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EFFECT OF PROBLEM SOLVING TEACHINGMETHOD ON HIGHER ORDER THINKING SKILLS OF PROSPECTIVE TEACHERS IN MATHEMATICS

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Abstract

Mathematics is recognized as the "Queen of Subjects." It is taught as a required subject in Pakistan from primary through secondary school; however it is also regarded as a monotonous and dull topic by pupils. There are numerous causes for this, but the primary one is the teacher's teaching technique. The purpose of this study was to determine the effect of the Problem Solving Teaching Method on the enhancement of Higher Order Thinking skills (HOTs) among prospective teachers at the BS level who study mathematics at the university level. The major objectives of the present study included; finding effect of the Problem Solving Teaching Method on element of higher order thinking skills of Revised Bloom's Taxonomy they were were wereanalyzing, evaluating and creating. This study was pre-testpost-test true experimental(double control group) design. The target cliental for the study consisted of 85 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 was analyzed byusing Pre-test, post-test, Levene test, ANOVA, t-test, Post Hock

	analysis, mean and standard deviation.The major results of the study were; that the Problem Solving Teaching Method performed better than the conventional method. The experimental achievement scores were significantly high than the control group-I and control group-II. The scores of control group-I and control group-II were close to one another which showed that extensors variable did not affect the intervention. The major findings showed the significant effect of this method on the development of higher order thinking skills. From the finding s it may be concluded that problem solving method not only develop the ability of problem solving but this could be used for the development of higher order thinking skills of Revised Bloom Taxonomy. It is recommended on the bases of findings that teacher may be provide training of this method so that they can use this method to develop higher order thinning skills among the students.

1. Introduction

Mathematics has been remained a subject of great importance. It is known as the queen of all subjects. It may be defined as the science of measurements and calculations. It also deals with digits, numbers, figures and shapes. The whole daily life is encircled by this subject. It is used in all science subjects it is also an important subject by which different mental faculties like observation, decision making, problem solving. Critical thinking and creative thinking can be developed. It is also known as the language of nature, means we can talk with nature if we know the mathematics.Fundamentally, science and technology do aid in the advancement of a country. Mathematics is the foundation for the growth of science and technology (Halil&Furkan, 2020).

According to Abdullah (2019) that thisthis topic is constantly present in science's activities and that science cannot exist independently without it. Through mathematics, inventions and innovations have been created (Muhtarom & Siswono, 2019).The objectives of teaching mathematics are in line with societal needs and mental capacities. These objectives include cultural goals, economic goals, social goals, international goals, technical and vocational goals, educational preparation goals, and goals for mental strength development. These goals inform the development of objectives, including knowledge and comprehension goals, skill goals, application goals, attitude goals, and appreciation and interest goals (Pettersen, 2017).

Pakistan's National Curriculum for Mathematics (2006) states that the focus is on acquiring skills amongst students, including the capacity to speak mathematically, purpose and evaluate, think and react in beneficial manner, comprehend the essential themes, assess the effectiveness that use different methods to solving the same problem, have used a various strategies to problem-solving and to make arithmetical connections, and distinguish among pertinent and irrelevant characteristics of a concept. This illustrates how the curriculum incorporates global objectives (Government of Pakistan, 2006, 2009).

At the primary and secondary levels, mathematics is taught in all public and private schools in Pakistan as one of the required topics. The curriculum offers a broad range of subject and life-related themes and ideas. As a result, despite the fact that it is a tragedy in Pakistan, neither public nor private school students find it particularly fascinating. The mathematics curriculum covers a wide spectrum of desired information. The learner's role encompasses a particular attitude, talents, analytical and logical ideas, and practices (Government of Pakistan, 2009). Collaborative pedagogy is necessary for the successful completion of all the criteria outlined in the National Curriculum (2006). These couldn't be learned using the conventional teaching approach. This phenomenon is clear from Prayitno's (2018) examination into Pakistani middle school kids' math proficiency. Students performed negatively on items demanding to reason and could only solve or try simple routine activities needing fundamental mathematical competencies.

As per National Research Councils, which is cited by Marzuki, Asih, & Wahyudin (2019), a large portion of mathematics failure at the secondary school level is attributable to the traditional methods of teaching mathematics, which are ineffective for how the majority of students understand. Numerous scientific researchers have demonstrated the inefficiency of the conventional teaching approach. Students are known as the reflection of teachers. This fact is described by Tan, &Halili,. (2017) that teaching plays a significant role in students learning.Teachers must empower themselves with fresh teaching strategies in order to educate students. Learning extends beyond the confines of the classroom. Staying proactive is really beneficial for updating prior knowledge.

Pettersen, (2017).stated thatHigher 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).

According to Sa'dijah (2021), the Problem-Based Teaching Technique is a platform for building problem-solving abilities that student will be able to employ to tackle everyday difficulties. It can also be used as a tool for learning more about something in-depth. According to Yaun (2013), the writings of Polya and Dewey had an impact on the most of mathematicians. Students' attitude of exploration or understanding can be fostered by the problem solving teaching method used in mathematics training. The problem-solving teaching approach can help students build Higher-Order Thinking Skills.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 method 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 mathetical teaching aid (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).

1.2 Rationale of the study

The subject of mathematics is considered the uninterested subject for students and many large scale assessment agencies like PISA (Porgamme of International Students Assessment), TIMSS

(Trends inInternational Mathematics and Science Study)and OECD(Organization of Economic and Cultural Development) 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. A popular approach to teaching mathematics is Polya's Problem Solving Method. therefore, this method is checked to train the prospective teachers of teachers for the improvement of Higher Order Thinking Skills.

1.3 Statement of the Problem

In the current era of technological advancement, the significance of mathematics cannot be questioned.It is the subject. According to large scale assessment agencies the concert of the students in this subject is not satisfactory and researches showed that the reason is the teaching pedagogy of the teachers. Students learning are the reflection of teacher's teaching. Problem Solving Method is a technique for improving problem-solving skills. The goal of the current study was to determine how this strategy affected the growth of higher order thinking abilities in potential mathematics teachers.

1.4 Objective of the Study

1. To calculate the effect of problem solving teaching method in mathematics on analyzing
2. To find out the effect of problem solving teaching method in mathematics on evaluating
3. To check the effect of problem solving teaching method in mathematics on creating

1.5 Hypothesis of the Study

Ho 1: There is no significant difference of the mean achievement scores of experimental group and control groups at analyzing.

Ho2: There is no significant difference of the mean achievement scores of experimental group and control groups at evaluating .

Ho3: There is no significant difference of the mean achievement scores of experimental group and control groups at creating.

1.6 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.

1.7 Delimitations of the Study

1. The study's focus was on conceptual knowledge sub-levels, including their analysis, evaluation, and creation using the revised Bloom's Taxonomy.
2. The study only included prospective teachers with a BS degree.
3. The research was restricted to word problems, real-world geometry, and theoretical geometry from the Mathematics-A curriculum.

2 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 pairsfor 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).

2.1 Aims of Teaching Mathematics at University level

Universities are the institutions from where the students are prepared for future profession. The students of education in universities are known as prospective teachers. It is essential that these prospective teachers may be provided training according to the need of subjects, so they inculcate the same among the students(Zimina, 2005).

As quoted by Tan and Halili, (2017) that mathematics is the subject of daily life. Its aims are encircling the whole life. The aims of mathematics are cultural, social, emotional, intellectual and international.

The curriculum and the way it is implemented are tools for achieving the objectives of math instruction. Contemporaryintentional 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).

2.2 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 teacherought to help students organize information and apply knowledge in actually useful contexts in addition to introducing them to mathematical concepts (Abdullah and Fadil, 2019).

2.3 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).

2.4 Cognitive Process Dimension of Revised Bloom Taxonomy

There are six categories for the cognitive dimensions in this classification. It describes a process of learning in which pupils are anticipated to gain knowledge as a result of instruction, in this Taxonomy the knowledge dimension is divided into four levels, they are Factual knowledge, conceptual knowledge, procedural knowledge and metacognition level(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 mental procedure that involves breaking down knowledge into its component aspects and studying those parts in order to fully understand the entirety. Identification, organization, and attribution are the learning outcomes associated with this ability. It also contributes to higher-order thinking abilities (Sezer, 2019).

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).

2.6 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 practices encourage lower-order thinking skills, whereas curricula encourage competencies in higher-order thinking. Polya's problem-solving method is a notable strategy that may be evaluated using Bloom's updated taxonomy for developing Advanced Order Cognitive Competencies. 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)

2.7 Theoretical framework of the study

Independent Variable **Dependent Variable**

Problem Solving Method ⟶ Higher order thinking skills (Analyzing, Evaluating & creating)

3 Research Design

The study used positivist philosophy and deductive theory. As per Cohen, Manion, and Morrison (2000), the effect of treatment can be affected by two ways one is sampling and second is the extraneous variable, To minimize the effect of sampling error randomization was used in making the groups. The second control group was employed to reduce the impact of extraneous variables. The treatment effect of extraneous variables is indicated by the scores of two control groups. If the score difference between groups was minimal, the effect of the extraneous variable would be lower; otherwise, it would be greater. As a result, a twofold control group design was utilized for the study to reduce the effect of sampling error and extraneous variables (Kumar, 2019).

3.1 Participants of the study

The target cliental for this experimental study were 85 students BS fifth semester. After randomization the participants were divided into three groups. The experimental group was consisted of 30 students, control group-I consisted of 28 students and control group-II consisted of 27 students. All the students of BS were from Faculty of Education, International Islamic University, Islamabad.

3.2 Research Instrument

For analyses of data a test was developed consisted of higher order thinking skills of analyzing, evaluating and creating items. This test was used as pre-test and post-test. The test

was consisted on the selected content from the course outline of BS programme "Teaching of Mathematics". Test was consisted of 30 items.

3.3 Strategy of Inquiry

True Pre-test post-test (double control) design was used in the study

Experimental $RO_1X \quad O_2$

Control –I $RO_3C \quad O_4$

Control –II $RO_5C \quad O_6$

3.4 Variables of the study

The study employed Poly's approach to teaching problem-solving as explanatory variables. The dependent variables in the study were the conceptual knowledge dimension sub-levels (analyzing, assessing, and producing). These may be the study's extrinsic factors (age, intelligence level, teaching experience, teacher education, and home tutoring).

3.5 Internal threats

Randomization and experimental design were used to control threats such history, maturation, statistical regression, testing, instrumentation and selection.

3.6 External threats

Threats such as the Hawthorne effect, insufficient operationalization of dependent variables, adaptation to experimental parameters, inability to expressly explain independent variables, lack of achievable and target, and significant interaction were addressed through a variety of measures, including the addition of a third category.

3.7 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 $\alpha = .91$ (i.e. evaluating) to $\alpha = .94$ across all scales and subscales (i.e. Creating, Overall abilities). Hughs alpha reliability of the three sub scales (i.e., $\alpha > .88$), that can be used with confidence.

4 Data Collection

The following statistical tests were used to enhance the validity and reliability of the analyses:

- For the confirmation of normality normal distribution analyses
- For analyses of variance among the groups one way ANOVA
- For analyses of homogeneity means calculated of all groups
- For responses analyses descriptive stat were used
- The t-test was employed to compare pre-test and post-test achievement scores.

Table1Normal Distribution Analysisof Control Group-I						
	Kolmogorov-Smirnov			Shapiro-Wilk		
Variables	Statistic	*df*	*p*	Statistic	*df*	*P*
Analyzing	.28	43	3.02	.31	43	.56
Evaluating	.16	43	.98	.13	43	1.53
Creating	.25	43	.09	.01	43	.29

Data in the table showed that values were not significant of both test. The tests of Kolmogorov-Smirnov and Shapiro-Wilk were conducted on p>.05. By this it was confirmed that the data was normally distributed. So the study variables of control group-1 were normally distributed.

Table.2 Normal Distribution Analysis of Control Group-II						
	Kolmogorov-Smirnov			Shapiro-Wilk		
Variables	Statistic	*df*	*p*	Statistic	*df*	*P*
Analyzing	.18	43	1.01	.27	43	1.09
Evaluating	.24	43	2.23	.38	43	5.04
Creating	.23	43	1.45	.07	43	2.12

Data in the table showed that values were not significant of both test. The tests of Kolmogorov-Smirnov and Shapiro-Wilk were conducted on p>.05. By this it was confirmed that the data was normally distributed. So the study variables of control group-1I were normally distributed

Table3 Normal Distribution Analysis of Experimental Group						
	Kolmogorov-Smirnov			Shapiro-Wilk		
Variables	Statistic	*df*	*P*	Statistic	*Df*	*P*
Analyzing	.04	44	.40	.18	44	5.24
Evaluating	.07	44	.67	.12	44	3.27
Creating	.03	44	.32	.14	44	.80

Normal distribution test was conducted to find out the normality among the variables of experimental group at p>.05 level. The data in the table showed that non-significant results which showed that the study variables of experimental group were normally distributed.

Table 4 Test of Homogeneity of Variances (Levene Test)				
Groups	Levene Statistic	*df1*	*df2*	*P*
Experimental Group	1.11	2	127	.38
Control Group-I	1.52	2	127	.24
Control Group-II	1.78	2	127	.46

Experimental group consisted of 30 students. Group-1 was consisted of 28 students and control group-II consisted of 27 students. To confirm the homogeneity among the variables of three

groups Levene test at (p>.05) were conducted. Data in the table showed that homogeneity was present among the variables of all groups

Table 5 Analysis Variance among the variables of Experimental Group, Control Group 1& control group-II

	Experimental Group		Control Group-I		Control Group-II				
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*P*	*Ή*
Outcome	65.34	18.24	50.16	10.34	47.07	10.77	22.37	.00	.34

Experimental group was taught by problem solving method while two control group-1 & 2 were taught by conventional method. To find out the effect of intervention mean of achievement scores of three groups were calculated. To analyses of variance One Way ANOVA teat was conducted on three groups. Data showed that the experimental group's mean was much higher than the control groups I and II. As a result of this discovery, problem solving methods have a significant impact on the acquisition of higher-order cognitive abilities. i.e. Analyzing, Evaluating and Creating.

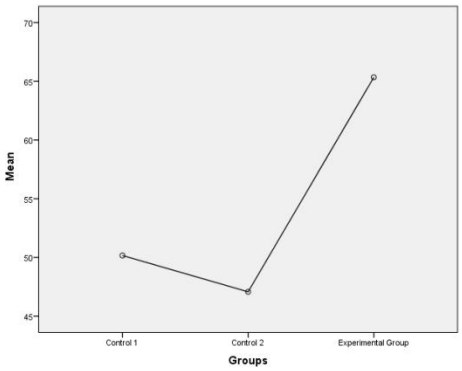
Table 6comparison of outcome variables by Post Hock test

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	*p*	95% CI	
					LL	*UL*
Outcome	Control Group 1	Control Group II	3.09	.54	-3.89	10.08
		Experimental Group	-15.17*	.00	-22.12	-8.23
	Control Group 2	Control Group 1	-3.09	.54	-10.08	3.89
		Experimental Group	-18.27*	.00	-25.22	-11.33
	Experimental Group	Control Group 1	15.17*	.00	8.23	22.12
		Control Group II	18.27*	.00	11.33	25.22

*p< .01

The experimental group, which was taught using the problem solving approach, was compared to the control groups-I and II, which were taught using the standard method for the acquisition of higher-order thinking abilities. A post-hoc test was carried out. The results of the experimental group were better than those of the control groups-I and II, according to the data in the table. These evaluations show that the technique of problem-solving is more efficient than traditional approaches. As a result, the problem-solving strategy demonstrated its impact on higher-order related to higher order thinking.

Figure 1: **Comparison of outcome variables**



The comparison of outcome variables of three groups showed in the figure-1. The results were comparable in the control groups-I and II, which were taught using the traditional manner. Although the experimental group received instruction in Polya's problem-solving method to enhance higher order thinking skills, the outcome variables improved significantly. When compared to the control groups, the experimental group fared better. These findings indicated that the problem-solving education technique had an influence on higher-orderrelated to higher order thinking.

Table7 Descriptive Statistics and t-test Results on Outcome variables for Experimental Group

	Pretest (n = 30)			Posttest (n = 4=30)				95% CI		
Outcome	*M*	*SD*		*M*	*SD*	*r*	*t*(42)	*LL*	*UL*	*Cohen's d*
Analyzing	9.02	4.31		14.77	4.25	.94**	25.76**	-6.20	-5.30	1.35
Evaluating	6.48	3.11		1350	4.22	.91**	24.86**	-7.59	-6.45	1.91
Creating	3.36	2.48		10.68	3.42	.77**	22.53**	-7.97	-6.66	2.47

Data in the table showed that experimental group performed better in all the outcome variables. The problem-solving strategy emphasized higher-order cognitive skills. The mean score of analyzing, evaluating, and generating improved significantly. As a result of the significant effect of the problem-solving teaching method on variables related to outcomes, this method was a successful strategy for facilitating the growth of higher-order-related to higher-order thinking.

Table 8 Pre-test and Post-test scores analyses of Control Group-1 on t-test										
	Pretest (n = 27)			Posttest (n = 27)				95% CI		
Outcome	*M*	*SD*		*M*	*SD*	*r*	*t*(42)	*LL*	*UL*	*Cohen's d*
Analysis	11.09	1.79		11.42	1.77	.91**	2.85*	.65	.09	.17
Evaluation	9.14	1.47		10.93	1.86	.54**	3.15**	1.29	.28	.47
Creating	6.26	2.50		4.35	2.60	.95**	.81	.32	.13	.03

Results of the pretest and posttest on the outcome variables for the Control Group, as well as descriptive statistics I demonstrated that there were notable disparities in the analysis. Conclusion: Results indicated considerable differences; however they were insufficient in comparison to the experimental group.

Table 9 comparison of 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	
Analyzing	8.02	13.77	5.75	11.09	11.42	0.33
Evaluating	6.48	13.50	7.02	9.14	9.93	0.79
Creating	3.36	10.68	7.32	4.26	4.35	0.09
Average			5			0.8

The outcome variables by net effect of teaching using the conventional method was 0.72, which is low, while the net effect of teaching using the problem-solving method was 5.2. The 4.48 point difference in averages between the Experimental Group and Control Group I demonstrated that the Experimental Group outperformed the Control Group I, who received instruction using the Conventional Method, in their performance.

Table 10 Mean Difference 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	
Analyzing	8.02	13.77	5.75	9.88	10.26	0.38
Evaluating	6.48	13.50	7.02	8.67	9.00	0.33
Creating	3.36	10.68	7.32	3.51	2337	-0.14
Average			5			0.10

According to Table 10, the instruction of problem solving techniques had a net effect on the outcome variables of 5.2, while conventional methods had a net effect of 0.9, which is extremely little. Between Experimental Group and Control Group II, there was a 43 point difference in means.

Table 11 Comparison of Mean Difference of Group1 & 2				
Outcome	Control Group-I	Difference	Control Group-II	Difference

Variables	Pre-test	Post-test		Pre-test	Post-test	
	Mean	Mean		Mean	Mean	
Analyzing	11.09	11.42	0.33	9.88	10.26	0.38
Evaluating	9.14	10.93	0.79	8.67	9.00	0.33
Creating	4.26	4.35	0.09	3.51	3.37	-0.14
Average			0.8			0.8

Comparing Control Groups I and II, who received instruction using the Conventional Method, had rather similar outcomes..

4.2Discussion 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 byArkady (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

5 Findings

Findings of the study were:

1. As indicated by the examinations of change of the result factors of trial bunch, the information showed a tremendous contrast. This implies that critical thinking showing technique altogether affected the advancement of higher request considering abilities examining, assessing and making.
2. As per the examinations of change of the result factors of control bunch I, the information showed not a tremendous distinction as contrast with exploratory gathering.. This implies that customary strategy significantly affected the advancement of higher request considering abilities investigating, assessing and making
3. As per the investigations of fluctuation of the result factors of control bunch II, the information showed not a huge contrast as contrast with trial bunch.. This implies that ordinary strategy meaningfully affected the improvement of higher request considering abilities investigating, assessing and making
4. Every one of the invalid speculations were not acknowledged on the foundations of accomplishment scores. So the exploratory gathering that was educated by critical thinking strategy essentially affected higher request thinking abilities. While on the opposite side the both benchmark groups-I &II that were shown by ordinary strategy had not critical on higher request thinking abilities.
5. Consequences of unmistakable insights and t-test affirmed that accomplishment scores pre-test and post-trial of exploratory gathering were higher that showed the impact of treatment that is critical thinking showing strategy on higher request thinking abilities.
6. Consequences of spellbinding insights and t-test affirmed that accomplishment scores pre-test and post-trial of control bunch I were not high that showed the impact of treatment that is ordinary strategy showed not a huge impact on higher request thinking abilities.
7. Consequences of distinct measurements and t-test affirmed that accomplishment scores pre-test and post-trial of control bunch II were not high that showed the impact of treatment that is ordinary strategy showed not a huge impact on higher request thinking abilities
8. Information showed the massive distinction in the accomplishment scores of examining abilities on per-test and post-test. It implies critical thinking showing strategy impact the higher request considering expertise examining. Consequently the main speculation was not acknowledged
9. Information showed the huge distinction in the accomplishment scores of assessing abilities on per-test and post-test. It implies critical thinking showing strategy impact the higher request considering expertise examining. Subsequently the subsequent speculation was not acknowledged
10. Information showed the massive contrast in the accomplishment scores of making abilities on per-test and post-test. It implies critical thinking showing strategy impact the higher request considering expertise examining. Consequently the third speculation was not acknowledged
11. Accomplishment scores of trial bunch was contrasted and the accomplishment scores of control group I on result factors of higher request thinking abilities. Exploratory gathering scores were altogether higher than the benchmark group-I. This reality demonstrates that critical thinking technique was a powerful strategy for the improvement of higher request thinking ability as contrast with traditional technique.
12. Correlation of scores of exploratory gathering was contrasted and the accomplishment scores of control bunch II on result factors of higher request thinking abilities. Exploratory gathering scores were altogether higher than the benchmark group-I. This reality demonstrates that critical

thinking technique was a powerful strategy for the improvement of higher request thinking ability as contrast with traditional technique.
13. Accomplishment scores of two benchmark groups were analyzed. The meanscore contrast between the benchmark group-I and control bunch II was not huge. This reality uncovered that superfluous variable didn't impact. So the procedure of twofold benchmark group worked and outside dangers were controlled through this plan..

5.1 Conclusions

Following conclusions were drawn;
1. It was closed from information examinations that exploratory gathering and both control grou-1 and control bunch II didn't have a huge distinction on pre-test scores so it was reasoned that all gatherings were same in the capacities of higher request thinking abilities
2. Ti was finished up from the post-trial of exploratory gathering that accomplishment scores were critical high than the pre-test. This reality demonstrates that critical thinking strategy dealt with the improvement of higher request thinking abilities
3. Information from the discoveries showed that accomplishment scores of exploratory gathering on post-test was higher than that of the benchmark groups I and II which were shown by traditional technique. This reality showed that critical thinking technique was a viable strategy for creating higher request thinking abilities than traditional technique
4. Scores of t-trial of pre-test and post-test control bunch 1 not showed a huge distinction which demonstrates that ordinary strategy couldn't foster higher request thinking abilities
5. Scores of t-trial of pre-test and post-test control bunch 1I not showed a massive contrast which demonstrates that regular strategy couldn't foster higher request thinking abilities
6. Discoveries of the review demonstrated that critical thinking technique foster the critical ability to think as well as by this strategy higher request thinking ledges like examining, assessing and making can be created.
7. In view of the One Way ANOVA, it is feasible to express that the Exploratory Gathering showed utilizing PSM performed higher on the post-test. PSM was in this way an effective technique for showing math for planned educators.
8. On the examination of information it was reasoned that the accomplishment scores of both benchmark groups were exceptionally close which implies outside dangers to explore were controlled.
9. Scores of t-trial of exploratory gathering of pre-test and post-test showed a massive distinction by which it very well may be reasoned that critical thinking strategy worked for the improvement of higher request thinking abilities.

5.3 Recommendations

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

1. It may be recommended that teachers utilize this strategy in the classroom to teach mathematics because of its benefits over the traditional approach.
2. It is proposed that the Problem Solving Method be utilized explicitly for developing Higher Order Thinking Skills (HOTS) given that it has demonstrated its strength in this area.
3. It is suggested that PSM be used to assist students in improving their problem-solving skills because it aids in the development of that skill.
4. Because PSM is effective at teaching math, it may be utilized to lay the groundwork for pupils in the primary grades.
5. Problem solving Method may be used in teachers training programmes

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