test): The achievement score of the experimental group is not equal to the control group.

Null Hypothesis (Post-test): There is no significant difference between the achievement of the experimental group and the controlled group in the post-test by using the problem-solving method.

Alternative Hypothesis (Post-test): The average achievement score of the experimental group is higher than the control group

Methodology

To meet the objectives of the research, the study was based on the experimental research method under the quantitative research design. Experimental research is identified as the design used for the study focusing on the "Effect of the Problem-Solving Approach on Academic Achievement of Students in Mathematics". It is a component of the quantitative research design (Kaur, 2019). The experimental research method was utilized to meet the specific objectives of this study, primarily concerning the establishment of cause-and-effect relationships regarding teaching effectiveness and to compare the mathematics achievement of the boys and girls taught by using the problem-solving approach. This was quantitative experimental research study and carried out only one school, Shree Latinath Secondary School Khar Naugad 03, Darchula. The population of this study is 118 students out of these 60 students were selected for sample of this study by using stratified sampling of random probability sampling. After this, researcher formed two equivalent groups named as experimental and control group.In this study we were selected students of class IX contain 118 students among them 51 Boys and 67 Girls studying compulsory mathematics in Shree Latinath Secondary School Naugad 03, Khar Darchula as the population of the study. Among them in experimental group 30 students (12 boys and 18 girls). Similar as in control group there was 30 students (10 boys and 20

girls) were selected as sample of the study by using purpose sampling on school selection and sample size. The stratified random sampling method was used to form groups while maintaining balance in terms of ethnicity, sex, locality, maturity, and knowledge ability for both the control and experimental groups. Furthermore, the experimental group was divided into five equivalent subgroups, each consisting of six students.

Table 1

Distribution of experimental and control group

Group	Pre-test	Treatment	Post-test
Experimental Group	T_1	Problem Solving method	T_2
Control Group	T_3	Traditional Method	T_4

In the process of sample selection, the researcher chose Shree Latinath Secondary School, located in Naugad-03, Darchula, from among all secondary schools in Naugad Rural Municipality. The selection was based on convenience and suitability, making it appropriate for the experimental research design of the study. In Grade IX, there were a total of 118 students, comprising 51 boys and 67 girls. Section A included 52 students (20 boys and 32 girls), while Section B consisted of 66 students (31 boys and 35 girls). For the purpose of the research, two groups were formed: the experimental group, consisting of 30 students from Section A, and the control group, consisting of 30 students from Section B.

Table 2

Students in IX Shree latinath secondary school, Naugad 03, khar ,Darchula

Group	Boys	Girls	Total
Section A	20	32	52
Section B	31	35	66
Total	51	67	118

Table 3

Students in Experimental and Control group of Shree latinath secondary school, Naugad 03, khar ,Darchula

Group	Boys	Girls	Total
Experimental group	12	18	30
Control Group	10	20	30
Total	22	38	60

The achievement test paper was the main instrument for data collection the researcher developed two achievement test papers pre-test and post-test achievement test papers. These tests were developed based on the curriculum and the text book of class IX, as prescribed by the curriculum development center, utilizing the specification grid for

the secondary level. The researcher also used the specification grid of secondary level for preparing achievements test papers.

Achievement Test Paper (for pre-test)

This test consisted of 10 total questions derived from the topics of set theory and arithmetic. The total marks allocated were 25. The structure included 2 very short questions (1 mark each), 5 short questions (totaling 10 marks), 2 long questions (totaling 8 marks), and 1 very long question (5 marks). The questions assessed knowledge, comprehension, application, and higher ability levels the topics of set theory and arithmetic. The total marks allocated were 25. The structure included 2 very short questions (1 mark each), 5 short questions (totaling 10 marks), 2 long questions (totaling 8 marks), and 1 very long question (5 marks). The questions assessed knowledge, comprehension, application, and higher ability levels.

Table 4

Question Paper Blueprint for pre-test

Q.N. Type	Knowledge	Comprehensive	Application	higher ability	Total question	Total marks
very short	2(1a,1b)				2	2
Short		3(2a,2b,4a)	2(3a,3b)		5	10
Long			2(5,6)		2	8
very long				1(7)	1	5
Total	2	3	4	1	10	25

Achievement Test Paper (for post-test)

This test consisted of 15 total questions, based on the textbook topics of set theory and arithmetic for grade IX. The test was administered to both the experimental and control groups. The total marks were 35. The structure included 4 very short questions (totaling 4 marks), 7 short questions (totaling 14 marks), 3 long questions (totaling 12 marks), and 1 very long question (5 marks).

Table 5

Question Paper Blueprint for post-test

QIN. Type	Knowledge	Comprehensive	Application	higher ability	Total question	Total marks
very short	4(1a,1b,2a,2b)				4	4
Short		3(4a,4b,5a)	2(5b,3a,3b)	1(6a)	7	14
Long		1(7)	2(8,9)		3	12

very long				1(10)	1	5
Total	4	4	5	2	15	35

The researcher taught both the experimental and control groups for 15 days. The experimental group taught by problem solving method and control group taught traditional method. The experimental group taught set and arithmetic by problem solving approach and the control group was taught the same topic by traditional approach. Experimental group divided into five subgroups; there are 6 students in each group. Both the experimental and control groups taught by the researcher himself.

This research paper details a controlled educational experiment designed to measure the effectiveness of specific instruction methods while eliminating outside influences. To ensure scientific objectivity, the investigator utilized identical teaching modules and maintained a consistent interpersonal environment for both the experimental and control groups. Participants were carefully sorted based on demographic factors and prior knowledge to ensure that final test results purely reflected the impact of the teaching style. Following the instructional period, the researcher administered post-tests and student interviews to gather comprehensive data on academic performance. The findings were then scrutinized using statistical analysis, specifically employing t-tests at 0.05 level of significance and variance calculations to determine if the results were mathematically significant. Ultimately, this methodology highlights a rigorous approach to evaluating how different pedagogical strategies influence student achievement.

The t-test with two tailed was also applied in the post-test to compare the result of the boys and girls of experimental group. The interview schedule was analyzed to obtain the effect of problem-solving approach.

Result and Discussion

Effectiveness of the problem-solving method in teaching mathematics

Analysis of Pre-test Results

Pre-test analysis used to evaluate the initial standing of two specific research categories namely the experimental group and the control group. Researchers utilized this preliminary assessment to identify any existing performance gaps between these sets of participants before the main study began. To ensure the accuracy of their findings, they applied a two-tailed t-test to determine if the variations were statistically significant. This mathematical approach was essential for testing the null hypothesis, which assumes no inherent difference between the groups. Ultimately, the process ensures that the study's baseline is scientifically sound and clearly defined. The pre-test raw scores of the experimental and control group are presented in Table-5 and statistical calculation of the pre-test of both groups is presented in below table.

Table 6

Descriptive statistical analysis of experimental and control group for Pre-test

	Score of Control Group					Score of Experimental Group				
	Score	Frequency				Score	Frequency			
1	25	1	25	7.33	53.7289	25	1	25	7.64	58.3696
2	24	1	24	6.33	40.0689	24	2	48	6.64	88.1792
3	23	2	46	5.33	56.8178	23	1	23	5.64	31.8096
4	22	2	44	4.33	37.4978	22	1	22	4.64	21.5296
5	21	2	42	3.33	22.1778	21	2	42	3.64	26.4992
6	20	2	40	2.33	10.8578	20	2	40	2.64	13.9392
7	19	3	57	1.33	5.3067	19	2	38	1.64	5.3792
8	18	2	36	0.33	0.2178	18	3	54	0.64	1.2288
9	17	2	34	-0.67	0.8978	17	2	34	-0.36	0.2592
10	16	3	48	-1.67	8.3667	16	3	48	-1.36	5.5488
11	15	2	30	-2.67	14.2578	15	2	30	-2.36	11.1392
12	14	3	42	-3.67	40.4067	14	3	42	-3.36	33.8688
13	13	2	26	-4.67	43.6178	13	3	39	-4.27	54.6987
14	12	3	36	-5.67	96.4467	12	3	36	-5.27	83.3187
		N=30					N=30			
Total Students (n)= 30						Total Students (n) = 30				
Mean = 17.67						Mean = 17.36				
Variance = 14.35						Variance = 14.34				
Standard Deviation = 3.79						Standard Deviation = 3.78				
Coefficient of Variation= 21.44%						Coefficient of Variation: 21.77%				

Comparison of pre-test result of Table-6

Group	No.of students	Mean	SD	CV	calculated value of t-test	level of significance
Experimental	30	17.36	3.78	21.77%	0.31	Two tailed test at 0.05
Control	30	17.67	3.79	21.44%		

The above table-6 shows that mean score of experimental and control group were 17.36 and 17.67 with standard deviation 3.78 and 3.79 respectively. The mean difference between two groups was found 0.31. The coefficient of the variance of the achievements scores of both group were found approximately same and also the calculated t-test value is 0.31 is less than tabulated value 2.005 at the 0.05 level of significance. Hence the researcher concludes that there is no significance difference between the achievement of experimental and control group students in pre-test result.

Analysis of Post- test Result

The post-test score of students of the experimental group and control group deviation and corresponding t-value of experimental and control groups on the post -test is presented below in Table-7

Table 7

Descriptive statistical analysis of experimental and control group for Post-test

	Score of Control Group					Score of Experimental Group				
	Score	Frequency				Score	Frequency			
1	35	1	35	9.04	81.7216	35	4	140	4.6	84.64
2	34	1	34	8.04	64.6416	34	3	102	3.6	38.88
3	33	1	33	7.04	49.5616	33	3	99	2.6	20.28
4	32	2	64	6.04	72.9632	32	4	128	1.6	10.24
5	31	1	31	5.04	25.4016	31	3	93	0.6	1.08
6	30	2	60	4.04	32.6432	30	3	90	-0.4	0.48
7	29	3	87	3.04	27.7248	29	2	58	-1.4	3.92
8	28	1	28	2.04	4.1616	28	2	56	-2.4	11.52
9	26	1	26	1.04	1.0816	27	1	27	-3.4	11.56
10	25	2	50	-0.96	1.92	26	1	26	-4.4	19.36

11	24	3	72	-1.96	11.5248	25	1	25	-5.4	29.16
12	23	3	69	-2.96	26.2848	24	1	24	-6.4	40.96
13	22	4	88	-3.96	62.7264	22	2	55	-8.4	141.12
14	21	2	42	-4.96	98.4064					
15	20	3	60	-5.96	106.5648					
		n=30					n=30			

Total Students = 30	Total Students = 30
Mean = 25.96	Mean = 30.4
Variance = 22.24	Variance = 13.77
Standard Deviation = 4.71	Standard Deviation = 3.71
Coefficient of Variation = 18.14%	Coefficient of Variation = 12.20%

Comparison of post-test result of Table-7

Group	**No.of students**	**Mean**	**SD**	**CV**	**calculated value of t-test**	**level of significance**
Experimental	30	30.4	3.71	12.20%	4.037	Two tailed test at 0.05
Control	30	25.96	4.71	18.14%		

The study demonstrated that students in the experimental group, who were taught using a problem-solving approach, achieved a higher mean score of 30.4 with a standard deviation of 3.71, whereas the control group using a traditional approach scored a mean of 25.96 with a standard deviation of 4.71. Beyond higher average scores, the experimental group showed greater consistency in their results, evidenced by a coefficient of variance (C.V.) of 12.20%, which was notably lower than the control group's C.V. of 18.14%. Statistical analysis confirmed these findings, as the calculated t-test value of 4.037 was significantly higher than the tabulated value of 1.96 at the 0.05 level of significance, allowing researchers to conclude that the problem-solving approach leads to significantly better academic achievement than traditional teaching methods.

Comparison between problem-solving approach with traditional methods in teaching mathematics to grade IX students

The comparison of post -test Results of boys and girls of experimental group.

The post-test of students of experimental group with achievement of boys and girls are presented in Table-9 the mean, standard deviation of scores obtained by experimental group students in the post-test were presented in the table-7 given below.

Table 8

Descriptive statistical analysis of boys and Girls

	Boy's					Girl's				
	Score	**Frequency**				**Score**	**Frequency**			
1	35	1	35	4.92	24.2064	35	3	105	5.32	84.9072
2	34	1	34	3.92	15.3664	34	2	68	4.32	37.3248
3	33	2	66	2.92	17.0528	33	1	33	3.32	11.0224
4	32	2	64	1.92	7.3728	32	2	64	2.32	10.7648
5	31	1	31	0.92	0.8464	31	2	62	1.32	3.4848
6	30	1	30	-0.08	0.0064	30	2	60	0.32	0.2048
7	29	1	29	-1.08	1.1664	29	1	29	-0.68	0.4624
8	28	1	28	-2.08	4.3264	28	1	28	-1.68	2.8224
9	22	2	44	-8.08	130.5728	27	1	27	-2.68	7.1824
						26	1	26	-3.68	13.5424
						25	1	25	-4.68	21.9024
						24	1	24	-5.68	32.2624
		N=12					N=18			
Total Students = 12 Mean = 30.08 Variance = 16.74 Standard Deviation = 4.09 Coefficient of Variation = 13.59%						Total Students = 18 Mean = 29.68 Variance = 12.54 Standard Deviation = 3.54 Coefficient of Variation = 11.92%				

Comparison of post-test results of the boys and girls of experimental group of table 8

Boys/Girls	**No. of students**	**Mean**	**SD**	**CV**	**calculated value of t-test**	**level of significance**
Experimental (Boys)	12	30.08	4.09	13.59%	0.28	Two tailed tests at 0.05
Experimental (Girls)	18	29.68	3.54	11.92%		

The above table-8 indicate that when students are taught using a problem-solving approach, there is no significant difference in how well boys and girls perform. In a study, boys scored an average of 30.08 and girls scored 29.68 with standard deviation 4.09 and 3.54 respectively showing a very small difference of only 0.40 and the coefficient of variance of the achievement score of the both groups were 13.59% and 11.92% respectively. The C.V of both groups are nearly about same. Statistical tests confirmed that this gap was not large enough to be meaningful, leading researchers to conclude that the effectiveness of this teaching method is not affected by gender.

Furthermore, the study highlight that the problem-solving method is more effective than traditional teaching methods. Students who were taught through problem-solving had higher achievement levels than those taught the traditional way. Because the method works well for both boys and girls, it is considered a gender-neutral way to improve learning outcomes.

The researcher fixed 15-day time period for this study. The researcher taught experimental group by the problem solving and control group by traditional approach. During this teaching it was seen that presence of students of experimental group also increased. The students of experimental group were seen more interested and curious during teaching and learning mathematics that of control group. During the experimental, the progress of experimental group was found better than that of control group. The uses of problem-solving approach had really made the researcher fully devoted in teaching with well preparation. When the researcher took post-test after 15 days experiment, he found that the achievement level of experimental group was seen better than that of control group.

In this section of the study, students expressed a highly positive response toward the problem-solving method. They showed great enthusiasm in participating and responding to the teacher's questions during the lessons. Initially, the researcher prepared eight questions related to both the problem-solving and traditional teaching methods. Five students were then randomly selected from the experimental group for detailed observation. These students had not been previously exposed to the problem-solving approach, as their earlier classes primarily relied on lecture-based, teacher-centered, and explanatory methods with minimal focus on problem analysis. Once the instruction shifted to a problem-solving approach, the students became more engaged and familiar with identifying and addressing mathematical problems systematically. This approach encouraged them to think critically and work through problems step by step, making the learning process more meaningful and effective. The method, grounded in identifying possible problems and exploring their solutions during classroom instruction, proved to enhance students' understanding and confidence in mathematics.

Problem solving method is student centered method. Since the students gain

knowledge by step to step both teacher and students are good participants. Problem solving method is sequential programmed in classroom instruction. It is also recognized as an example of a scientific approach of learning which mentions the rational competition of students in a group or individual. Every student was very excited to learn by problem solving method. The implementation of the problem-solving method sparked a profound shift in student engagement and academic confidence. Previously, students reported a growing sense of anxiety and alienation under traditional instructional methods, which they felt rendered mathematics increasingly impenetrable. In contrast, the problem-solving approach was met with unanimous enthusiasm; students perceived no negative drawbacks and expressed a heartfelt preference for this pedagogical style. This positive reception led to a collective recommendation that the method be applied to the entire curriculum, as it successfully transformed a once-daunting subject into one that was both accessible and emotionally manageable. Students pointed so many differences about traditional method and problem-solving method and suggested that every subject should be taught by taught by problem solving method.

Conclusion

Based on the statistical analysis, it was concluded that the problem-solving approach plays a significant role in enhancing students' learning in mathematics. The findings revealed that this approach effectively reduces gender disparities, demonstrating equal benefits for both boys and girls. Moreover, students taught through problem-solving methods showed greater engagement and interest in mathematics compared to those taught through traditional methods. The results further indicated that the problem-solving approach not only improves mathematical achievement but also fosters meaningful motivation, encouraging students to actively participate and develop a positive attitude toward learning mathematics.

In summary, the findings of the study reveal that the problem-solving pedagogical approach is significantly more effective than traditional teaching methods in facilitating the learning contents of mathematics among grade IX students. This approach not only fosters a deeper conceptual understanding of mathematical concepts but also cultivates analytical thinking and active engagement in the learning process. Furthermore, students taught through the problem-solving approach demonstrated higher levels of motivation and interest in mathematics, which contributed to their improved performance in achievement tests. These results suggest that incorporating problem-solving strategies into mathematics instruction can create a more dynamic, student-centered learning environment that promotes both academic success and a positive attitude toward the subject.

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