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Effect of Problem-Solving Teaching Method on Improvement of Higher Order Thinking Skills of Early Childhood Teachers in Mathematics

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Abstract

Mathematics subject is known as the queen of all subjects. In Pakistan it is taught as a compulsory subject from class one to secondary level but it is also considered the uninterested subject for the students. There are many reasons but the major one is the teaching method of the teacher. This study was intended to find Problem Solving Teaching Method having effect on the improvement of HOTs among Prospective teachers at early childhood level who learn Mathematics at the University level. The major objectives of the present study were; to find out the effect of the Problem Solving Teaching Method on element of conceptual knowledge sub level analysis, evaluating and creating. This study was true experimental double control group. The sample of this study consisted of 75 Prospective teachers from department of Education, International Islamic University Islamabad. The students were from BS Education group of fifth semester, for the collection of data course contents of mathematics including theoretical geometry, practical geometry and word problem of BS Education of the 5th semester were selected. Data were analyzed by using Pre-test, post-test, Levene test, ANOVA, Post Hock analysis, mean and standard deviation. The major finding showed that the achievement scores of per-test and post-test of experimental group were significant. The achievement scores of both control groups-I and II showed non-significant difference. The difference between the achievement scores of control group-I and II were same to some extent. The major conclusion of the study was that problem solving method of teaching developed the higher order thinking skills among the prospective teachers as compete to conventional method, so this method may be added in professional training of mathematics science teachers.

Keywords: Problem Solving Method, Higher order thinking, Early childhood level teachers

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Introduction

As Higher Order Thinking Skill is a fundamental ability of thinking and using mathematical knowledge to achieve tasks like reasoning, problem solving, communication, questioning, and conceptual skills, teaching mathematics nowadays is more concentrated on teaching students to think higher level (HOTS). These capabilities are crucial for mathematical research. Due to the shortcomings of this talent, learning mathematics presents several difficulties. As they use their abilities to expand their mathematical knowledge as lifelong learning, students should be able to create learning objectives (Muhtarom, 2019).

Problem Solving Teaching method is a resource for developing skills of problem solving that student will be able to use to solve everyday problems. It can also be used as a tool for learning more about something in-depth. Yaun (2013) asserts that the majority of mathematicians are influenced by the works of Polya and Dewey. The Problem Solving Teaching Method in mathematics instruction can help pupils develop their sense of discovery or learning. Higher Order Thinking Skills can be developed via the Problem Solving Teaching Method. According to several studies (Walshaw, 2012; Schoenfeld, 2010); Weber, 2008) that the problem-solving strategy is regarded as an excellent way to teach mathematics, (Prayitno, 2018)

The current problem-solving focus in mathematics education is credited to George Polya. He authored several books on mathematics and was a well-known mathematician. Polya offered a four-step approach in his book "How to solve" to resolve the issue. The popularity of this teaching strategy has been noted by Weber (2008). The most popular technique for honing problem-solving abilities is this one. "Problem solving is a means to build mathematical problem-solving skills," claims Polya (1980). Students are allowed to become autonomous researchers and apply this approach to real-world math challenges. Higher level abilities like analysis, integration, assessment, and creativity can be developed by pupils thanks to it (Kholid et al, 2020).

This four-step approach to solving arithmetic problems is methodical.

Step 1: Understanding the problem

Based on the available information, the exact problem is now understood. You may ask questions and make charts and diagrams to help you comprehend various things. These requests are all dependent on the type of the issue (Polya, 1980).

Step 2: Developing a Plan

Students are eager to understand the connection between known and unknown facts at this point. The problem is better understood at this stage. For this, a similar-type problem is brought up with the pupils. Students are asked to recall and answer a comparable problem if they are familiar with it. It might take a while and be challenging to go from understanding the issue to modeling a program. You can create the problem statement using a "great thought" or "help problem" (Polya 1980).

Step 3: Implementing the Plan

This step involves putting into practice the solution that was chosen after meticulous planning in step 2. Making a strategy and putting out an idea are difficult tasks. It takes a lot of practice. On the contrary, applying it is simple. It gives us an overview of the program, but to test its functionality, we must input data. Given that a lot of effort has already been done, the instructor can use this information if the pupils intend to solve the problem. Students forgetting the plan are the major risk at this time, but that happens when they ask for it. They feel content when they grow as individuals (Polya, 1980).

Step 4: Retrospective

Students are required to validate their answers at this level by using them in a different scenario. At this point, students research new theories and attempt to verify their judgments by contrasting the known with the unknown. Retrospective entails repeatedly re-examining the outcomes and the method of resolution to improve your understanding and cultivate the capacity to resolve such cases on your own in real-world situations. The instructor must clarify that the answer to this issue is merely a step in the trip, not its final goal (Polya 1980).

Students can infer, examine, test, analyze, synthesize, evaluate, and develop a better grasp of creativity via problem-solving. The ability to accomplish the practical, logical, and aesthetic objectives of mathematics instruction makes the problem-solving approach an essential teaching tool in mathematics (Schoenfeld, 2010). As stated by Polya (1980), "If education doesn't help people become more intelligent, it isn't complete. However, intelligence is fundamentally the capacity to address both common and unique challenges" (Kolawole, 2011). The usefulness of problem-solving techniques on various brain functions has been demonstrated by several researchers. Although Polya's approach to problem-solving aids in the development of several mental skills that can be portrayed in educational materials. We can get learning results from students using a framework that classifies educational objectives. Therefore, it is crucial that Polya's problem-solving approach may be evaluated against some established taxonomy to prove its efficacy (Betne, 2010; Ellis, 2011).

Rationale of the study

The subject of mathematics is considered the uninterested subject for students and many large scale assessment agencies like PISA, TIMMS and OECD showed that the students just have route memorization of mathematics and no understanding of the subject. The main reason for this is the pedagogy of the teacher. If teachers are trained with emerging pedagogies they may teach math4matics in a good way. Polya's Problem Solving method is a currency method for teaching of mathematics therefore, this method is checked to train the prospective teachers of early childhood teachers for the improvement of Higher Order Thinking Skills/

Statement of the Problem

Through Problem Solving Method problem solving skill can be developed. The intent of the present study was to find out the effect of problem solving method on the improvement of higher order thinking skills of early childhood teachers in the subject of mathematics

Objective of the Study

1. To find out the effect of problem solving teaching method on improvement of conceptual knowledge sub level analyzing.
2. To check the effect of problem solving teaching method on the improvement of conceptual knowledge sublevel evaluating.
3. To determine the effect of problem solving teaching method on the improvement of conceptual knowledge sub level creating.

Hypothesis of the Study

Ho1: There is no significant effect of the problem solving teaching method on the mean achievement scores at element of conceptual knowledge sub level analyzing in Mathematics.

Ho2: There is no significant effect of the problem solving teaching method on the mean achievement scores at the element of conceptual knowledge sub level evaluating in Mathematics.

Ho3: There is no significant effect of the problem solving teaching method on the achievement scores at element of conceptual knowledge sub level creating in Mathematics.

Significance of the Study

The study may be useful for future university-level mathematics prospective teachers who plan to employ a problem solving technique to instruction. The development of lesson plans by means of the problem solving method would be beneficial for prospective teachers. It would be beneficial for curriculum designers to provide courses that might aid in choosing the material for problem solving techniques. Utilizing this strategy to instruct prospective teachers using the Revised Blooms' Taxonomy may be beneficial to universities.

Delimitations of the Study

1. The study's focus was the Revised Bloom's Taxonomy's conceptual knowledge sub-levels of analysis, evaluating, and creating.
2. The study was delimited to the department of education, International Islamic University Islamabad having 85 prospective teachers.
3. The study was delimited to the 4^{th} semester of the BS in Education's mathematics word problems, real-world geometry, and theoretical geometry.

Review of Literature

The development of higher order thinking abilities is crucial to learning. How well someone thinks can affect how quickly and well they learn. Thus, it is important to focus on developing students' critical thinking abilities during the learning process (Heong et al., 2011). After learning, student creativity is a type of flexibility based on creative thinking abilities. Thinking pupils are aware of the relevance of the material they are taught to everyday life and acquire the skills necessary to comprehend difficulties and find straightforward solutions. Thus, by creating mathematical educational activities supported on unique teaching and learning techniques that can progress students' analytical abilities, teachers can help students esteem and promote critical thinking abilities (Runisah, Herman, & Dahlan, 2016). We can speed up the shift from low-level patterns to higher-level patterns and improve cognitive processes in children if we carefully study their mathematics thinking processes and talents (Sezer, 2019).

A key component of schooling is HOTS. If the teacher intentionally fosters higher order thinking skills improvement, by supporting students to engage in problem of real world, discussions in classroom, and experiments based on inquiry, then students will have a great opportunity to do so (Miri, David, and Uri, 2007). In addition to being successful at enhancing students' academic performance, HOTS training also focuses on their deficiencies (Heong et al., 2019). Additionally, Pogrow (2005) promotes HOTS educational initiatives that help kids get ready for challenging coursework, careers, and future responsibilities. Thus, it is possible to forecast student progress using HOTS. It is anticipated that students with high HOTS scores will succeed in their subsequent academic endeavors (Muhtarom et al, 2019).

Problem-solving methods provide an emphasis on crucial mathematical ideas and techniques that are best taught through activities or tasks that require students to think critically about the crucial mathematical ideas and abilities they must learn. A methodical process of envisioning and comprehending a problem, creating solutions, and assessing those solutions for execution is problem-solving (Allen and Graden, 2002). "Problem-solving" in mathematics education refers to mathematical exercises with the potential to present intellectual challenges to strengthen students' comprehension and growth of mathematics. These exercises can raise students' conceptual knowledge, encourage mathematical reasoning and communication, and pique their interests and curiosities (Cai & Lester, 2010). Problem-solving methods provide an emphasis on crucial mathematical ideas and techniques that are best taught through activities or tasks that require students to think critically about the crucial mathematical ideas and abilities they must learn. The process of thinking and comprehending an issue, coming up with solutions, and then deciding which solutions to use is known as problem-solving. "Problem-solving" in mathematics education refers to mathematical exercises with the potential to present intellectual challenges to strengthen students' comprehension and growth of mathematics. These exercises can raise students' conceptual knowledge, encourage mathematical reasoning and communication, and attract their interest and curiosities (Cai & Lester, 2010).

Students at various achievement levels collaborate in groups as well as in pairs for learning mathematical ideas by problem solving tricks in learning environments that use a problem-solving technique to teach mathematics, but the necessary solutions and processes are not explicitly specified. They are at work. Students must therefore investigate ideas, gain a grasp of problems, connect them to previously studied mathematics, and utilize the proper mathematical techniques to solve them. Students of varying achievement levels work in pairs or small groups to complete problem-solving tasks or activities where the solutions and processes involved are not entirely grasped in learning environments that apply a problem-solving approach to teaching mathematics. Students must therefore investigate ideas, comprehend problems, connect them to previously studied material, and employ proper math techniques that result in problem solutions (Marzuki et al, 2019).

Aims of Teaching Mathematics at University level

Of course, the direction a student's study takes based on several upper math courses determines their specialism. Consequently, it is necessary to profile university mathematics courses. Such a curriculum's development and justification of the inclusion of several branches of mathematics required a great deal of work. The availability of mathematics to students, the growth of thinking while studying, and teachers' estimations of the pupils' ages and unique qualities are all considered to be essential components of mathematical education. Of course, not all educators are capable of applying these opposed ideas to some extent (Zimina, 2005).

The curriculum and the way it is implemented are tools for achieving the objectives of math instruction. Contemporary intentional management dictates that they ought to be chosen subsequent to clearly outlining their objectives and prioritizing them because it is impossible to accomplish everything at once with the resources available. Math teachers have the idea that they wait until they see the numbers before solving a problem. It is feasible to determine realistic mathematical values for the comparative precedence of learning mathematics targets based on Saaty's (2011) theories. The hierarchy of goals in the teaching of mathematics is not taken into account in the undergraduate training of only the technical, economic, and humanities are taught in institutions to aspiring mathematicians, physicists, and other professionals in the basic sciences (Tan and Halili, 2017).

Concept of Problem Solving Teaching Method

It provides students with the chance to ask questions, take chances, learn new ideas, put information to use, deal with real-world challenges, and experience the excitement of discovery. The ideal learning environment for problem-based learning, according to Pettersen (2017), is focused on the students. The student is the main participant in the educational process. Instead of passively copying, discovering, and learning from the material they are given, the aim of learning is for students to actively and creatively participate in group work and individual study to transmit skills and knowledge. Students are given the flexibility to autonomously and intentionally choose the learning tactics and timetables they want to use through individualized, independent and self-directed learning. Inspiring children to pursue independent learning is a teacher's greatest accomplishment. The teacher in problem based learning serves as a facilitator relatively than the main information provider or communicator. According to Roh (2003), problem-based learning environments place a greater emphasis on a teacher's teaching abilities than do traditional, teacher-centered classrooms. The situation where problem-based learning is applied so the teacher ought to help students organize information and apply knowledge in actually useful contexts in addition to introducing them to mathematical concepts (Abdullah and Fadil, 2019).

Application of Revised Bloom Taxonomy in Teaching of Mathematics

Using teacher-revised materials to teach mathematics, Bloom's taxonomy aids in modifying student thinking task depend on the setting of the classroom. Students learn more, retain it longer, and think more. Advanced thinking skills are described as making considerable use of the mind to generate new difficulties by Heong et al. (2019). Utilizing both new and prior knowledge, advanced thinking skills involve manipulating information to identify potential solutions in novel situations. Teachers will benefit immensely from Bloom's updated taxonomy, which groups students' thinking abilities into six levels, from low to high. It is anticipated that when students gain experience responding to questions concerning their problem-solving requirements in daily life, their problem-solving abilities will enable them to attain their learning objectives in the best possible way (Sajidah et al, 2021).

Bloom's Taxonomy (Bloom, 1956) has had a significant manipulation on teaching and evaluation round the world for more than 50 years and is yet frequently applied in education of mathematics. For example, Kastberg (2003) and Vidakovi, Bevis, and Alexander (2003) offer illustrations of techniques used by math teachers in high school and college to develop assessments. The Bloom Taxonomy has been utilized in several studies to establish whether a test is a LOT or HOT. Analytical, synthesis and evaluative thinking abilities are fascinating, but many Bloom Taxonomy thinking skills involve information and understanding. Frequently, applications fit into both categories (Widjaja, 2013).

Cognitive Process Dimension of Revised Bloom Taxonomy

There are six categories for the dimensions in this classification. It describes a process of learning in which pupils are anticipated to gain knowledge as a result of instruction (Anderson, 2001).

1. **Remembering**

Students are expected to notice and retain pertinent knowledge and facts from long-term memory in this element. This dimension has two major subcategories: recognition and recall, which refers to the capacity to instantly recall and access prior knowledge (Anderson, 2001).

2. **Understanding**

This aspect of cognitive processes relates to students' comprehension of meaning, their capacity to clarify and paraphrase ideas, and their capacity to infuse their meaning into their knowledge (Anderson, 2001).

3. **Applying**

A cognitive process having this feature is concerned with the capacity to apply learned information in comparable or novel circumstances. Execution and implementation in both new and old situations are examples of learning outcomes (Anderson; Lorin & David; Krathwohl, 2012).

4. **Analyzing**

Analyzing is a cognitive process that entails breaking knowledge down into its component elements and examining those parts to comprehend the whole. Identification, organization, and attribution are the learning outcomes associated with this ability. It also contributes to higher-order thinking abilities (Anderson; Lorin & David; Krathwohl, 2012).

5. **Evaluating**

This talent is a part of higher thinking. This competency's learning outcomes include investigation and critique (Anderson; Lorin & David; Krathwohl, 2012).

6. **Creating**

The redesigned Bloom taxonomy now includes this new component. It is not categorized previously. The old classification synthesis has been replaced with this, which is the maximum capacity. Combining existing knowledge to produce fresh insights and creating something new. The ability to put bits of knowledge together to create new concepts and things is the foundation for learning outcomes. Students are expected to accomplish tasks like generating plans and coming up with new ones to measure this competence (Anderson, 2001).

Revised Bloom Taxonomy' Knowledge Dimension

The second dimension in the two Revised Bloom Taxonomy techniques is knowledge. It contains four dimensions, each of which represents a different quality. The study of mathematics is crucial for both individual and societal development. However, Pakistani students' performance in this subject is very well. Traditional teaching strategies promote lower-order thinking abilities, whereas curricula call for higher-order thinking abilities. Polya's problem solving approach is a distinguished technique that may be assessed using Bloom's revised taxonomy for making Higher Order Thinking Skills. Therefore, an attempt was prepared to evaluate how this approach affected the updated Bloom taxonomy in the context of Pakistan through this study (Anderson; Lorin & David; Krathwohl, 2012).

Research Methodology

Research Design

The study was true-experimental pre-test post-test (double control group) design. To minimize the effect of extensors variable double control group design was used. The current study is set up in a manner that the modification may be credited to the independent variable (Polya's Problem Solving Teaching Method), as well as to reduce the impact of auxiliary factors (Teachers' Qualification and Experience) and random variables (Instrument and population).

Population

The population of the study consists of 75 prospective teachers of the department of Education, International Islamic University Islamabad. These are further divided into a double control group and an experimental group.

Sample and Sampling Procedure

The current study was quantitative in nature and true experimental pre-test post-test (double control group) design was used. The targets cliental for the experiment were 75 prospective teachers. Each group was consisted of 25 prospective teachers.

Research Instrument

The pre-test and post-test research instrument consisted of Mathematics contents of theoretical geometry, practical geometry and word problem of BS Education 4th semester.

Validity and Reliability

To validate a test created for Prospective teachers based on a conceptual knowledge component, ten experts were consulted. The test items and treatment were modified in light of the expert's opinions. The usage of action verbs for the various levels, which were enhanced, was the main issue raised by experts in regards to the test. The scale and its subscales were subjected to an alpha reliability analysis. Results reveal that reliability varies from α = .91 (i.e. evaluating) to α = .94 across all scales and subscales (i.e. Creating, Overall abilities). Hughs alpha reliability of the three sub scales (i.e., α >.88), that can be used with confidence.

Data Collection

The instrument used for data collection was a pre-test consisting of the items of analyzing, evaluating, and creating. Post-test was also similar as the pre-test by shuffling the items. Pre test consisting of marks 100 was managed with 75 prospective teachers. Based on obtained marks they were alienated into three frames of sampling for randomization:

Table 1

Marks allocation into Groups of Pre-Test

Groups	10-30	15-30	31-40
Number of Prospective Teachers	25	25	25
Proportionately randomly selected respondents from each group	09+08+08	08+09+08	08+08+09

Table 2

Structuring of Post-Test Groups

Group 1 (Control)	Group 2 (Control)	Group3(Experimental)
09+08+08=25	09+08+08=25	08+09+08=25

Three sampling frames were created based on pre-test results. Three groups were created after proportionate numbers of students were randomly chosen from each sample frame. Three routine class sections were the chosen three groups' names (Section-A, B, and C). Section B and C were handled as control groups whereas Section-A was treated as the experimental group. Each control group comprised of 25 prospective teachers and 25 prospective teachers in experimental group, for a total of 75.

Results

After doing analysis of normal distribution on the variables of study for the Control Group I, II, and Experimental Groups, it was discovered that every variable of the study and each group's overall performance fit the definition of a normal distribution. The reliability and validity of the results based on mean and SD were demonstrated by the fact that all study variables including analyzing, creating, evaluating, and whole abilities were verified using p-p probability plot. The entire points were located close to straight line and displayed normal distribution characteristics. Control group I, II and experimental group all met the requirement for Levene Test on the homogeneity of Variances.

Table 3
Study Variables' Normal Distribution Analysis among Control Group-I

	Kolmogorov-Smirnov			Shapiro-Wilk		
Variables	Statistic	*df*	*P*	Statistic	*df*	*P*
Evaluating	.19	25	1.00	.49	25	.45
Analyzing	.28	25	3.02	.31	25	.56
Creating	.25	25	.09	.01	25	.29
Overall abilities	.12	25	.67	.20	25	.11

Table 3 displays the results for the analysis of normal distribution of study variables for the Control Group I's conceptual element of the Revised Bloom's Taxonomy. Results indicate that results were not statistically significant for either test, including Kolmogorov-Smirnov and Shapiro-Wilk ($p>.05$ = Normal Distribution). Similar to how the whole abilities were not considerable ($p>.05$ = Normal Distribution), the data conformed to the normal distribution assumptions.

Table 4
Study Variables' Normal Distribution Analysis among Control Group II

	Kolmogorov-Smirnov			Shapiro-Wilk		
Variables	Statistic	*df*	*p*	Statistic	*df*	*P*
Evaluating	.15	25	.85	.45	25	.40
Analyzing	.18	25	1.01	.27	25	1.09
Creating	.22	25	1.44	.06	25	2.12
Overall abilities	.15	25	.22	.38	25	.23

Table 4 displays the results for the analysis of normal distribution of study variables for the conceptual element of the revised Bloom's taxonomy among Control Group II. Results indicate that results were not statistically significant for either test, including Kolmogorov-Smirnov and Shapiro-Wilk ($p>.05$ = Normal Distribution). The results of the abilities variable as a whole were also non-significant, which met the requirements of data normality.

Table 5

Study Variables' Normal Distribution Analysis among Experimental Group

	Kolmogorov-Smirnov			Shapiro-Wilk		
Variables	Statistic	*Df*	*P*	Statistic	*df*	*P*
Evaluating	.07	25	1.21	.19	25	.87
Analyzing	.05	25	.40	.18	25	5.24
Creating	.04	25	.31	.13	25	.80
Overall abilities	.17	25	.55	.12	25	2.13

Table 5 displays the normal distribution analysis for the experimental group's study variables. Results demonstrate that study variables and general abilities were non-significant on both tests, together with Kolmogorov-Smirnov and Shapiro-Wilk (p >.05 = Normal Distribution), that satisfied the hypothesis of data for normal distribution.

Table 6

Levene Test of Control Group-I, II and Experimental Group

Groups	Levene Statistic	*df1*	*df2*	*P*
Control Group I	1.44	2	25	.22
Control Group II	1.86	2	25	.44
Experimental Group	1.27	2	25	.36

Levene Test results for the Experimental Group (P=.36), Control Group I (P=.22), and Control Group II (P=.44) are shown in the above table. The findings demonstrate that Levene test results of all groups were non-significant (p>.05 = Equal Variance), satisfying the homogeneity of variation assumption.

Table 7

Analysis of One Way ANOVA for Problem Solving Teaching Method effect & Conventional Teaching Method on Outcome variables for Control Group 1, 2 and Experimental Group

	Experimental Group		Control Group-I		Control Group-II				
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*P*	*Ή*
Outcome	64.33	17.23	52.16	10.32	47.08	10.73	22.38	.00	.35

For the Experimental Group, Control Group 1 and 2, Table 7 displays the results of a One Way ANOVA analysis to establish the impact of the Problem Solving Teaching Method on the outcome variables. According to the findings, the experimental group's mean was significantly superior to that of control groups 1 and 2 (M = 52.16, SD =10.32; t = 6.61, and M = 47.08, SD =10.73, respectively) (M = 64.33, SD =17.23; F= 22.38 p<.01, ή =.35). Although many differences between the control group 1, experimental group as well as Control Group 2 were observed, Post Hoc analysis was used to further examine these differences. In terms of mean and standard deviation, the data demonstrate that the Experimental Group outmatched Control Group 1and 2 in terms of achievement scores. Therefore, teaching by Problem Solving Teaching Method was more efficient than teaching by Traditional Method in the teaching of Mathematics. The control group 1's (M = 52.16, SD =10.32; t = 6.61) and control group 2's (M = 47.08, SD =10.73) similar changes in mean and standard deviation indicate that Groups I and II's performances were somewhat similar, and the change was due to the teaching style of the teachers because the teacher role might not be disregarded.

Table 8

Post Hock Analysis of Problem Solving Teaching Method effect on Outcome variables for Control Group 1, 2 and Experimental Group

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	*p*	95% CI *LL*	95% CI *UL*
Outcome	Control Group 1	Control Group 2	3.08	.53	-3.87	10.06
		Experimental Group	-15.17*	.00	-22.12	-8.23
	Control Group 2	Control Group 1	-3.08	.53	-10.06	3.87
		Experimental Group	-18.27*	.00	-25.22	-11.33
	Experimental Group	Control Group 1	15.16*	.00	8.22	22.13
		Control Group 2	18.26*	.00	11.34	25.23

*p< .01

The effects of the problem solving technique on the outcome variables for the experimental group, control group 1 and 2 are shown in the table 8 using Post Hock Analysis (Tuckey HSD technique). Outcomes indicate that when compared to Control Group 1 and 2, which were taught using the standard style of instruction, Method of teaching by Problem Solving produces excellent results on the outcome variables of analyzing, evaluating, and creating. The information in the table above thus provides evidence that the Problem Solving Teaching Method had an impact on the Revised Bloom's Taxonomy.

Table 9

Groups' mean in Homogeneous subsets for Problem Solving Teaching Method effect on Outcome variables for Control Group 1, 2 and Experimental Group.

		Subset for alpha = 0.05	
Groups	*N*	1	2
Control 2	25	47.07	
Control 1	25	50.16	
Experimental Group	25		65.34
Sig.		.54	1.00

The means for groups in homogeneous subsets are shown in table 9. The sample size using the harmonic mean was 43.32. Unequal group sizes existed. The group sizes' harmonic mean was applied. Error levels of type I was not assured.

Table 10

Descriptive Statistics among Experimental Group's Study Variables

Variables	*N*	Minimum	Maximum	*M*	*SD*	Skewness	Kurtosis
Evaluating	75	4	18	11.54	3.20	.12	-.62
Analysis	75	4	20	10.83	3.30	.51	-.10
Creating	75	0	16	5.17	4.29	.69	-.50
Overall abilities	75	20	94	54.28	15.79	.46	-.48

Table 10 displays descriptive statistics for the experimental group's study variables. The findings indicated that the data were normally distributed (i.e., Skewness = 2, Kurtosis = 2), and as a result, the Experimental Group did not experience any symmetry or routine problems. This establishes a foundation for further investigation and the validity of the estimated results.

Table 11

Descriptive Statistics among Study Variables for Control Group-I

Variables	*N*	Minimum	Maximum	*M*	*SD*	Skewness	Kurtosis
Evaluating	25	4	16	10.23	2.80	-.05	-.69
Analysis	25	4	14	9.26	2.26	.18	.05
Creating	25	0	10	2.37	2.27	1.41	2.72
Overall abilities	25	26	72	47.07	10.77	.30	-.44

Descriptive statistics for Study variables were displayed in this table for Control Group 1. The data was found to be normally distributed (Kurtosis < 2, Skewness < 2), hence there was no symmetry problem in Control Group I, and the data were found to be regularly distributed.

Table 12

Results of Descriptive Statistics and t-test for Pretest and Posttest Differences on Outcome Variables in Control Group-1

	Pretest (*n* = 25)		Posttest (*n* = 25)				95% CI		
Outcome	*M*	*SD*	*M*	*SD*	*r*	*t*(42)	*LL*	*UL*	*Cohen's d*
Evaluating	10.42	1.93	11.42	2.27	.81**	5.03**	1.43	.61	.47
Analysis	10.09	1.79	10.42	1.77	.91**	2.84*	.55	.09	.19
Creating	3.26	2.50	3.33	2.59	.95**	.82	.32	.13	.03
Overall abilities	45.84	9.57	51.14	10.34	.94**	8.43**	5.36	3.29	.43

*$p < .05$, **$p < .01$

The Control Group-I outcome variables' descriptive statistics and the results of the t-test for the pretest and posttest are shown in the table 12. According to the findings, there were significant differences on the posttest in the areas of assessing (M = 11.42, SD = 2.27; t = 5.03, p>.01, Cohen's d =.47), analyzing (M = 10.42, SD = 1.79; t = 2.84, p>.05, Cohen's d =.19), and overall abilities (M = 51.14, SD = 10.34; t = 8.43, p>.01, Cohen's d =.43) The findings on creation were not statistically significant

(M = 3.33, SD = 2.59; t =.82, p>.05, Cohen's d =.03). It was possible to draw the conclusion that although there were significant variations in the results, they were too tiny and had smaller effect sizes than those of the experimental group.

Table 13

Comparison of Mean difference for Experimental Group with Control Group-I

Outcome Variables	Experimental Group		Difference	Control Group-I		Difference
	Pre-test	Post-test		Pre-test	Post-test	
	Mean	Mean		Mean	Mean	
Evaluating	7.73	12.91	5.18	10.42	11.44	1.02
Analyzing	7.02	12.77	5.75	10.09	10.42	0.33
Creating	2.36	9.68	7.32	3.26	3.35	0.09
Average			5.3			0.71

According to the table 13, teaching using the problem solving teaching method had a net effect on the end variables, the conceptual knowledge element at three sub-levels—of 5.3, but teaching through the conventional teaching method had a net effect of 0.71, which is poor. Average difference between the Experimental Group and the Control Group-I (5.3, 0.71)=4.59 demonstrated that the Experimental Group outmatched the Control Group-I, which was instructed using the conventional teaching method, in terms of performance. Thus, it was concluded that the problem solving teaching method was superior to the conventional teaching method for mathematics teaching.

Table 14

Descriptive Statistics of Study Variables for Control Group-II

Variables	*N*	Minimum	Maximum	*M*	*SD*	Skewness	Kurtosis
Evaluating	25	4	18	12.91	3.79	-.44	-1.04
Analysis	25	4	20	12.77	4.25	-.44	-.88
Creating	25	2	16	9.68	3.42	-.20	-.34

Overall abilities	25	20	94	65.34	18.24	-.60	-.56

Table 14 for Control Group II displayed Study Variables of Descriptive Statistics. Results indicate that the data were generally disseminated (Kurtosis < 2, Skewness < 2) and as a result, Control Group II did not experience any symmetry problems.

Table 15

Results of Descriptive Statistics and t-test for Pretest and Posttest Differences on Outcome Variables in Control Group-II

	Pretest (*n* = 43)		Posttest (*n* = 43)				95% CI		
Outcome	*M*	*SD*	*M*	*SD*	*r*	*t*(42)	*LL*	*UL*	*Cohen's d*
Evaluating	9.67	2.68	10.23	2.80	.90**	3.08**	-.92	-.19	.21
Analysis	8.88	2.06	9.26	2.26	.93**	3.09**	-.61	-.13	.16
Creating	2.51	2.00	2.37	2.27	.93**	1.14	-.10	.38	.07
Overall abilities	41.67	10.91	47.06	10.77	.98**	21.43**	-5.90	-4.88	.50

*p< .05, **p< .01

The Control Group-II outcome variables' descriptive statistics and t-test results are shown in the table 15. According to the findings, there were significant differences on the posttest in the areas of evaluating (M = 9.67, SD = 2.68; t = 3.08, p>.01, Cohen's d =.21); analyzing (M = 8.88, SD = 2.06; t = 3.09, p>.01, Cohen's d =.16); and overall abilities (M = 47.06, SD = 10.91; t = 21.43, p. In terms of creation, the results weren't statistically significant (M = 2.51, SD = 2.00; t = 1.14, p>.05, Cohen's d =.07). As compared to the experimental group, the results indicate substantial changes, although those differences were too tiny and certain factors had modest impact sizes.

Table 16
Mean Difference Comparison of Experimental Group with Control Group-II

Outcome Variables	Experimental Group		Difference	Control Group-II		Difference
	Pre-test	Post-test		Pre-test	Post-test	
	Mean	Mean		Mean	Mean	
Evaluating	7.73	12.91	5.18	9.67	10.23	0.56
Analyzing	7.02	12.77	5.75	8.88	9.26	0.38
Creating	2.35	9.69	7.33	2.52	2.36	-0.15
Average			5.3			0.8

According to the table 16, teaching using the problem-solving method had a net effect of 5.3 on outcome variables, or the conceptual knowledge element at three sub levels, while teaching through the Conventional Teaching Method had a net effect of 0.9, which is extremely little. The fact that there was a difference in average between control group 1 and experimental group and of (5.3, 0.8) =4.5 indicates that the Experimental Group outperformed the Control Group-II that had been taught using the Conventional Teaching Method.

Table 17
Mean Difference Comparison of Group-I with Control Group-II

Outcome Variables	Control Group-I		Difference	Control Group-II		Difference
	Pre-test	Post-test		Pre-test	Post-test	
	Mean	Mean		Mean	Mean	
Evaluating	10.42	11.44	1.02	9.67	10.23	0.56
Analyzing	10.09	10.42	0.33	8.88	9.26	0.38
Creating	3.27	3.34	0.08	2.52	2.38	-0.15
Average			0.6			0.8

Comparing Control Groups I and II, which received instruction using the Conventional Teaching Method, revealed rather similar outcomes. It indicates that there was no impact of an auxiliary variable. Additionally, it demonstrated that the Hawthorne effect, effect of interaction, the natural validity, and the reactive effect did not exist. Polya's Problem Solving Teaching Method was the treatment used, and this result was generated by the Experimental Group. The impact of the teacher's teaching style may be responsible for the modest discrepancy in accomplishment results.

Discussion of Findings

Higher-order thinking is thinking beyond memorization of information or following instructions. A key necessity of the twenty-first century is development advanced thinking abilities for students, and prospective teachers have a critical task to cooperate in attaining this aim. It may be possible to improve kids' arithmetic performance by encouraging pupils to use non-traditional problem-solving strategies, foster the growth of critical and innovative thinking, and support them to create their understanding. Teachers that are unconcerned with their students' acquisition of critical thinking abilities conversely will introduce irregularities into instructional activities that incorporate these skills and are more likely to adopt conventional teaching techniques. However, in instructional activities, this is a very unpleasant scenario. The current analysis was supported by the findings of Halil and Furkan (2020) discovered that mathematical thoughts were not a major interpreter of describing the critical thinking temperament. The lack of or limited availability of courses in undergraduate mathematics programs that foster high-level thinking, the low self-confidence of pre-service teachers in the subject area, and low self-assurance in mathematics, particularly in mathematical problem solving, are a few factors that may have an impact on this finding. High-level thinking skills suggest that unusual mental processes or processing that demands a more challenging and unusual effort are necessary. The current study's finding that it's critical to harmonize a mathematics curriculum with the curricula of the syllabus's particular disciplines was also backed by Arkady (2016). Ideal candidates for teaching mathematics should be acquainted with the special disciplines' content and mathematical techniques. It is challenging, but not impossible, to accomplish this in the current era by effectively managing the continuing education of aspiring math teachers. Working with aspiring instructors of specialized, informal, continuing-education-related subjects is another option. The creation of curricula by university administrative employees is detrimental to this process. The Problem-Solving Teaching Method was also successful in teaching of mathematics at the university level, according to our statistics. When compared to the Conventional Teaching Method, the Problem-Solving Teaching Method on the Revised Bloom's Taxonomy produced greater outcomes. Problem Solving Teaching Method had a considerable effect on conceptual dimension sub-level evaluation (Mean difference is 12.91-7.73=5.18), analysis (Mean difference is 12.77-7.02=5.75), and creation (Mean difference is 9.68-2.36=7.32) at Revised Bloom Taxonomy. This finding was very similar to that of Riasat et al. (2010), who found a large gap between the academic accomplishment of students trained using the conventional technique and those trained using the problem-solving method. Additionally, it was discovered that children who received problem-solving instruction fared better academically than those who received standard instruction.

Conclusions

After the analyses of data findings were drawn. On the bases of findings it was concluded that problem solving method was used to develop the problem solving ability. In the present study this method was used to find out the effect of this method on the development of higher order thinking skill of Revised Bloom's Taxonomy. The skills were analyzing, evaluating and creating. The comparisons of pre-test and post-test achievement scores of experimental group were significantly higher on sub-variables of higher order thinking skills of analyzing, evaluating and creating. It means problem solving method developed the higher order thinking skills among the prospective teachers of BS fifth semester. As students learning based on the learning of their teachers. So these teachers can also develop higher order thinking skills among their students by this method.

The comparison of achievement scores of group-I and group-II showed not a significant difference which were taught by the conventional method. So it may be concluded by this that conventional method has no significant effect on the development of higher order thinking skills. The scores of experimental group were higher than that of control group-I & control group-II. By this it can be concluded that problem solving teaching method was more effective as compare to the conventional method.

The comparison of achievement scores of group-I and group-II had no significant difference. It showed that their achievement were same to some extent. By this it concluded that extraneous variable was controlled. Hence the internal threats and external threats were maximally controlled in the experiment.

Recommendations

Following are the recommendations of the study based on major findings:

1. It may be recommended that Prospective teachers employ the problem-solving method in the classroom to teach mathematics, as it has demonstrated advantages over the conventional approach.
2. It is proposed that the Problem Solving Teaching Method be utilized explicitly for developing Higher Order Thinking Skills given that it has demonstrated its strength in this area.
3. Since the Problem Solving Teaching Method aids in the development of problem-solving skills, it is proposed that it be employed to foster these skills in pupils.
4. The Problem Solving Teaching Method is useful for teaching mathematics and can be applied to laying the foundation for University students.
5. Since Problem Solving Teaching Method affects Revised Bloom's Taxonomy; it is advised that lesson plans may be created using Revised Bloom Taxonomy.

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