MS Research Thesis

Effect of Laboratory Method on Higher Order Thinking Skills (HOTs) in the Subject of Mathematics at Elementary Level

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FACULTY OF EDUCATION

INTERNATIONAL ISLAMIC UNIVERSITY ISLAMABAD PAKISTAN

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This thesis is submitted to the Education department of Leadership and Management, Faculty of Education International Islamic University, Islamabad to fulfill the requirements for degree of MS (Educational Leadership and Management).

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DEDICATION:

Researcher dedicates his dissertation work to his family and many friends. A special feeling of gratitude to his loving parents, Hamdillah Rahi and Ishrat Jahan whose words of encouragement and push for tenacity ring in his ears. His brothers and sisters who have never left his side and are very special.

Researcher also dedicates this dissertation to his many friends and his university friends who have supported him throughout the process. He will always appreciate all they have done.

Researcher dedicates this work and give special thanks to his supervisor Dr Sheikh Tariq Mehmood for being there for him throughout the entire MS program. Researcher thanks his supervisor for being so cooperative to him. Supervisor has been his best teacher.

FORWARDING SHEET

This thesis entitled **"Effect of Laboratory Method on Higher Order Thinking Skills (HOTs) in the Subject of Mathematics at Elementary Level",** submitted by **Muhammad Zaki Ullah** Registration # **627-FSS/MSEDU/F21** to fulfill the partial requirements, for the award of degree of MS (Master Studies) in Educational Leadership and Management, under my guidance and Supervision is forwarded for the further necessary action.

DATE__________ Supervisor: ____________________

Dr. SHEIKH TARIQ MEHMOOD

Thesis Completion Certificate

This thesis entitled **"Effect of Laboratory Method on Higher Order Thinking Skills (HOTs) in the Subject of Mathematics at Elementary Level"** by **Muhammad Zaki Ullah** Registration # **627-FSS/MSEDU/F21** in partial fulfillment for the requirement of MS Educational Leadership and Management degree in Education has been completed under our guidance and supervision. We are satisfied with the quality of student research work and allow him to submit this thesis for further process as per IIUI rules and regulation.

Supervisor: ____________________

Dr.SHEIKH TARIQ MEHMOOD

APPROVAL SHEET

EFFECT OF LABORATORY METHODS ON HIGHER ORDER THINKING SKILL (HOT) IN THE SUBJECT OF MATHEMATICS AT ELEMENTARY LEVEL

BY

MUHAMMAD ZAKI ULLAH

(Reg.No:427-FSS/MSEDU/F21)

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STATEMENT OF UNDERSTANDING

The researcher **"Muhammad Zaki Ullah"** having registration number 627-FSS/MSEDU/F21 and student of MS Educational Leadership and Management, Faculty of education, International Islamic University Islamabad do declare that thesis entitled **"Effect of Laboratory Method on Higher Order Thinking Skills (HOTs) in the Subject of Mathematics at Elementary Level"** submitted by me in specific satisfaction of MS degree in the original work except other acknowledgement of text has not been submitted or published earlier nor in future be submitted by me for any degree from this university of institution.

DATE______________ Signature: _______________

Muhammad Zaki Ullah

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ABSTRACT

Mathematics is often tagged as the universal language of the sciences, to unlock the mysteries of the world it is considered a prominent tool. It also plays a pivotal role in everyday life, from managing personal finances to advancing technological innovation. There are many methods of teaching mathematics subject and one of these methods is the laboratory method to improve the students' higher ordered thinking skills. The purpose of this research was to investigate the "Effect of Laboratory Method on Higher Order Thinking Skills (HOTs) in the Subject of Mathematics at Elementary Level"; its purpose was to find out the effect of Laboratory method on analyzing, evaluating and creating. The hypothesis was tested that the mean score of the test group and the control group is not significantly different on analyzing, evaluating and creating skills of students. The objectives of the study was to find out the effect of laboratory method on analyzing, evaluating and creating. The research design that was used in the study was experimental/ control group research design. The population of study was all students at primary level in district Lower Dir. The sample size was 60 students and two groups of each were made. The method is used experimental and the design is pretest-postest control group. The major finding was analysed by applying t-test and conclusion was drawn. This study concluded that the Laboratory method is important for academic performance in elementary school since it is more efficient for mathematics learners. Comparing the impact of the Laboratory Method and the traditional method for academic results, the Laboratory method is more efficient than a traditional method since it has an influence on the student's learning process forever because the effect of learning motivate environment.

On the basis of findings, it is suggested that the Laboratory method should be applied for teaching at elementary level. The curriculum maker/experts should include this strategy best for teaching of mathematics at elementary level. The Laboratory method policy should be included in the Ministry of Education for new students. Teachers involved in educational institutions suggest and emphasis on Laboratory method as teaching approaches for learning, since it enhances students' academic achievements particularly in mathematics.

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List of Abbreviations

AL: Active Learning

CM: Classroom Management

ES: Elementary School

FBISE: Federal Board of Intermediate and Secondary Education

LM: Laboratory Method

HEC: Higher Education Commission

KP: Khyber Pashtunkhwa

LP: Lesson Planning

MCQs: Multiple Choice Questions

MS: Master in Education

PhD: Philosophy of Education

QA: Questions Answer

SASS: School and Staff Survey

SE: Secondary Education

SPSS: Statistical Package of Social Science

SSE: Secondary School Education

Chapter 1

INTRODUCTION

One of the most troublesome challenges encountered by students struggling with mathematics is exploring new, innovative, and workable teaching methodologies. One of these ways is called the "laboratory method." It is a hands-on learning technique that uses tangible and visual elements to teach difficult mathematical concepts. With this method, students get to use things they can touch and see to learn math ideas. The present study focuses on the application of the laboratory method in the instruction of different topics in sixth-grade math. It delves deeply into this method that how it helps students to think more deeply about the difficult subject of math, examining its effectiveness in fostering a wholesome understanding in students (Moore & Stanley, 2010).

In the world of cognitive development, thinking skills can be divided into two big groups: low-level thinking skills (LOTS) and high-level thinking skills (HOTS). LOTS include the first three parts of Bloom's Taxonomy, which are remembering, understanding, and using. On the other hand, HOTS include the last three parts of Bloom's Taxonomy, which are analyzing, evaluating, and creating (Moore & Stanley, 2010). In this method, the intellectual engagement reaches a more sophisticated level, having the ability to deconstruct information, assessing its main components, and create novel and innovative ideas. HOTS, hence, reflects deeply on cognitive development, showing the esteemed echelon of thinking abilities, as individuals progress from basic understanding to advanced cognitive abilities within this framework. In other words, HOTS is the highest part in Bloom's taxonomy of cognitive domain.

The significance and scope of high-level thinking skills cannot be overly emphasized in the context of education. However, these skills are enormously important in teaching and learning processes, creating the bedrock of intellectual advancement. HOTS are important aspects in teaching and learning. Thinking skills are fundamental in educational process. A person's ability to think critically deeply affect the speed, efficiency and effectiveness of learning. Therefore, thinking skills is associated with learning process. Students who are trained to think and demonstrate a positive impact on the development of their education. Students with HOTS are able to learn, improve their performance and reduce their weaknesses (Yee, Othman, Yunos, Tee, Hasan, and Mohammad, 2011).

1.1 Background of the Study:

The scope and significance of mathematics in the context of human life and societal development is enormous, and it plays a mammoth role in various walks of human life, such as science, engineering, technology, industry and arts. The place of mathematics in man's way of life and development cannot be over emphasized. However, mathematics is a very desirable tool in virtually all spheres of human endeavor. There is a non-negotiable and most important nature of mathematics in scientific glory and technological advancement of humans, and no nation can develop scientifically and technologically if it neglects mathematics (Azuka, 2003).

Since the beginning of human life, mathematics is not only a subject but the foundation of science and technology in multiple ways of life. Okereke (2006) stated that mathematics is the foundation of science and technology and the functional role of mathematics to science and technology is so multifaceted that no area of science technology without which a nation can never be prosperous and business enterprise escapes its application. The multi-layered and diverse functions of mathematics within these fields are profoundly underscored, while recognizing that no sector is that crucial for a nation's prosperity as mathematics, and human race can afford to ignore the practical application of mathematical principles. This holistic and collective perspective places mathematics not merely as an academic field but as an essential and key and tool which is integral to progress and development. Orokpo, A., & Achor, E. E. (2016) referred to mathematics as the foundation of science and technology without which a nation can never be prosperous and economically independent.

Mathematics is a key subject in the school curriculum and is considered a knowledge that is indispensable to the educated person. According to Azuka, (2003) all major professions in life today require the knowledge of mathematics to practice. These professing include engineering, accountancy, medicine, economics, banking, technology etc. In offices, industries and other human establishments, mathematics is needed for analysis, organization and evaluation of the information needed to make new decisions.

Teachers follow age-old methods such as the lecture method (Talk and chalk) in a classroom. As a result, the power of thinking understanding, and retention are not developed amongst students, owing to which the student show less interest in mathematics learning. Hence, the traditional methods being used all along by teachers have failed to develop the skills such as those needed in formulating, modeling and solving problems. Students are not always able to remember and retain what they have previously learned. Simple geometrical shapes such as cubes, cuboids, pyramids, cylinders, and cones to mention but a few are studied in the classroom without presenting the real objects to other students.

The abstract nature of mathematics should be reached through demonstration and practical methods. To develop the skills and provide practical experiences of mathematics concepts assumptions, assertions and rules, a strategy is needed. Davou, (2019) observed that the problem of ineffective teaching can be tackled through planned and intelligent application of the mathematics laboratory. Hence, in search for the method of teaching that can cater for the cognitive affective and psychomotor aspects of learning, the concern of this researcher is to ascertain whether the students' performance of mathematics in secondary schools could be improved upon by using the laboratory method of teaching. Since mathematics is a subject, which has to be learnt by doing rather than by, reading the doing of mathematics gives rise to the need for a suitable method and a suitable place. Laboratory method and mathematical laboratory are the proper answer to it. This activity method leads the students to discover mathematical facts. It is based on the principles of learning by observation and proceeding from concrete to abstract.

Teaching through Laboratory Method is method or a mathematics laboratory is a place where students can learn and explore various mathematical concepts and verify different mathematics facts and theories using varieties of activities and materials. Based on the advantages of Laboratory method, it is expected that teaching and learning of mathematics using laboratory method may help to reduce abstract nature of the subject, increase the students' interest in the subject and develop analyzing, evaluating and creating skills (HOTs) Kim, Minsu, et al. (2020).

1.1.2 Revised Bloom Texonomy

In 1950, a smart person named Benjamin Bloom made categories for thinking and learning. Then in the 1990s, another smart person named Lorin Anderson made some changes to these categories. They changed from being about things to being about actions or actions words. This way of sorting things is very smart and helps people understand things better. One day, a math teacher found that when they talked to students about math, using the higher-level categories from Bloom's categories like analyzing, evaluating, and creating, it helped the students become better at solving problems. When the teacher asked students to explain their math answers using words, pictures, or numbers, it was a great way to check if they really understood the math idea. The teacher also had students think about and explain a number pattern they saw. This helped them become better at thinking. The teacher even had students come up with their own questions about the lesson to help each other. At first, it was hard, and they mostly asked simple questions. But with practice, the students got better at asking questions they could explain the answers to (Anderson, 2001).

Tutkun (2012) define contented that in reconsider blossom's scientific categorization; noteworthy dynamic were made to address the impediment of old sprout domain.

1.1.3 Higher Order Thinking

The component spread huge number of the exercise and targets however they don't address the new destinations exhibited by the development and reconciliation of information and communication technologies into the study hall and the lives of our understudies.

1.1.4 Revised Bloom Taxonomy Cognitive Process Dimension

This taxonomy consists of six categories that gathering and clarifies "verb". They tends towards knowledge or understudies relied on the possible teaching.

i. Remembering:

   The first dimension of the revised bloom taxonomy (RBT) in lower order thinking skills. On the behalf of this dimension the learner recognizes and recalls more significant information and knowledge on entire arrangement memorial. The estimation is consisting both fundamental substitute sessions i-e recognizing and recalling the capacity recalled past information and recollection it that a required.

ii. Understanding:

The second dimension of revised bloom taxonomy (RBT) in lower order thinking skills. The understanding progression agreements by ability between understudies it can hugeness describe as well as repeat concepts, they give their own understanding. They has more parts such as interrelating, comparing, exemplifying and summarizing.

iii. Applying:

The third or last aspect of revised bloom taxonomy (RBT) in lower order thinking skills. The aspect arrangements ability of utilizing learned knowledge related or innovative condition. That they demonstrate its learning outcome through executing and implementing in a condition moreover innovative or ancient.

iv. Analyzing:

This is the first aspect of (RBT) taxonomy in higher order thinking skills. The aspect agreements of separating the knowledge into different part and study all portions comprehend the entire data. This dimensions ability are differentiating, organizing and attributing.

v. Evaluating:

The second aspect of (RBT) taxonomy in higher order thinking skills. The aspect process agreements the ability of checking and critiquing.

vi. Creating:

The third or last dimension of the revised bloom taxonomy (RBT). It's not encompassed in the old taxonomy. It has most astounding capacity as well as changed through combination of past taxonomy. They include placing knowledge and improve innovative knowledge and create somewhat new. It incorporates creating, delivering and arranging. The learning results of this capacity depend on consolidating the bits of information making of new or novice thoughts and things. For the evaluation of the capacity to understand require to achieve task was making plan to prepare new things.

1.2 Statement of the Problem

The primary and fundamental role of mathematics in the progress of science and technology is undeniable and immeasurable. However, the conventional and traditional approach to teaching mathematics often depends on rote memorization, leading to a perceived lack of engagement and interest from students. Research has indicated that the traditional teaching method may not efficiently and effectively cultivate higher-order thinking skills (HOTs) in mathematics. In the context of elementary level mathematics education, there is an acknowledged belief to enhance students' HOTs, which is crucial for a profound and deep grasp of mathematical concepts. The laboratory method has been recognized as a potential solution, offering an experiential and interactive learning atmosphere. However, the specific impact of the laboratory method on the development of HOTs in elementary level mathematics remains insufficiently explored. The present study aims to examine the influence of integrating laboratory-based activities on the enhancement of HOTs, including critical thinking, problem-solving, and analytical reasoning, among elementary level students. In order to address this gap, the research seeks to provide important insights into the efficiency and effectiveness of the laboratory method for cultivating essential cognitive skills in young students and learners and fostering mathematics education methodologies

1.3 Significance of The Study

The study should be very significant of mathematics teacher than they teach on Laboratory Method. They are helpful for the preparation of lesson plan and making them consistent to Laboratory Method. Identify a better teaching method that could be adopted by mathematics teachers so as to improve the performance of students in mathematics. The abstract nature of mathematics will be reduced and will increase the students' interest in the subject. When people see, study, analyze and synthesize what they are doing, there will be insight and any solution to obtained from this scientific method of reasoning will be a confidence builder. That they are important to discover future strategies, planning in mathematics at elementary level. It would be beneficial for the curriculum makers to prepare the course content, curricula by Laboratory Method It's helpful to establish innovative strategies in mathematics.

1.4 Objectives of The Study

1. To find out the effect of Laboratory Method on analyzing skills of students.
2. To investigate the effect of Laboratory Method on evaluating skills of students.
3. To check the effect of Laboratory Method on creating skills of students.

1.5 Research Hypotheses

Ho1: There was no significant difference between the mean score of experimental group and control group on analyzing skills of students.

Ho2: There was no significant difference between the mean score of experimental group and control group on evaluating skills of students.

Ho3: There was no significant difference between the mean score of experimental group and control group on evaluating creating skills of students.

1.6 Delimitation of The Study

The study was delimited to:

1. Class 6th
2. Male students
3. Higher Order Thinking Skills (HOTs, Analyzing, Evaluating, Creating)
4. Laboratory Method
5. Traditional Method
6. Mathematics Grade 6: Unit 10 (Geometry) unit 11 (Perimeter and Area) unit 12 (Three Dimensional Solids)

1.7 Major Terms Definitions

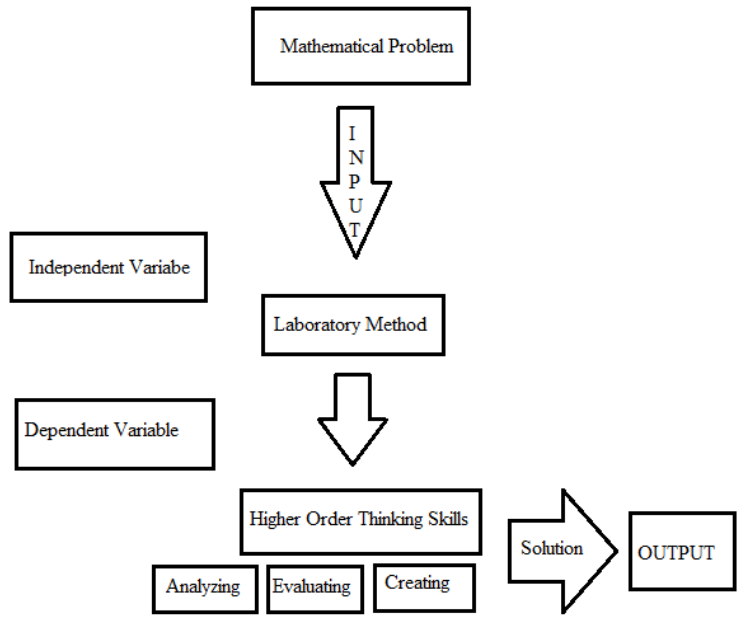
a) **Problem:** an issue that is tough to achieve or request beginning from given circumstances to analyze or illustrate a reality, result, or control.

b) **Effect:** an alter which could be a result or result of an activity or other cause or capacity to do or act; capability of doing or finishing something.

c) **Method:** a specific shape of strategy for fulfilling or drawing nearer something, particularly an orderly or built up one.

1. 8 Theoretical Framework

Theoretical framework assists the researcher to use the accurate and applicable theories with the help of which the researcher examine, and unveil the proposed study (Varpio et al. 2020). It is the offshoot of the research, and it ushers the plan of the proposed study and helps in the systematic armament of the study. The investigation into the Effect of Laboratory Method on Higher Order Thinking Skills (HOTs) in Elementary Mathematics reveals a complex correlation of pedagogical strategies and cognitive development. By integrating laboratory methods into mathematics education at the elementary level, the present study aim to show that how hands-on, experiential learning assists the cultivation of critical thinking, problem-solving, and analytical skills. Through constructivist learning theory and Bloom's Taxonomy, laboratory activities are theorized to stimulate deeper engagement and conceptual understanding, thereby nurturing students' ability to analyze mathematical concepts, evaluate various strategies, and create innovative solutions. The findings of the present study hold promise for informing educational practices aimed at enhancing HOTs development in young learners.



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Chapter-2

LITERATURE REVIEW

2.1 Mathematics

Mathematics is a subject that everyone needs at some point in their life. It is an important and mandatory part of school level curriculum almost all over the world. It is the study of quantity, structure, space and change and is also an interdisciplinary language and tool that is considered one of the fundamental principles of the education system (Roy, 2011). Mathematics is the science of well-defined objects and concepts that can be analyzed and used in a variety of ways to produce results that we believe to be true (OECD, 2018). Coping with life's challenges is an essential and important requirement in every field of intellectual endeavor and human development (Ihechukwu & Ugwuegbulam, 2016).

The word 'mathematics' comes from a Greek word 'mathema', which means learning, study, science and also in classical times its short and technical meaning is 'the study of mathematics'. It is an important subject with wide applications in everyday life, yet mathematics is often considered a difficult subject in schools. From the beginning of formal education, students begin to develop negative attitudes towards learning mathematics, shying away from mathematics and gradually developing it into a form of mathematics anxiety. Mathematics is often considered a difficult subject by many students in school education (Capuno, et al., 2019). Regardless of the importance given to mathematics, a large number of students struggle to understand the subject (Mazana, Montero & Casmir, 2020). As Piaget (1971) stated that mathematics is a subject that should be conceived as a vehicle for training a child to think, reason, analyze and express logically, a specific And apart from being the main subject, it should be considered alongside any subject involving analysis and reasoning.

2.2 Mathematics Education

Mathematics is considered as a subject that is very important as a research field. This means teaching and learning mathematics to solve problems involving learning algorithms and formulas necessary for computation. It is a common platform for learning and teaching mathematics better. It includes aspects of teaching, learning and assessment. Mathematics education is the history and pedagogy of the domain of mathematics which can be characterized by an interesting and rich past and a dynamic and promising future (Clark, 2020). and applying mathematics to a real-life problem and develops a positive attitude toward the study of mathematics (Kanwar, 2019).

The subject of Mathematics is primarily concerned with the real needs of an individual, society and human being as a whole. Thus, it has to address the needs, wants, concerns, expectations, feelings, etc. of people, whether they are students, mathematics teachers or researchers. Mathematics education, by its very nature, is a highly multidisciplinary field. Thus, various research methods can be employed in the field of mathematics education. Mathematics education has a reflective relationship with its research objectives. These are not seen as absolutes but as the opposite of its diverse purpose. Mathematics is focused entirely on courses or content, but mathematics education encompasses general education classes and focuses specifically on the tools, methods, and approaches to effectively deliver a mathematics class. Facilitates focused practice. It is also a concern for curriculum and instructional decisions (Clements, 2012). Mathematics education focuses on the needs, interest and potential of learners in society. Thus it considers psychology, culture and social aspirations with as much rigor and attention as the content and practice of mathematics (Lowry, 2015). It also has strong foundations within the academic discipline of mathematics. It is also closely related to mathematics teachers in the classroom and their content knowledge and instructional content knowledge (Fried & Dreyfus, 2014).

Mathematics education covers not only psychology but also sociology, anthropology, philosophy, ethics and other fields (Lerman, 2014). But still, the main focus is, of course, on the teaching and learning of mathematics. As Jorgensen (2014) points out, we may need to create a transformative model of knowledge creation, the completion of which disrupts current (and past) pedagogical and classroom-based practices. Mathematics education includes a truly engaging and empowering curriculum that can be transformed into classroom practice (Wright, 2020).

2.3 Status of Mathematics Education in Pakistan

Mathematics education in Pakistan faces both challenges and opportunities. Although the importance of mathematics is recognized in Pakistan, many factors affect its status in the education system.

Mathematics is part of the curriculum in Pakistan from primary to higher education level. However, there are concerns about mathematics education, teacher training, and curriculum design. Limited access to quality education, especially in rural areas, exacerbates disparities in mathematics skills among students (Iqbal, 2011).

Rote memorization and teacher-centered approaches are prevalent in Pakistani schools and classrooms, which may hinder the development of critical thinking and problem-solving skills. Additionally, gender disparities in mathematics education persist, with girls often facing cultural, religious, and social barriers to pursuing STEM fields (Aslam, 2017).

Efforts are underway to improve mathematics education in Pakistan. Curriculum reform, teacher training initiatives, and technology integration are being explored to enhance instructional practices and learning outcomes. However, challenges such as lack of resources and barriers, inconsistent implementation, and lack of professional development opportunities for teachers still need to be addressed (Javed, 2019).

2.4 A Comprehensive Literature Review of Methods of Teaching Mathematics

Effective mathematics education is critical for developing problem-solving skills and logical thinking among students. The choice of teaching methods plays a pivotal role in shaping students' understanding and engagement with mathematics. This literature review aims to provide an overview of various methods of teaching mathematics and their effectiveness, drawing from existing research.

2.4.1 Traditional Lecture-Based Teaching

Traditional lecture-based teaching involves the teacher presenting mathematical concepts to the students through lectures and demonstrations. While this method is widely used, it often promotes passive learning and may not facilitate deep understanding. It can be effective when supplemented with interactive elements and hands-on activities (Bishop, 2017).

2.4.2 Problem-Based Learning (PBL)

Problem-Based Learning is an instructional approach that encourages students to explore and solve real-world problems, fostering critical thinking and application of mathematical concepts. PBL has been found to enhance students' problem-solving skills and their ability to transfer mathematical knowledge to practical situations. Lee and Kim conducted a case study analysis to explore the implementation of Problem-Based Learning (PBL) in STEM (Science, Technology, Engineering, and Mathematics) education. Through in-depth case studies, they examined how PBL was integrated into STEM courses and its impact on student engagement and learning outcomes. The study revealed insights into effective practices for designing and facilitating PBL activities in STEM disciplines, highlighting the importance of authentic problem-solving tasks, collaborative learning environments, and supportive instructor guidance. (Lee, S., & Kim, H, 2022)

2.4.3 Collaborative Learning

Collaborative learning methods involve group activities and discussions to encourage students to work together on mathematical problems. Research suggests that collaborative learning can improve students' mathematical reasoning, communication skills, and problem-solving abilities (Sarfo, 2014).

2.4.4 Technology-Enhanced Learning

The integration of technology, such as computer software and interactive apps, has transformed mathematics education. Technology-enhanced learning provides students with opportunities for visualizing complex concepts, immediate feedback, and individualized learning experiences. The effectiveness of technology in teaching mathematics has been widely acknowledged (Clark-Wilson et al., 2016).

2.4.5 Flipped Classroom

The flipped classroom model reverses traditional teaching by delivering lectures outside of class and using class time for active learning, discussions, and problem-solving. Research has shown that the flipped classroom approach can lead to improved student engagement and deeper understanding of mathematical concepts (Strayer, 2012).

2.4.6 Inquiry-Based Learning (IBL)

Inquiry-Based Learning encourages students to ask questions, explore, and discover mathematical concepts through guided inquiry. IBL promotes active learning, critical thinking, and a deeper understanding of mathematics. It has been found to be effective in enhancing students' mathematical reasoning skills(Chin, 2007).

2.4.7 Multiple Representations

Teaching mathematics using multiple representations, such as diagrams, graphs, and equations, can help students build a more comprehensive understanding of concepts (Sproesser, Vogel, Dörfler, & Eichler. (2022). This method emphasizes the importance of connecting various mathematical representations.

Teaching mathematics is a complex endeavor, and educators employ a variety of methods to engage students and facilitate learning. Each method has its strengths and weaknesses, and their effectiveness often depends on factors like the age of the students, the specific mathematical content, and the teacher's expertise. A combination of these methods, tailored to the needs of the students, can lead to a more holistic and effective mathematics education.

2.5 Traditional Methods and Their Disadvantages in Teaching Mathematics in Pakistan

Mathematics education is a fundamental component of a well-rounded education system and is crucial for the development of analytical and problem-solving skills. In Pakistan, as in many other countries, traditional teaching methods have long been the dominant approach to teaching mathematics. This literature review aims to explore the disadvantages of traditional teaching methods in the context of mathematics education in Pakistan. By understanding these limitations, educators and policymakers can work towards implementing more effective and engaging teaching strategies.

2.5.1 Rote Memorization

One of the primary disadvantages of traditional teaching methods in Pakistan's mathematics education is the overemphasis on rote memorization. The curriculum often focuses on memorizing formulas and procedures without fostering a deep understanding of mathematical concepts (Hussain, 2017). This rote approach can lead to students struggling to apply their knowledge to real-world problems and inhibits their critical thinking abilities.

2.5.2 Lack of Conceptual Understanding

Traditional methods tend to neglect the development of conceptual understanding. Students may solve problems mechanically without grasping the underlying principles. This lack of comprehension can hinder their ability to tackle complex mathematical concepts and adapt to new problem-solving scenarios (Shafiq & Aziz, 2016).

2.5.3 Limited Engagement

Traditional teaching methods in Pakistan often rely on passive learning, where students passively listen to lectures and complete exercises. This lack of engagement can result in disinterest in the subject and reduced motivation to learn mathematics (Khan, 2015). Consequently, many students perceive mathematics as a daunting and uninteresting subject.

2.5.4 Inadequate Use of Technology

The integration of technology in mathematics education is limited in traditional teaching methods. In a rapidly evolving digital age, this approach hampers students' exposure to modern tools and resources that could enhance their learning experience (Bashir, 2019). The use of technology can make learning mathematics more interactive and visually stimulating.

2.5.5 Inequality in Access

Traditional teaching methods can exacerbate educational inequalities in Pakistan. Many students in rural areas have limited access to quality mathematics education due to a lack of resources, qualified teachers, and modern teaching materials (Ali & Fatima, 2018). This educational divide further widens the gap between urban and rural students.

2.5.6 Assessment-Centered Education

Traditional methods often focus heavily on assessments, emphasizing rote learning and exam-oriented teaching (Shahzad & Amin, 2017). This approach may encourage surface-level learning to achieve good grades rather than fostering deep understanding and critical thinking skills.

Traditional teaching methods in Pakistan's mathematics education system exhibit several disadvantages, including an overemphasis on rote memorization, limited conceptual understanding, reduced student engagement, inadequate use of technology, educational inequalities, and an assessment-centered approach. Addressing these drawbacks is essential to enhance the quality of mathematics education in Pakistan. Implementing more innovative and student-centered teaching approaches, investing in teacher training, and promoting the use of technology can contribute to a more effective and engaging mathematics education system in the country.

2.6 Mathematics Laboratory

A mathematics laboratory is a place where students can learn and explore different mathematical concepts and verify different mathematical facts and theories using a variety of activities and materials Okigbo, (2008). The use of a mathematics laboratory helps to integrate theory and practical work in the teaching/learning of mathematics, and advocated the need for moderately equipped mathematics laboratories. Ogunkunle (2000) described the benefits of using a mathematics laboratory as follows;

- Display math information.
- Avenue for experiences through practical work
- A repository of math content for easy access
- Removing abstraction and enhancing effective teaching/learning.

Based on the benefits of a math laboratory, it is expected that teaching and learning mathematics with a math laboratory can help reduce the abstract nature of the subject and motivate students to follow through.

2.7 Laboratory Method in Education

Laboratory methods, commonly employed in various educational settings, provide students with hands-on experiences and practical learning opportunities. This literature review aims to explore the laboratory method in education, examining its applications, advantages, challenges, and effectiveness as reported in the existing body of research.

2.7.1 Applications of Laboratory Method in Education

a) Science Education:

Laboratories are integral to science education, offering students the chance to conduct experiments and investigations, fostering scientific inquiry, and enhancing understanding (Gönen et al., 2023).

b) Engineering and Technology Education:

Laboratory work is fundamental to engineering and technology programs, where students apply theoretical knowledge to real-world projects (Kaya et al., 2020).

c) Medical Education:

In medical schools, clinical and simulation laboratories are used to train future healthcare professionals, allowing them to practice procedures and develop clinical skills (Gökçek et al., 2021).

d) Mathematics Education:

Laboratory methods in mathematics involve interactive problem-solving and visualization techniques to deepen students' conceptual understanding (Moyer et al., 2018).

2.7.2 Advantages of Laboratory Method in Education

a) Experiential Learning:

Laboratory activities provide students with opportunities for experiential learning, facilitating a deeper understanding of concepts (Kolb, 2015).

b) Active Engagement:

Students are actively engaged in the learning process, which can improve motivation and retention of knowledge (Prince & Felder, 2019).

c) Development of Critical Skills:

Laboratory work fosters critical thinking, problem-solving, and decision-making skills (Lopatto, 2016).

d) Application of Theoretical Knowledge:

Laboratory experiences allow students to apply theoretical knowledge to practical situations, bridging the gap between theory and practice (Bransford et al., 2018).

2.7.3 Challenges and Considerations

a) Resource Constraints:

Setting up and maintaining laboratories can be costly in terms of equipment, materials, and infrastructure (Gökçek et al., 2021).

b) Safety Concerns:

Ensuring the safety of students in laboratory environments requires strict protocols and vigilant supervision (Walters & Wong, 2022).

c) Alignment with Curriculum:

Integrating laboratory work into a curriculum requires careful planning to ensure that it complements learning objectives and content coverage (Kaya et al., 2020).

d) Assessment:

Designing appropriate assessments for laboratory-based courses can be challenging, as traditional testing methods may not capture the full range of student learning (Lopatto, 2016).

2.7.4 Effectiveness and Impact

a) Research suggests that laboratory methods are effective in improving students' content knowledge, problem-solving skills, and attitudes toward learning (Koksal et al., 2019).

b) Laboratory-based courses often result in higher levels of student engagement and satisfaction compared to traditional lecture-based courses (Prince & Felder, 2019).

c) The impact of laboratory methods on student learning outcomes may vary depending on factors such as the quality of instruction, alignment with learning objectives, and the nature of the subject matter (Gönen et al., 2023).

Laboratory methods in education offer a range of benefits, including experiential learning, active engagement, skill development, and the practical application of knowledge. However, their successful implementation requires addressing challenges related to resources, safety, curriculum alignment, and assessment. Laboratory Methods can significantly enhance the learning experience and outcomes of students across various educational domains."

2.8 A Historical Overview of the Laboratory Method in Mathematics Education

The use of laboratory methods in mathematics education, although less commonly associated with mathematics than with science, has a unique and evolving history. This literature review aims to trace the historical development of the laboratory method in mathematics education, examining key milestones, influential figures, and the evolving role of mathematical laboratories in pedagogy.

2.8.1. Early Origins and Antecedents

a) Ancient Mathematics:

The roots of experimental mathematics can be traced back to ancient civilizations like Babylon and Greece, where mathematical discoveries were made through practical problem-solving (Kline, 1972).

b) Islamic Mathematics:

Scholars in the Islamic Golden Age (8th to 13th centuries) made significant contributions to mathematics, often using practical applications and geometrical models (Hogendijk & Sabra, 2010).

2.8.2 Emergence of Experimental Mathematics

a) Descartes and Analytic Geometry:

René Descartes' introduction of analytic geometry in the 17th century paved the way for algebraic representation and the use of coordinates in mathematical investigations (Burton, 1985).

b) Newton and Calculus:

Sir Isaac Newton's development of calculus and mathematical physics in the late 17th century involved extensive experimentation and observation (Westfall, 1980).

2.8.3. 19th-Century Developments

a) Humboldtian Educational Reforms:

The Humboldtian university model in the early 19th century, which emphasized laboratory work and experimentation, had a significant impact on mathematics education (Geiger, 1993).

b) Crelle's Journal:

August Leopold Crelle's founding of the Journal für die reine und angewandte Mathematik in 1826 provided a platform for mathematical research that often featured experimental and applied mathematics (Schubring, 1988).

2.8.4. Twentieth Century and Beyond

a) Computational Mathematics:

The advent of computers in the mid-20th century revolutionized mathematical experimentation and modeling, giving rise to computational mathematics (Bailey & Borwein, 2005).

b) Mathematical Software:

The development of mathematical software such as Mathematica, MATLAB, and Maple enabled students and researchers to perform complex mathematical experiments (Nocedal & Wright, 2006).

2.8.5. Challenges and Critiques

a) Integration into Curricula:

The integration of laboratory methods in mathematics curricula has been challenging, with traditional lecture-based instruction remaining predominant (Almeida & Mesquita, 2013).

b) Assessment and Evaluation:

Designing appropriate assessments for mathematics laboratory work can be complex, and the impact on learning outcomes is a subject of ongoing research (Ben-Chaim et al., 1988).

The history of laboratory methods in mathematics education is a story of evolving approaches and changing technologies. While mathematics is often seen as an abstract discipline, its history reveals that experimentation, visualization, and practical applications have always played a crucial role in its development. The challenges of integrating laboratory methods into mathematics education, particularly in formal curricula, remain areas of exploration and innovation.

2.9 Laboratory Method in Teaching Mathematics

The laboratory method in mathematics education is an approach that emphasizes hands-on, experiential learning to enhance students' understanding of mathematical concepts.

a) Experiential Learning:

The laboratory method in mathematics is characterized by experiential learning, where students actively engage with mathematical concepts through practical activities and experimentation (Albano, G., & Pierri, A. (2014).

b) Application of Concepts:

It involves the practical application of mathematical principles, allowing students to see how mathematical ideas relate to real-world situations (Noss et al., 2017)..

c) Collaboration and Problem Solving:

Laboratory activities often promote collaboration among students, encouraging them to work together to solve mathematical problems (Mousoulides et al., 2016).

Mathematics is distinct from subjects primarily involving reading; practical work constitutes a significant component of its pedagogy. Laboratory methods, characterized by a "learning by doing" approach, are adept at handling practical work in mathematics. Employing a diverse array of tools and equipment, including drawing implements for various shapes, instruments for measuring geometric figures, and resources for creating charts and graphs, these methods facilitate hands-on learning experiences. Students engage in a series of experiments within the laboratory or classroom setting, where they learn through self-observation and calculation. Throughout this process, they have the opportunity to draw conclusions and derive generalizations concerning various laws and formulas. Consequently, this method can be aptly described as an extended form of the inductive method (Sundstrom et al., 2021).

The use of laboratory methods in teaching mathematics is an innovative approach that aims to enhance students' understanding and engagement with mathematical concepts. This literature review provides an overview of the utilization of laboratory methods in mathematics education, drawing from existing research to explore its advantages and potential challenges.

2.9.1 Steps in Implementing the Laboratory Method in Mathematics Education

Step No:1 Planning and Preparation:

Educators must carefully plan laboratory activities, selecting appropriate mathematical topics and designing hands-on tasks or experiments that align with learning objectives (Lambdin & Johnson, 2019).

Step No:2 Introduction and Context:

Teachers introduce the mathematical concept and provide the context for the laboratory activity, explaining its relevance and potential real-world applications (Lester, 2018).

Step No:3 Hands-On Exploration:

Students engage in practical activities or experiments that involve manipulating mathematical objects, conducting investigations, or using technology tools to explore mathematical ideas (Hegedus & Roschelle, 2010).

Step No:4 Data Collection and Analysis:

In the laboratory, students collect data and analyze results, applying mathematical principles to draw conclusions and make connections between theory and practice (Jacob & Yeo, 2003).

Step No:5 Reflection and Discussion:

After completing the activity, students engage in reflective discussions, sharing their findings, insights, and questions with peers and the teacher (Kaur & Dindyal, 2015).

Step No:6 Integration and Application:

The laboratory experience is integrated into the broader mathematics curriculum, reinforcing concepts learned and providing opportunities for further exploration (Selden & Selden, 2013).

2.9.3 Advantages Teaching Mathematics Through Laboratory Method

a) Concrete Understanding:

Laboratory methods allow students to explore mathematical concepts through hands-on activities, enabling them to develop a concrete understanding of abstract ideas (Lampert, 2019).

b) **Enhanced Problem-Solving Skills:** Laboratory experiments often involve solving real-world problems, promoting critical thinking and problem-solving skills (Chinnappan et al., 2020).

c) Visual and Tangible Learning:

Visual aids, manipulatives, and interactive simulations make complex mathematical concepts more tangible and accessible, catering to diverse learning styles (Hiebert & Lefevre, 2020).

d) Active Learning:

Laboratory activities engage students actively, shifting the focus from passive listening to active participation and exploration (Kirschner et al., 2006)

2.9.4 Types of Laboratory Methods in Mathematics Education

a. Manipulatives and Physical Materials:

   The use of physical objects such as blocks, counters, and geometric shapes to explore mathematical concepts (Sarama & Clements, 2009).

b. Computer-Based Laboratories:

   Utilizing computer software and simulations to visualize and experiment with mathematical concepts (Koedinger et al., 2012).

c. Mathematical Modeling:

   Encouraging students to construct and analyze mathematical models to solve real-world problems (Lesh & Doerr, 2003).

d. Exploratory Activities:

   Providing students with open-ended tasks and exploratory challenges that promote inquiry-based learning (Hiebert & Grouws, 2007).

2.9.5 Challenges and Considerations

a) Resource Availability:

   Implementing laboratory methods may require access to materials, technology, and teacher training, which can pose challenges in resource-constrained settings (Selden & Selden, 2013).

b) Time Constraints:

   Integrating laboratory activities into the curriculum may necessitate careful planning to ensure that essential content is covered within the allocated time (Ruthven, 1998).

c) Assessment:

   Designing effective assessments that align with laboratory-based teaching methods can be complex and may require the development of new evaluation tools (Artzt & Armour-Thomas, 1992).

d) Teacher Training:

Teachers may require specialized training to effectively implement laboratory methods, including managing classroom dynamics during hands-on activities (Heid, 2006).

2.9.6 Effectiveness and Impact

a) Research indicates that laboratory-based teaching methods can lead to improved mathematical achievement, especially when integrated with traditional teaching approaches (Hiebert et al., 1997).

b) Positive outcomes include increased student motivation, improved problem-solving skills, and a deeper conceptual understanding of mathematical concepts (Kaput, 1998; Lesh et al., 2000).

c) The impact of laboratory methods on student learning may vary depending on factors such as the quality of materials, teacher expertise, and the alignment with curriculum goals (Selden & Selden, 2013).

2.9.7 Merits and Demerits of Laboratory Method

This method has also some merits and demerits (Baig, F. (2015). Merits of this method are as follows.

i. It is student centred method.

ii. Students play an active role so they do not get bored.

iii. It is based on discovery approach.

iv. Knowledge gained through practical work is long lasting.

v. As students establish laws and formulas by themselves so they gain confidence.

vi. Practical utilisation of mathematics is realised by the students.

vii. When students work in the groups then their learning becomes fast because of sharing information and ideas.

viii. The teacher-student relationship gets strengthened.

Laboratory method has the following demerits.

i. It is very lengthy process.

ii. It is restricted to those topics only in which practical work is involved.

iii. In Pakistan, it is very difficult for so many schools to spend a lot of money on tools and equipments involved in this method.

iv. Teachers have to practise a lot before applying this method in the classroom or laboratory.

v. v.Students cannot practise this method to establish laws or principles independently.

vi. It is more effective in lower level classes as compare to secondary level.

Teaching mathematics with laboratory methods offers a range of advantages, including promoting concrete understanding, enhancing problem-solving skills, providing visual and tangible learning experiences, and fostering active learning. However, the successful implementation of these methods requires addressing challenges such as resource availability, time constraints, assessment design, and teacher training. Overall, the literature suggests that when implemented effectively, laboratory-based teaching methods can significantly impact student learning and engagement in mathematics.

2.10 What is of bloom taxonomy?

Recognizing that the phrases "taxonomy" but also "classification" are the same assists ease the fears of the word. Bloom's Taxonomy is a multi-tiered paradigm for categorizing thought based on six cognitive levels of sophistication. The levels have often been described as a passageway over the years, encouraging many instructors to encourage their students "climb to a higher (level of) thinking." Awareness, comprehension, and implementation are the three lowest categories. Evaluation, synthesis and Analysis are top three stages. “Each grade is absorbed by higher levels. The taxonomy is hierarchic. In other words, a person working throughout the stage of "application" was also taught during the phases "intelligence" and "knowledge."” 2003 (UW Teaching Academy). It is easy to see where this arrangement resulted in normal distinctions between lesser and greater thought.

Clearly, the time test was held by Bloom's Taxonomy. It was shortened, extended and reinterpreted in a number of ways thanks to its long reach and success. Research results have contributed to the exploration of a true smorgasbord of meanings and implementations that go from close surveys to extended explications. However, a recent review (designed by a co-editor with a former Bloom participant for the original taxonomy) deserves special consideration. Krathwohl (2002)

2.10.1 History Bloom's Taxonomy

The concept to increase learning, from the lesser level of red learning and recall to higher level analyses, evaluations, creativity and solution of problems, Dr. Benjamin Bloom with Max Englehart, Edward Furst, Walter Hill & David Krathwohlput; an educational Psychoanalyst, set forth in 1956. Three areas of academic learning include Bloom's taxonomy: cognitive, emotional and psychomotor. The psycho-motoric domain incorporates physical abilities; the emotional field increases the steady emotional growth of attitude and self. Thus it is reduced as KSA (knowledge [cognitive], skills [psychomotor] and attitude [affective]). The six steps initially focused on cognitive issues were: knowledge, comprehension, application, analysis, synthesis and assessment (Bloom, 1956).

The Associate Director of the Review Board of University of Chicago, Benjamin S. Bloom, was entrusts the task to create benchmarks in order to measure the same educational objectives for different schools. This effort was accompanied by several remarkable specialists in the United States. Twice a year in 1949 the whole Bloom management group convened. In 1956, the work was finished and published with the last draught named "Taxonomy for educational aims."

This taxonomy is, according to Krathwohl (2002), a means to measure subjects and results and to express education goals in a common vocabulary. For the following purposes the taxonomy of Bloom was considered to be used:

- It can be used as a communication source between the subjects, teachers and assessors.
- The curriculum may be utilized for national, state and local criteria.
- It may be used to measure courses.
- The range of informative results imaginable can be determined on these grounds.

A Blossom's scientific classification comprised of six degrees of cognitive domain; each space was obviously partitioned into its sub levels. The request for continuing depended on easy to complex and from cement to digest. It is introduced in a total chain of importance; every classification was essential for the following classification (Krathwol, 2002)

Tutkus (2012) put another phrase in instruction at the beginning of the taxonomy term 'taxonomy' in the Bloom. The educators had no indication of the relevance of this; hence little care was given. But, with time, the phrase acquired the cash and was commonly recognized and mentioned. The scientific categorization of Blossom has been transformed into 25 dialects. There are six major taxonomies levels.

2.10.2 Plan of Taxonomy

Table No 2.1: Cognitive Domain

(Table is on the next page)

Levels	Cognitive Domains	Exlplained
1	**Knowledge**	Knowledge of specifics facts Knowledge on available resources of managing points of interest Knowledge of vocabulary Knowledge of patterns as well as successions Knowledge of criteria, classification Knowledge of wide-ranging and field reflection People who are connected of standards and speculations
2	**Comprehension:**	Translation Interpretation Extrapolation
3	**Application**	Utilization of information, realities, rules in an unexpected way Conduct training theory Remove the issue Use in different circumstances of reality and information Induce and predict new things by using information
4	**Analysis**	Element Analysis Relationship Analysis Company principle analysis
5	**Synthesis**	production of special correspondence Creation or planned collection of activities an arrangement A collection of conceptual relationships

6	**Evaluation**	Evaluation as far as inward proof Decisions as far as outside criteria

(Krathwol, 2002)

Table No. 2.2: The action verb for all sub-levels

Skill	**Definition**	**Key words**
Knowledge	Recall data	Recognize, label, Describe, follow, identify,
Comprehension	Know the importance of the notion paraphrase	Covert, defend, resume, interpret, paraphrase, exemplify
Application	Implementing the information or notion is new	Make, construct, predict prepare, built
Analysis	Divided information or notion into components to fully comprehend	Break apart, choose, differentiate, and separate comparison and contrast.
Synthesis	set up plans to shape something new	Reconstruct, generalize, categories
Evaluation	make judgment about esteem	Judge, justify, appraise, support.

2.10.3 Rationale/Objective of Revised Bloom Taxonomy

In the 21st century, various learning spectra and techniques were invented by psychological and instructional scientists. As Alagic (2009) points out, constructionism, metacognition and structured learning are only among these emerging learning theories. With these teachings in mind, learning is regarded as a "proactive activity," requiring inspiration and social cycles with meta-cognition.

Educators today have better understanding of the learning cycles and their assessment; teachers have new teaching approaches (Startalk, 2009, refered to by Tutkus, 2012)

"The taxonomy of The Bloom, as Tutkus put it (2012), was meant to categories educational programmed objectives as far as specific, unmistakable psychological talents and abilities are concerned. Scientific classification is acknowledged as one of the significant examinations that influence the educational plan in 21st century. For example, a web crawler shows 455,000 outcomes for Sprout's Bloom's taxonomy." This Bloom's taxonomy was exhaustive to the point that it made due for seemingly forever. In spite of the different scientific classifications, just Blossom's scientific classification is acknowledged (Forehand, 2005). Yet, As a result of progress in brain research and education, In order to meet the growing demands of the 21st century this scientific classification needed significant adjustment (Tutkus, 2012).

2.10.4 Revised Bloom's Taxonomy

The Bloom's under view Anderson returned to the Bloom's Taxonomy and presented his revised version for 2001 together with a number of well-known psychological analysts. The revision and the introduction of Revised Taxonomy Bloom's (RBT) were followed by new advances on the area of training, understudy, new assessment and evaluation techniques and an instructor's practice to arrange the previous taxonomy (Anderson, 2001). Tutkun&OK (2012) has made major modifications to the previous Bloom's Taxonomy limit in the revised Bloom Classification. As for the previous taxonomy, the new Bloom classification comprises three mainly consist of transformation (Forehand, 2005). It has shown increasingly comprehensive and appropriate to the current study assumptions through these progressions (Anderson, 2003). The key areas of change are hereafter.

2.10.5 Variations in Terminologies

Bloom's updated Taxonomy version has transformed things into action. In the revised Bloom Taxonomy, the synthesis cycle is replaced by innovation and maintained to the greatest degree since the integration of various information impacts creativity. As per Farzad (2010), Bloom's Taxonomy (RBT) has been updated to give a wide-ranging view on all terms in the action word;

Table No 2.3: Comparisons/Examinations of Ancient bloom taxonomy and new Revised Bloom Taxonomy

Ancient bloom taxonomy	New Revised bloom taxonomy
Knowledge	Remembering
Comprehension	Understanding
Application	Applying
Analysis	Analyzing
Synthesis	Evaluating
Evaluation	Creating

2.10.6 Fundamental Variations

The difference in the measures is as per the structural change between the old and the updated taxonomy. The initial Bloom taxonomy was one-dimensional, ranging from simple to complicated, while the RBT was twin. The "dimension of knowledge" is one evaluation and the other "dimension of the cognitive process." The RBT isolated the item in two independent measures. The measured word and the action word. The measurement of information shall be divided into four portions which are the "thing viewpoint" and the research result shall be isolated into six sections which are the "word perspective"

2.10.7 The revised taxonomy table of Bloom is shown below:

Table No. 2.4: Revised Bloom Taxonomy structural modifications

Knowledge Dimension	The Cognitive process dimension 1	2	3	4	5	6
	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating
Factual Knowledge						
Conceptual Knowledge						
Procedural Knowledge						
Meta Cognitive knowledge						

2.10.8 Importance changes/emphasis changes

Under the previous Bloom Taxonomy, three classes provided RBT another categorization extension. 'Metal cognitive knowledge' (factual, conceptual and procedural). This is how somebody is able to obtain information. Students can modify their learning techniques and reflect on their solidarity and weaknesses. The RBT offered the designer, educational organizer, informational conveyor instructors and evaluators a legitimate and reliable mechanism for evaluation and evaluation. (Forehand,2012).

The RBT has given an enormous scope of showing exercises for educating and appraisal and reclassify the showing learning measure. Pockard (2016) expressions support this reality This reality "RBT empowers teachers to distinguish which information they anticipate that students should utilize and to figure out which cognitive process dimension is utilized"

2.10.9 Cognitive RBT Process Dimension

This taxonomy dimension is split into six categories that reflect the word 'activity.' It covers the approach of learning and the learning has to be learned via education (Anderson, 2000).

1-Remembering

It is typical that undergraduate studies should recognize, recognize and retrieve or review the relevant knowledge and facts from the removed memory in this dimension or measurement. This measurement includes two major sub-classes I-e that recognize, perceive, recall or review, or it is a memorable capacity to review prior knowledge as necessary.

Table no 2.5: Cognitive process remembering

	Examples
Memorizing : Producing factual memory info	
1) Recalling	➢ Replicate the loss and profit formula. Write angels and types of angels. ➢ Write about the multiplicative fact.
2) Recognizing	➢ Recognize the shape of geometry or angels. ➢ Solve answer any true-false or fill in the blanks.

2- Understanding

This is the second component of the cognitive process which regulates the ability of the understudies to understand the necessity to clarify, explain and refine or re-examine thoughts and ideas. It contains interrelated, embodied, contrasted and summarised sub-levels

Table no 2.6: Cognitive process understanding

	Examples
Understanding : meaning via education or experimentation	
1) Exemplifying	The parallelogram is a development of development. ➢ There should be a total square for what should be added to 81.
2) Classifying	➢ The right Angel Triangle Sides of Mark. ➢ There angels list.
3) Interpreting	➢ Draw a chart with the given estimation. ➢ Make an interpretation of a story issue into in algebraic equation.
4) Brief	➢ Create two triangles equal ➢ Grade essential elements needed in addressing issue linked circle.

3- Applying

The ability to use the knowledge received in a comparable or fresh scenario is managed by this cognitive process interaction aspect. It illustrates the results of learning through performing and performing in new or old circumstances.

Table 2.7 Cognitive dimension Applying

Cognitive process	Example
Applying – utilize a methodology	
1) Implementing	➢ Develop 49 square roots. ➢ Solve the equation of 256.
2) Executing	➢ Add a 2-digit number segment. ➢ Compose a greatest in four digits.

4-Analyzing

Breaking off is a cognitive process, which divides information into the components and studies the components to understand the whole. The study results of this capacity are separated, arranged, assigned or assigned. It is also known for its higher thought capacity (HOTS).

Table 2.8 Cognitive dimension Analyzing

Cognitive process	Example
Analyzing – separate an idea into parts and portray how the parts identify with the entirety.	
1) Organizing	➢ Mastermind the quantities of as indicated by the condition. ➢ Make a list of any four question
2) Differentiating	➢ Make the important facts for the math issue of the world a complete overview. ➢ • Take a chart that shows the square diagonal is the same.

3) Attributing	➢ Discuss about the properties of rational numbers. ➢ Make a list of even number.

5- Evaluating

This ability also includes an ability to think more in order. Control and evaluation are part of the learning consequence of this skill.

Table 2.9 Cognitive dimension Evaluating

Cognitive process	Example
Evaluating - decision making based on criteria and timetable rules	
1) Critiquing	➢ Picked a best strategy for tackling a complex mathematical. ➢ Assess how well a venture meets the models of rubrics.
2) Checking	➢ Which number doesn't have a place with the arrangement? ➢ settle the quadratic equation check it by recipe or formula

6-Creating

The dimension or measurement in RBT is new; the most remarkable ability was eliminated from the previous taxonomy and is replaced or replaced by a mixture of the prior taxonomy. It comprises combining information and constructing something new to generate fresh information. It includes creation, arrangement and delivery. The consequences of this learning ability rely on the pieces of knowledge used to create new ideas and things. To evaluate the capacity, students have to do out tasks such as planning and developing new items. (Anderson, 2000).

Table 2.10: Cognitive process creating in bloom taxonomy

Creating – build parts that form or perceive part of a building	
Planning	➢ Draw the stage of RAM,ROM building. ➢ Circle in a triangle design diagram
Generating	➢ Create a formula to discover the unknown value. ➢ Create a square root whose volume is the same as the rectangle perimeter.
Producing	➢ Write the importance in everyday life of mathematics. ➢ The drawing is sloped or slanting with different angles

2.10.10 the updated bloom taxonomy RBT knowledge dimension

RBT knowledge is in the second dimension in both cases. Each dimension is distinct in its four characteristics. It has four measurements. It is shown in the table below:

Table 2.11 Dimension of RBT knowledge

The dimensions in factual and fundamental knowledge	
Knowledge of certain information and elements	➢ Component of the pyramid diet, names of lawmakers of the Congress, key fighting of the Second World War.
Knowledge of terminology	➢ Mathematical symbol, alphabet vocabulary ,musical notation

- Conceptual knowledge – the relationship between components of a broader system that make them work together

Knowledge of principal and generalizations	- Literary conflict types, newton rule of motion, democratic principles. Democratic principles.
Classification and category knowledge	- Species animals and geological periods, different types of argument
Theory, modalities and structural knowledge	- economic theories,

- Procedural knowledge - how something can be done

Knowledge of certain subject and approach techniques.	- The examination of historical texts in mathematical problem resolving approach Critical literary
Knowledge of criteria for establishing the usage of acceptable methods	- Methods suitable for different sorts of investigations, statistical analytical techniques utilized for various situations.
Knowledge of subject-specific skills	- Mixed color's in oil painting, served by volleyball, to solve quadric equations

- Metacognitive knowledge – understanding in general aside your thinking in specific

Knowledge of cognitive tasks, including relevant contextual and conditional knowledge	- Various requirements for reading textbooks and novels; thought while utilizing an electronic database; distinction between business letters
Strategic knowledge	- Various meaning information, understanding reading tactics, planning approaches for a website

Chapter-3

METHODOLOGY

The study was defined the effect of laboratory method on higher order thinking skills (HOTs) of mathematics at elementary level. For appraising academic achievement of elementary students pretest post-test design of experimental research was implemented of both groups experimental and control group. Quantitative techniques were implemented and data is collected through experimental design following scientific research methodological steps. For measuring academic achievement of elementary school student, two group experimental and group controls have adopted a pretest post-test control strategy for experimental research. Only the laboratory method was used to treat the experimental group. Only traditional methods have been supplied to the control group for teaching. The number of courses was 14 and the duration of the lessons was 45 minutes. The experiment group was treated with the effect of the mathematics laboratory's instrument and the control group was kept constant. The data analysis consisted of a simple, independent sample t-test (t-test) using the version of statistical SSPS 2.2 software.

3.1 Design of Research

The research was quantitative. The approach was truly experimental, namely the independent variable for the pretest and post-test control group while achievement is dependent variable. The sample of study was preserved with experimental and control group techniques through laboratory method.

Table no 3.1 Pretest & Post-test Design Methods

Particular	Pre-test	Post-test	total
Laboratory method	30	30	60
Traditional method	30	30	60

Pretest and posttest design is a form of real experimental design controls the threats of validity and reliability. During the whole experiment, pretests and posttest control groups were employed. This design is represented as below;

R	O1	X1	O2
R	O1	X2	O2

Where

X1	unusual treatment
X2	control treatment
O1	Observation or measurement (Pre-Test)
O2	Observation or measurement (Post-Test)
R	Random assignment (Gay 2012)

Planning of Teaching

lesson plan	Timing
14	45 mints

3.2 Experimental research concept chart

Table 3.2 IVCDV Chart

Independent variable	Constant	Dependent variable
Laboratory method	Same sexual category	Students' academic achievement

Same atmosphere

Same ages

Same place

3.3 Population of the Study

The population is a group of individuals having few similarities, according to Gay (2000). The sample was picked as a study, and then the findings abstracted was made available for the entire population. Creswell (2012) defined population as a collection of people who have shared features or belong to a certain demographic.

The target population was comprised of 60 elementary students who study at Govt. High School (GHS), Dherai Talash, Lower Dir, KPK.

3.4 Sample and Sampling Technique

The sample of the research was taken from Govt. High School (GHS), Dherai Talash, Lower Dir, KP. Only one of government schools for boys in district District Lower Dir was selected to be studied.

The population of the research was Govt. High School (GHS), Dherai Talash, Lower Dir, KP. The school was chosen for the study. The list of students was provided to allow a simple random sampling technique to retrieve the sample. The size of the sample was 60 students of class 6^{th}.

The school was picked for students studying in the field of mathematics in class 6^{th}. Both school group (experimental and control group) samples were collected by means of simple random samples for pre-test and post-test treatment.

Table 3.3 Table of Sample

	Experimental Group	Control Group	Total
Male	30	30	60

3.5 Research Instrumentation

Two techniques for measuring the instruments were used in this investigation. First, the right response paper was selected and the question was answered by both the research supervisor and specialists. Second, under the supervision of the supervisor, the subject of the mathematics was picked. The researcher selected the right answer paper when minor modifications were made. After the review process, mathematics was picked as the right answer paper for the pre-test processes. The students received the correct reply paper. The assessment tool for students has been developed using Khyber Pukhtukhwa Text Book Board Mathematics book. The gadgets were utilized as the test for fixed marks for assessing the experimental and control group. The test was of 100 marks in the data gathering performance / performance test.

In line with the core objectives of the study, the assessment tool was impeccably designed to measure the effect of the Laboratory Method on Higher Order Thinking Skills (HOTs) among elementary students. The instruments used for assessment were carefully calibrated to make sure the reliability and validity. The examination papers were used as the standardized test for evaluating both the experimental and control groups, while each test comprising of 100 marks.

3.6 Variables of the Study

Two variables were present in the study.

3.7 Independent Variables

The independent variable was Laboratory Method

3.8 Dependent Variables

The dependent variable was higher order thinking skills (HOTs) in the subject of mathematics.

3.9 Intervening Variables

Laboratory Method was used as intervening variable

3.10 Extraneous Variables

(Students Age, experience of teachers, intelligent quotient level, qualifications of teachers).

3.11 Internal Validity Threats

1. History

Sometimes, things that we didn't plan for can happen while we're doing a study. These things might accidentally affect the outcome. The people we're studying often have different experiences as the study goes on, which can also have an impact. For instance, if we compare test results from the beginning and end of a class, the environment at the start of the class is not the same as at the end. This can affect the test results. So, researchers try to prevent unexpected events and make sure both groups have the same environment.

2. Maturation

Changes in the participants' bodies or genes that can happen over time during the study might affect the results. The people being tested could get bored, tired, hungry, or older as the study goes on, which can be a problem in long studies. But in our study, the treatment only lasts for eight weeks, which is not a very long time, so we don't expect big changes in the students' minds. We are making sure that this potential issue is managed in both groups of participants.

3. Testing

In the experiment, the initial test could make people perform better in the following tests because they already know what to expect. People tend to do better when they see others doing well. The testing period was only eight weeks, which is not enough time for people to get used to it.

4. Instrumentation

In a study, sometimes the tools that are used to test things can change. This can affect what we measure and how we measure it. Also, when people watch and take notes; and the way they see things might change over time even before the test subjects start doing what they need to do.

5. Statistical Regression

In studies where some people are very excited and others are not, the middle score can be a problem. After the test, most people usually get lower scores, so it's hard to compare scores before and after the test. Randomly choosing people for the study can help avoid really high or really low scores.

6. Selection

In the subject, teams were formed in a specific way, not by chance, at the beginning of the schoolwork. Because of this, all the results from the schoolwork were based on personal opinions when we compared the teams at the end. To avoid this problem, we can randomly select participants instead of choosing them in a specific way

7. Experimental Mortality

The test subject failed for various reasons. Some people from the comparison group left, which might make the study's results less accurate because many people in both groups might have gotten sick or lost motivation. This means the groups are not the same anymore. The 8-week period where this problem could happen is over, and this study showed that nobody dropped out of the test, and everyone answered all the questions. This problem was taken care of during the study.

3.12 Threats to External Validity

1. Selection Bias

When we choose some people in a certain way, it doesn't mean they represent everyone. Picking people randomly helps make sure our study is valid and accurate, which is really important.

2. Reactive Effects of Experimental Testing

The way we do the treatment is carefully managed, but when we do experiments in a real lab, things may not be as controlled. Sometimes, the regular habits of the subject could be influenced more by the surroundings than the thing we're testing.

3. Multiple Treatment Interference

We are very careful when we give someone treatment, but when we do experiments in a real lab, things might not be as well organized. Sometimes, the behavior of the person we are studying can be more affected by the environment around them than by what we are testing..

4. Validity and reliability

"We picked the questions from the Khyber Pakhtunkhwa textbook. The supervisor and teacher from the Department of Educational Leadership and Management at the Faculty of Education in the Islamic International University, Islamabad, looked at the questions on the test before and after teaching. To make sure the questions are good, we used a reliability test called Cronbach's alpha.

3.13 Data Collection

For data collecting, the researchers utilized an experimental technique. Both groups were chosen from the institution for this investigation. The study was conducted in the field of mathematics using Laboratory Method, such that two groups, experimental and control groups received a chapter.

3.14 Data Analysis

Data is statistically significant ANOVA and t-testing using SPSS analyzed one way. Lesson planning was used for the contents of the mathematics of Khyber pukhtunkhwa text book board. The sample test is prepared and tested upon the students accordingly.

Chapter-4

DATA ANALYSIS AND INTERPRETATION

We used a computer program called SPSS to look at the information we gathered in this part. We wanted to see how the Laboratory Method affected one group and the traditional method affected another group. We made some tables to show and explain the results for both methods regarding time and how information is shown. Our main goal in this study was to see how the Laboratory Method helps people think better in math. We split this chapter into two parts. In the first part, we explain information about the people we studied, and in the second part, we test our ideas. The first part shows what we found when we collected information and gives some numbers to help us understand it better.

Demographic information about respondents is provided at the beginning of the statistical research. The following details are given.

Table 4.a Demographic data of experimental group

Sr. No	Age group	Frequency
1	11-12	20
2	13-15	9
3	16-17	1
		Total = 30

Table 4a: Experimental Group of demographic information

The research experimental group was taught by laboratory method, in which the majority of participating respondents are from the 11 to 12 age group. It is approximately 66.6% of all respondents. Age of 13-15years was 30% in respondents. There were 3.3 per cent of the 16-17 age groups,

Table 4.b: Demographic data of control group

Sr. No	Age group	Frequency
1	11-12	17
2	13-15	9
3	16-17	4
		Total = 30

Table 4b: Control Group of demographic information

The participant is 56% from the age of 11-12, and statistically the groups were grouped to determine how many learners are inside each age group. The second class intervals, i.e. 13–15, representing around 30% of the total population, were associated with most of the responses. This control group was taught by traditional methods and 13% of learners are 16 to 17 years old. In 16-17 years, the lowest number of people examined.

4.1 Comparison between mean values of the laboratory method and traditional method

On the data collection of this investigation the T - test was employed. The comparison of the mean is made using SPSS-22 before and after tests. The descriptive statistics tables and the Levene test are shown below.

Table 4.1 Comparison between Laboratory and traditional method post-test technique Mean by Macq's sections

Table 4.1 Section 1: multiple choices Question

Group statistics					
Particular Mcqs		N	Mean	Std. deviation	Std. means error
Teaching strategies	Laboratory method	30	48.3000	20.68174	3.77595
	Traditional Method	30	32.5000	11.16568	2.03856

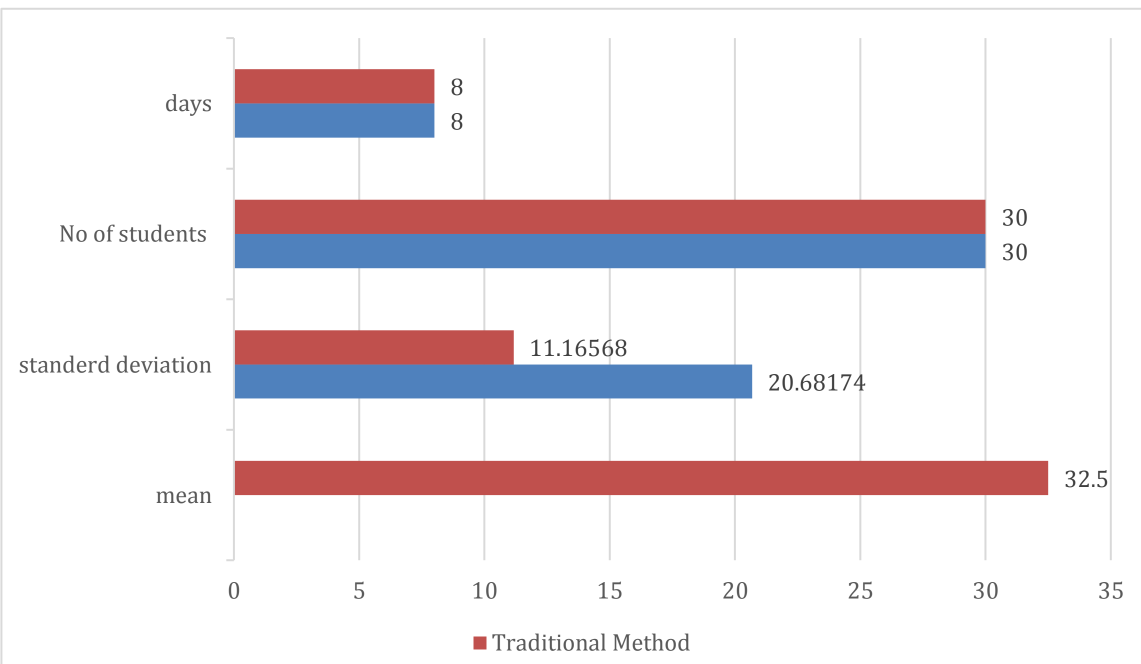
Levene's test for equality of variances

	T	DF	Sig.(2-	95% confidence interval of the tiled difference		
				Upper	lower	F
Equal variances Assumed	3.682	58	.001	7.21042	24.38958	4.536
Equal variances not assumed	3.682	44.582	.001	7.15504	24.44496	

Above table describes the mean, standard deviation and std. error and Means both groups' values. The Laboratory is higher than the traditional teaching method. The mean difference shows that the two techniques of teaching are not the same. The mean difference from traditional method is 32.5000. The Laboratory method is 48.3000. The value of t-test occupied from the independent sampling test of Laboratory method and traditional method with are significant in 2 tailed tests that mean that there is high level of significance between two groups.

The Laboratory method mean was larger than the traditional method means. This shows that before teaching the topic to students, the Laboratory method is useless. The Laboratory method has been shown to be good for the students' academic success, which results better at the conclusion of their research. Capital letter N refers to the total number of participants. DF in the above table shows the degree of freedom. The above-mentioned variation table assumes that upper and lower confidence interval values are dispersed in the standard deviation which shows that the distance from the research data is not higher. The standard deviation is less important in the study than the unknown arithmetic method of control and experimentation group. The entire total amount of the total of two mean additional MCQ classifications (see questions of multiple choices) cannot provide results when dispersed.

Figure 1; Comparison of the traditional and Laboratory method mean by parts of Mcqs



4.2 Post-testing mean question-answers analysis of the experimental and control group

Table 4.2 Section 2: Question Answers

Question Answers

Particular Question Answers		N	Mean	Std. deviation	Std. means error
Teaching strategies	Laboratory method	30	9.4667	4.73238	.86401
	Traditional Method	30	7.1000	3.83586	.70033

Levene's test for equality of variances

	T	DF	Sig.(2-	95% confidence interval of the tiled difference upper	lower	F
Equal variances Assumed	2.128	58	.038	4.59296	.14037	.690
Equal variances not assumed	2.128	55.617	.038	4.59500	.13834	

The mean result of the Laboratory Method differs greatly from the old one. It indicates that both techniques did not get the same outcomes. This section illustrates the difference in the mean value that the Laboratory method is more successful than traditional teaching methods when answering questions.

4.3 Descriptive statistics: pre-test and post-test mean comparison of the Laboratory Method

Pre-test & post-test Means of Laboratory method of teaching		
Particulars	**Pretest**	**Posttest**
Multiple choice question	36.5333	48.3000
Question Answers	4.0667	9.4667
Total	40.6	57.7667

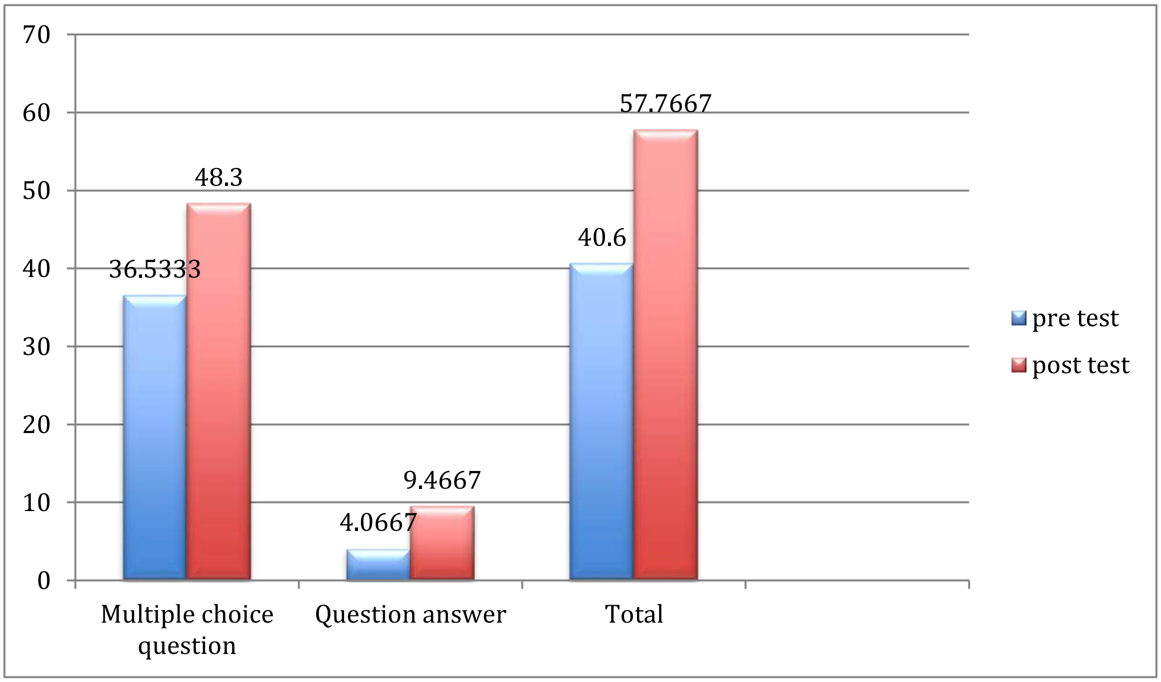
The scores after the test were better than before in Table 4.3 when we compared how students did before and after using the Laboratory Method. Before the test, students who answered multiple-choice questions didn't do as well as those who used the Laboratory Method. This suggests that students who learned through multiple-choice questions didn't improve as much.

There were a total of 36,5333 questions asked using the Laboratory Method, and the average score after the test was 48.3000. This means that students improved when using the Laboratory Method, and it worked better for their academic performance.

On the other hand, students who used the Laboratory Method didn't perform as well as expected after the test. The average score after the test was lower than before. This suggests that students who learned through the Laboratory Method didn't get better results.

In total, 4,0667 questions were answered using the Laboratory Method. This shows that the Laboratory Method made progress, but it wasn't as effective in improving students' academic performance as expected.

Figure 2 Laboratory method mean pre-test and post-test



4.4 Detailed comparison of the pre-test and post-test mean of the Laboratory method

The graph shows that the mean of the Laboratory Method before and after test results is slightly different. The difference between pre-testing post-test shows the participant's teaching method. In this graph shows that the mean differences of multiple choice question and question answer.

4.5 Comparison of traditional method mean pre-test and post-test

Table 4.5 Comparison of the traditional method of teaching pre-test and post-test mean

Pre-test & post-test Means of traditional method of teaching		
Particulars	**Pretest**	**Posttest**
Multiple choice question	28.1000	32.9667
Question Answers	3.4000	7.1000
Total	31.5	40.0667

In simple words, the traditional method was tested, and the results showed that the values after the test were higher than the values before the test in Table 4.5. We compared the scores before and after using the traditional method.

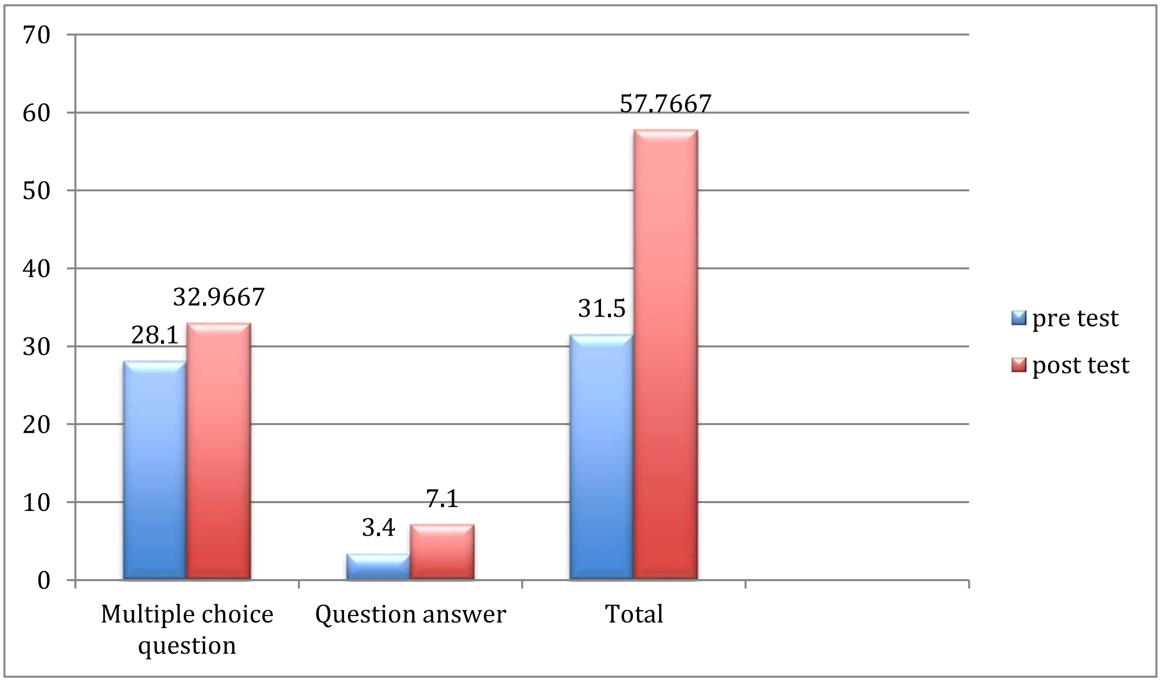
For the multiple-choice questions, the scores before the test were lower than the scores after the test. This means that students who used the traditional method did better on the post-test.

The average score before the test for all questions was 28.1000 when using the traditional method. After the test, the average score was 32.9667. This shows that the post-test scores are higher than the pre-test scores, which is a good thing.

However, for a specific question, the scores before the test were lower than the scores after the test when using the traditional method. This means that for that question, the traditional method helped students do better on the post-test.

So, the traditional method was tested, and the results showed that it helped students improve their scores after the test.

Figure -3 Traditional method mean pre-test and post-test



4.6 Comparison of traditional method pre-test post-test mean

The pictures that show the average scores make it clear that students are getting better results on their tests over time. In all the multiple-choice questions, their scores are going up. The total scores are very different, which means that the Laboratory Method is better at motivating students to do well in their studies.

4.7 Section Two: Testing of Hypothesis

The researcher looked at the idea they were studying and said if the idea was right or wrong. They did this by using special computer software called SPSSS (version 2.0) to analyze the numbers.

4.7.1 Test hypothesis procedure

Step No. 1:

Null hypothesis (H) acceptance or dismissal conditions where the mean Group 1 ($\mu 1$) and Group 2 $\mu 2$ values are equivalent, otherwise null Ho hypothesis will be approved.

Ho: $\mu 1 = \mu 2$

Where the mean values of the 1μ1 and 2μ2 group are unusual, the null hypothesis (Ho) must be rejected while the alternative hypothesis shall be created and accepted.

H ı: $\mu 1 \neq \mu 2$

In case of rejection of Null Hypothesis the following hypothesis is formed. There has been a substantial difference in the mean post secondary tests of experiments and control groups which are taught at school by the Laboratory Method and traditional method.

Step No. 02: Significance Level (a)

The significance value should not exceed 5%, which is a= 0.000628

Step No. 03 Apply t-test paired to SPSS

SPSS offers two sorts of findings that combine group test results with t-test results. The t-test table paired sample checks whether or not the null hypothesis has been accepted or refused.

Step 04 Comparison between T-value and Tabulated value calculation

The key value of the study is the importance of liberty (df). In the T-table the t value of the simple, t-test is calculated. If the p value (significant value) is below the t value, the null hypothesis is otherwise rejected. When p is larger than the degree of freedom or t-test is accepted than the zero hypotheses.

Step No. 05 Discussion

The value decides that the value is higher than the value that the zero hypothesis is determined to reject or accept. At the end, whether the null hypothesis is accepted or not would have to be decided.

4.7.2 The Researcher's Hypotheses and Interpretations

Hypotheses for testing

Step No. 1 Null Hypothesis (Ho) and Alternative Hypothesis (H ı)

H o = There is no significant difference in the mean pretests post-tests scores of the experimental group and control group taught Laboratory Method and traditional method in the subject mathematics in elementary level.

By testing the Null Hypothesis

Ho: $\mu 1 = \mu 2$

The values of both groups mean are given in the table below;

Particular		N	Mean
Teaching strategies	Laboratory Method	30	57.7667
	Traditional method	30	40.0667

By putting the values:-

Ho: 57.7667= 40.0667=> values are not equal

The null hypothesis is nullified. The new hypothesis would be tested. The alternative hypothesis is as follows.

H1: = There's a big difference in the average scores before and after the teaching methods used in math class at school. We used a "Laboratory Method" and a "Traditional Method" for two groups: one called the experimental group and the other called the control group. We made a guess, called an "alternate hypothesis," which is written like this:

$$H1: \mu 1 \neq \mu 2.$$

This means we think the averages (μ1 and μ2) for the two groups are not the same. In this case, the average for the first group (μ1) is 57.7667, and the average for the second group (μ2) is 40.0667. They are not the same. This shows that our guess in the alternate hypothesis is correct, and we reject the original idea, called the "Null hypothesis."

Step No. 02 Significance level

A probabilistic value is like a measure of how important something is. It's a number between 0 and 1. When the value is 0, it means there's evidence supporting the idea that nothing special is happening. When the value is 1, it means the idea that nothing special is happening is confirmed.

In simple tests, when the significance threshold is set at zero, it means something really important is happening. In all the tests, the answers to the questions showed that nothing important is going on. This means the test results are very important.

Step No. 03 Comparison of Calculated t- value and Tabulated value

In the table before, we found a number called the "T-value," which was 2.128 for our study. The other number in the table, called the "tabulated value," is zero. Our 2.128 is smaller than zero, which means it's less. This shows that we don't agree with the idea we were testing, called the "null hypothesis."

In the next table, the T-value is bigger than another number called the "p value" (or significant level). This means we still don't agree with the null hypothesis.

So, to sum it up, our calculated value, 2.128, is bigger than p, which again shows that we don't agree with the null hypothesis.

Step No. 04 Decision

Based on the steps we did earlier, we found out that we are saying "no" to our initial guess. This means that the outcome was really important when we used the Laboratory Method to teach math to the students.

Chapter-5

Summary, Findings, Discussion, Conclusion and Recommendations

5.1 Summary

In this chapter, the researcher talked about the main things he found in his study and what he concluded. He will also explained how he used numbers and statistics to understand this study better.

Researcher's main goal in this research was to see how well the Laboratory method works. He wanted to see if it's better than the usual way of teaching. So, he tried two different ways of teaching: the Laboratory method and the regular way. He did this with 30 students in each group.

Researcher tested both groups before and after the teaching to see if they improved. He used multiple-choice questions from a specific book. He chose the book with the help of the school and teachers. He used questions from past exams to make his test. This way, he could see how well the students did in different areas.

Researcher looked at the data carefully and compared the Laboratory method with the traditional way of teaching. His results showed that the Laboratory method is better. It helps students learn more. He talked about why the Laboratory method is important and how it can help students.

Researcher also looked at other research papers to make sure his study was good. He talked about the Laboratory method, what it means, and why it's good. He also looked at the challenges of using the Laboratory method.

Researcher used numbers and statistics to understand his data better. He explained this in detail. He looked at the data in different ways to get a good picture of what he found in his study.

Researcher used social package of social science (SPSS Version .25), which is statistical analytics and data interpretation computer software.

1. Statistical t-table

2. Description of the table

3. Description of the graph

Two researchers in part tested the hypotheses of the study that was the most important element of the study. The researchers tested five-step hypothesis and null hypotheses was done which are mentions in this study.

5.2 Findings

In this study, researchers wanted to find out if using the Laboratory method for teaching math to elementary school students would improve their higher-order thinking skills. They conducted an experiment and compared two ways of teaching and learning: the Laboratory method and the traditional method.

In the present study, a total of 36, 5333 questions were asked using the Laboratory Method, and the average score after the test was 48.3000. This means that students improved when using the Laboratory Method, and it worked better for their academic performance. On the other hand, students who used the Laboratory Method didn't perform as well as expected after the test. The average score after the test was lower than before. It was found out that students who learned through the Laboratory Method didn't get better results. In total, 4, 0667 questions were answered using the Laboratory Method. It was found out that the Laboratory Method made progress, but it wasn't as effective in improving students' academic performance as expected.

Here's what they found:

1. The students in the study were all from the 6th grade, mostly between 11 to 12 years old, and all of them were boys. More than half of the students came from middle-class families.
2. The researcher conducted meetings for two groups: the Experimental Group and the Control Group. The Experimental Group was taught using the Laboratory technique, which focused on creating an exciting and motivating learning environment. The students in this group enjoyed this new approach and were engaged and interested in learning. They performed well on multiple-choice questions, showing significant improvement from their pretest scores.

3. The results showed that students in the Laboratory method group had an average score of 48.3000, while those in the traditional method group had an average score of 32.5000. This means that the new teaching style inspired and motivated students to perform better academically.
4. The Laboratory method improved students' cognitive skills, including understanding, remembering, applying, and generating ideas, compared to the traditional method.
5. Some students were initially hesitant about the new teaching approach, but they soon adapted to it and learned how to study effectively using the Laboratory technology. They performed better in the first segment of multiple-choice questions compared to the traditional method group.
6. In the second section, which included both multiple-choice questions and question answers, students in the Laboratory method group outperformed the traditional method group. They provided clear answers and better comprehension.
7. The total average score of the participants in the control group was lower than that of the Laboratory method group, indicating that the Laboratory method was more effective in improving learning outcomes.
8. Pre-test results showed that students in both groups improved in the post-test. However, the traditional method group showed only a slight improvement, while the Laboratory method group showed more significant progress.
9. The statistical analysis revealed that the Laboratory method was more successful than the traditional method in improving students' performance in all parts of the multiple-choice questions.

In conclusion, the study demonstrated that the Laboratory method was more effective in enhancing higher-order thinking skills and academic performance in mathematics compared to the traditional teaching method. Students in the Laboratory method group showed greater improvement and engagement in the learning process.

5.3 Discussions

The study aimed to see how using the Laboratory method in teaching math makes a difference. The researchers chose to do an experiment and looked at the results from tests taken before and after the experiment. They wanted to find out if the Laboratory method helps elementary school students do better in their studies. To compare it with the usual way of teaching, they made some objective-type tests.

The researchers met with each student personally. They noticed that the students in the experiment group liked this new way of teaching. According to Saha (2020), this method really helps students do better in their studies when compared to traditional teaching. The students were able to discuss what they learned in class more easily and take good notes. They talked about important things and asked questions that the whole class could discuss. Rosenthal also found similar results, showing that this method encourages students to be more engaged in class.

The new way of teaching made students more interested in talking about the subject. Some students may not usually like studying, but with the Laboratory method, they paid attention and were motivated to learn. They discussed things in groups and switched to more focused groups to learn better. They were actively involved in class discussions. Different types of classes encourage different ways for students to interact with each other. The Laboratory method helps students understand things better (MartínezSanchis et al., 2020).

Students were participating equally in class during the lessons. They were separated from the teaching materials to make sure they understood everything equally. Motivation helps improve how well you understand things. Students were also able to remember and understand things for a long time. This made the students and their classmates interested, even those who weren't paying much attention before. According to Kim, Kim, Koo, and Cannon (2019), this method helps students of all abilities.

In traditional teaching, students sometimes lose focus, especially towards the end of the lesson. The researcher noticed that some students would get distracted and make noise during the lecture. Gentrup and Rjosk (2018) also found that students can lose interest in traditional learning. After a while, they stop paying attention.

The teacher couldn't always answer questions well at the end of the lesson in the traditional way of teaching. Eden (2018) says that traditional teaching doesn't help students as much as the Laboratory method does.

The researchers found that the Laboratory method really helps students learn better, and this leads to better grades in math..

5.4 Conclusions

1. In elementary schools, the Laboratory method is famous as a valuable tool for increasing student learning. Teachers widely accept its incorporation into the Ministry of Education's educational framework, particularly for subjects like mathematics, where it has showed a profound impact on academic performance. The present study focused on sixth-grade students predominantly aged 11-12 and primarily male, depicts the method's efficacy. The researchers actively engaged in both Experimental and Control Group activities, showing the Laboratory method to the Experimental Group and observing their response.
2. Enthusiasm among students in the Experimental Group was seen, as they showed excitement and satisfaction with the new learning approach. Their heightened excitement and interest showed into tangible academic improvements, depicting the effectiveness and efficiency of the Laboratory method. It was suggested that incorporating information about the Laboratory method into textbooks used in Khyber Pakhtunkhwa schools, along with recommendations for subjects suitable for Laboratory method instruction along with traditional teaching approaches. The present research conducted in District Lower Dir emphasized the method's significance, particularly in increasing mathematics education for elementary students.
3. Comparative analysis shows the Laboratory method's preference over traditional teaching methods in terms of academic performance. Its way to make learning enjoyable encourages better comprehension and retention among students. By encouraging a holistic and harmonious learning environment, the Laboratory method motivates student participation and facilitates academic improvement. Students showed heightened excitement and critical thinking skills, while staying active and attentive throughout the lesson. Unlike traditional methods that may result in disinterest, the Laboratory method maintains student involvement and promotes effective learning through peer interaction.

4. Student encouragement strives in classrooms where the Laboratory method is employed, fostering active participation and enthusiasm for learning. It was recognized as a valuable tool, particularly in combating boredom, the Laboratory method injects vitality and interactivity into the learning process. Teachers play a central role in motivating students and cultivating a positive learning environment. By suggesting lessons with excitement and relevance, educators inspire students to embrace learning as a rewarding pursuit.

5.5 Recommendations

The following suggestion were given on the basis of study findings:

1. **Using Labs in Elementary Schools:**

Research Topic: Investigating the Impact of Hands-on Laboratory Activities on Students' Understanding of Complex Concepts in Elementary Mathematics.

Research Objective: To enhance students' understanding of complex concepts by incorporating hands-on laboratory activities into the elementary school curriculum.

Short Methodology: Conducting a mixed-methods study involving elementary schools that have implemented laboratory activities and those that have not. Administering pre- and post-assessments to measure students' understanding of complex concepts. Interview teachers to gather insights into the training and resources required for effective utilization of the laboratory method. Facilitate collaborative workshops among educators to share best practices and innovative ideas for integrating labs into elementary education.

2. **Education Ministry's Role:**

Research Topic: Assessing the Role of Policy Recommendations and Resource Allocation by the Education Ministry in Promoting the Utilization of Laboratory Method in Elementary Education.

Research Objective: To promote the utilization of the laboratory method in elementary education through policy recommendations and resource allocation.

Short Methodology: Conduct a policy analysis to identify existing guidelines and standards related to laboratory-based learning in elementary education. Survey educators and administrators to assess the need for additional training and resources. Collaborate with stakeholders to develop principles and guidelines for promoting the utilization of the laboratory method. Advocate for resource allocation by presenting findings and recommendations to the Education Ministry.

3. **Combining Methods:**

Research Topic: Exploring the Effectiveness of a Balanced Approach to Education: Integrating Traditional Teaching Methods with Hands-on Laboratory Activities in Elementary Classroom Settings.

Research Objective: To encourage a balanced approach to education that integrates traditional teaching methods with hands-on laboratory activities.

Short Methodology: Implement a longitudinal study comparing the academic performance and engagement levels of students exposed to both traditional and laboratory-based instruction. Provide professional development workshops for teachers on adapting instructional strategies to accommodate diverse learning styles. Collect student feedback through surveys and focus groups to assess the effectiveness of combined teaching methods.

4. **Planning for Labs:**

Research Topic: Developing Comprehensive Plans for Incorporating Laboratory Activities into the Elementary School Curriculum: Strategies, Objectives, and Assessment Methods.

Research Objective: To establish comprehensive plans for incorporating laboratory activities into the elementary school curriculum.

Short Methodology: Collaborate with curriculum developers and educators to design a framework for integrating laboratory activities with clear objectives, timelines, and assessment strategies. Assess school infrastructure and resource availability to determine the feasibility of conducting laboratory experiments. Develop guidelines for selecting appropriate materials and resources to support laboratory-based learning.

5. **Motivating Students:**

Research Topic: Enhancing Student Motivation and Enthusiasm for Science through Hands-on Laboratory Activities: Awareness Campaigns, Recognition Programs, and Community Engagement Initiatives.

Research Objective: To increase student motivation and enthusiasm for science through hands-on laboratory activities.

Short Methodology: Organize awareness campaigns and parent-teacher meetings to educate stakeholders about the benefits of laboratory-based learning. Implement recognition programs to celebrate student achievements in laboratory-based projects and experiments. Provide opportunities for students to showcase their projects to their peers and the wider community to foster enthusiasm for science and innovation.

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Annexure 1

Experimental Group Lesson Plans

Lesson plan No 1

Class: 6th **Time: 40 mint**

Date: __________ **Subject: Mathematics**

Topic: Exploring Types of Lines

Learning Objectives:	By the end of this lesson, students will be able to identify and describe different types of lines, such as straight lines, curved lines, and zigzag lines, and understand their characteristics.
Instructional Materials:	Whiteboard and markers, Rulers, Various objects with lines (e.g., books, pencils, rulers), String or yarn, Colored tape, Chart paper
Teaching Method:	Laboratory Method
Presentation:	**Step 1: Introduction** Begin by discussing with students what they know about lines and their importance in geometry. Write the term "line" on the whiteboard and ask students to share their thoughts. Introduce the lesson's objective: "Today, we will explore different types of lines and their characteristics in geometry." **Step 2: Types of Lines** Explain the three main types of lines: straight lines, curved lines, and zigzag lines. Provide examples of each type and draw them on the whiteboard. Discuss real-life examples of these types of lines. **Step 3: Line Exploration** Divide the students into small groups. Provide each group with a set of objects (books, pencils, rulers) and a piece of string or yarn. Instruct them to find and trace various types of lines using the string or yarn and attach them to chart paper. Encourage students to label and describe the lines they find. **Step 4: Presentation** Ask each group to present their findings to the class. Have them describe the lines they traced, their characteristics, and any interesting observations. **Step 5: Discussion and Reflection** Lead a class discussion on the different types of lines and their importance in everyday life. Encourage students to reflect on how understanding lines can be useful in various situations.
Assessment:	Assess students' understanding through their participation in line exploration, their ability to describe the characteristics of different lines, and their contributions to the class discussion.
Homework:	Assign homework that involves finding and describing different types of lines in their surroundings and reflecting on their observations.

Lesson plan No 2

Class: 6th **Time: 40 mint**

Date: __________ **Subject: Mathematics**

Topic: Understanding Line Segments and Ray

Learning Objectives:	By the end of this lesson, students will be able to differentiate between line segments and rays, identify their characteristics, and apply this knowledge in practical scenarios.
Instructional Materials:	Whiteboard and markers, Rulers, Colored tape, Small objects (e.g., buttons, coins), Chart paper
Teaching Method:	Laboratory Method
Presentation:	**Step 1: Introduction** Start the lesson by asking students if they know what line segments and rays are and if they have any prior knowledge about them. Write the terms "line segment" and "ray" on the whiteboard. Introduce the lesson's objective: "Today, we will learn about line segments and rays in geometry and explore their characteristics." **Step 2: Line Segment vs. Ray** Explain the difference between a line segment (a part of a line with two distinct endpoints) and a ray (a part of a line with one endpoint that extends infinitely in one direction). Use the whiteboard to illustrate these concepts with diagrams. **Step 3: Line Segment and Ray Activity** Divide the students into pairs or small groups. Provide each group with rulers, colored tape, and small objects (buttons, coins). Instruct them to create line segments and rays using the colored tape and objects on their desks. Encourage them to identify the endpoints and direction for each. **Step 4: Presentation and Discussion** Ask each group to present their line segments and rays to the class. Have them explain how they determined the endpoints and direction. **Step 5: Practical Scenarios** Provide examples of practical scenarios (e.g., drawing a line segment to measure a bookshelf's length, drawing a ray to represent the path of a flashlight). Ask students to apply their knowledge of line segments and rays to these scenarios.
Assessment:	Assess students' understanding through their participation in the line segment and ray activity, their ability to differentiate between line segments and rays, and their application of this knowledge in practical scenarios.
Homework:	Assign homework problems related to drawing line segments and rays and identifying their properties in different contexts.

Lesson plan No 3

Class: 6th **Time: 40 mint**

Date: __________ **Subject: Mathematics**

Topic: Exploring Surface Area

Learning Objectives:	By the end of this lesson, students will be able to calculate and visualize the surface area of 3D shapes, including rectangular prisms.
Instructional Materials:	Various rectangular prism objects (e.g., boxes, books), Rulers, Grid paper, Whiteboard and markers
Teaching Method:	Laboratory Method
Presentation:	**Step 1: Introduction** Begin by discussing what surface area is and why it is important in real-life situations. Write the terms "surface area" and "rectangular prism" on the board. Introduce the lesson's objective: "Today, we will explore how to calculate the surface area of rectangular prisms and understand why it matters." **Step 2: Exploring Rectangular Prisms** Show students various rectangular prism objects and ask them to identify the different faces of each prism. Discuss how to calculate the area of each face (length x width for rectangles). Ask students to measure the length and width of one of the faces using rulers. **Step 3: Hands-On Activity** Provide students with grid paper and ask them to draw a net for a rectangular prism using the measurements they took. Have them calculate the area of each face and label it on their net. Instruct them to cut out the net and fold it to create a physical model of a rectangular prism. **Step 4: Presentation and Discussion** Ask students to share their physical models with the class. Discuss the process of calculating surface area and how it relates to the net they created. Write down the formula for the surface area of a rectangular prism on the board (2lw + 2lh + 2wh) and explain how it works. **Step 5: Application** Present a real-life scenario (e.g., wrapping a gift box) and ask students to calculate the surface area needed for wrapping the box.
Assessment:	Assess students' understanding through their participation in the hands-on activity, their ability to calculate surface area, and their responses to the real-life scenario.
Homework:	Assign homework problems related to calculating the surface area of rectangular prisms.

Lesson plan No 4

Class: 6th **Time: 40 mint**

Date: __________ **Subject: Mathematics**

Topic: Discovering Volume

Learning Objectives:	By the end of this lesson, students will be able to calculate and visualize the volume of 3D shapes, including rectangular prisms.
Instructional Materials:	Various rectangular prism objects (e.g., boxes, books), Cubes or unit cubes, Rulers, Grid paper, Whiteboard and markers
Teaching Method:	Laboratory Method
Presentation:	**Step 1: Introduction** Begin by discussing what volume is and why it is important in real-life scenarios. Write the terms "volume" and "rectangular prism" on the board. Introduce the lesson's objective: "Today, we will explore how to calculate the volume of rectangular prisms and understand its significance." **Step 2: Exploring Rectangular Prisms** Show students various rectangular prism objects and ask them to identify the length, width, and height of each prism. Discuss how to calculate the volume of a rectangular prism (length x width x height). Ask students to measure the length, width, and height of one of the prisms using rulers. **Step 3: Hands-On Activity** Provide students with cubes or unit cubes. Instruct them to build a rectangular prism using the measurements they took. Ask them to count the number of cubes used to fill the prism. **Step 4: Presentation and Discussion** Ask students to share the number of cubes they used to fill their rectangular prisms. Discuss the concept of volume as the number of cubes needed to fill a shape. Write down the formula for the volume of a rectangular prism on the board (lwh) and explain how it relates to the activity. **Step 5: Application** Present a real-life scenario (e.g., calculating the volume of a water tank) and ask students to calculate the volume.
Assessment:	Assess students' understanding through their participation in the hands-on activity, their ability to calculate volume, and their responses to the real-life scenario.
Homework:	Assign homework problems related to calculating the volume of rectangular prisms and applying the concept to different contexts.

Lesson plan No 5

Class: 6th **Time: 40 mint**

]ate: __________ **Subject: Mathematics**

Topic: Exploring Angles

Learning Objectives:	By the end of this lesson, students will be able to understand different types of angles, measure angles using protractors, and apply their knowledge to solve angle-related problems.
Instructional Materials:	Protractors, Rulers, Whiteboard and markers, Angles worksheet, Chart paper
Teaching Method:	Laboratory Method
Presentation:	**Step 1: Introduction** Begin by discussing what angles are and why they are important in geometry. Write the term "angle" on the board and ask students to share their thoughts. Introduce the lesson's objective: "Today, we will explore different types of angles, learn how to measure them using protractors, and solve angle-related problems." **Step 2: Types of Angles** Explain the different types of angles: acute, obtuse, right, and straight. Use the whiteboard to illustrate each type of angle and its characteristics. **Step 3: Measuring Angles** Provide each student with a protractor and an angles worksheet. Instruct students to measure the angles indicated on the worksheet. Encourage them to discuss their findings with their peers. **Step 4: Hands-On Angle Construction** Show students how to construct angles using rulers and protractors. Have them practice constructing different types of angles on their own. **Step 5: Problem Solving** Present a few problems related to angles (e.g., finding missing angles in a triangle) and have students solve them independently or in pairs.
Assessment:	Assess students' understanding through their participation in angle measurement, their ability to classify angles, and their performance on angle-related problems.
Homework:	Assign homework problems that involve measuring and classifying angles, as well as solving angle-related problems.

Lesson plan No 6

Class: 6th **Time: 40 mint**

Date: __________ **Subject: Mathematics**

Topic: Exploring Symmetry

Learning Objectives:	By the end of this lesson, students will be able to understand the concept of symmetry, identify lines of symmetry in various shapes, and create symmetrical designs.
Instructional Materials:	Various shapes (cutouts or printouts), Mirrors, Chart paper, Colored markers, Whiteboard and markers
Teaching Method:	Laboratory Method
Presentation:	**Step 1: Introduction** Begin by discussing what symmetry is and why it is important in geometry and art. Write the term "symmetry" on the board and ask students to share their thoughts. Introduce the lesson's objective: "Today, we will explore the concept of symmetry, identify lines of symmetry, and create symmetrical designs." **Step 2: Types of Symmetry** Explain the two main types of symmetry: line symmetry and rotational symmetry. Use the whiteboard to illustrate each type of symmetry and provide examples. **Step 3: Identifying Line Symmetry** Show students various shapes and ask them to identify lines of symmetry using mirrors. Discuss the concept of a line of symmetry being a line that divides a shape into two identical halves. **Step 4: Creating Symmetrical Designs** Provide students with chart paper and colored markers. Instruct them to create their symmetrical designs by drawing one half and then reflecting it to complete the other half. **Step 5: Presentation and Discussion** Ask students to share their symmetrical designs with the class. Discuss the lines of symmetry in their designs and any observations about symmetry in everyday objects.
Assessment:	Assess students' understanding through their participation in identifying lines of symmetry, their ability to create symmetrical designs, and their contributions to the class discussion.
Homework:	Assign homework problems that involve identifying lines of symmetry in various shapes and objects at home or in the environment.

Lesson plan No 7

Class: 6th **Time: 40 mint**

Date: __________ **Subject: Mathematics**

Topic: Constructing Basic Geometric Shapes

Learning Objectives:	By the end of this lesson, students will be able to use basic construction tools to create geometric shapes, such as perpendicular bisectors, angle bisectors, and parallel lines.
Instructional Materials:	Compasses, Rulers, Protractors, Pencils, Drawing paper or graph paper, Whiteboard and markers
Teaching Method:	Laboratory Method
Presentation:	**Step 1: Introduction** Begin by discussing the importance of geometric construction in mathematics and real-life applications. Write the term "geometric construction" on the board and ask students if they have any prior knowledge about it. Introduce the lesson's objective: "Today, we will learn how to use basic construction tools to create geometric shapes and lines." **Step 2: Constructing Perpendicular Bisectors** Explain the concept of a perpendicular bisector and its role in dividing a line segment into two equal parts. Demonstrate how to construct a perpendicular bisector using compasses and rulers. Have students practice constructing perpendicular bisectors on their own or in pairs. **Step 3: Constructing Angle Bisectors** Introduce the concept of an angle bisector and its role in dividing an angle into two equal angles. Demonstrate how to construct an angle bisector using compasses and protractors. Have students practice constructing angle bisectors on their own or in pairs. **Step 4: Constructing Parallel Lines** Explain the concept of parallel lines and their importance in geometry. Demonstrate how to construct parallel lines using compasses and a straightedge. Have students practice constructing parallel lines on their own or in pairs. **Step 5: Presentation and Discussion** Ask students to present their constructed shapes and lines to the class. Discuss the construction process and the properties of the shapes and lines created.
Assessment:	Assess students' understanding through their ability to successfully construct geometric shapes and lines, as well as their contributions to the class discussion.
Homework:	Assign homework problems that involve constructing perpendicular bisectors, angle bisectors, and parallel lines for different geometric figures.

Lesson plan No 8

Class: 6th **Time: 40 mint**

Date: __________ **Subject: Mathematics**

Topic: Constructing Geometric Patterns

Learning Objectives:	By the end of this lesson, students will be able to use geometric construction techniques to create intricate geometric patterns and designs.
Instructional Materials:	Compasses, Rulers, Pencils, Drawing paper or graph paper, Colored pencils or markers, Whiteboard and markers
Teaching Method:	Laboratory Method
Presentation:	**Step 1: Introduction** Begin by discussing the role of geometric patterns in art, architecture, and mathematics. Write the term "geometric patterns" on the board and ask students if they have seen or used any before. Introduce the lesson's objective: "Today, we will learn how to use geometric construction techniques to create beautiful and symmetrical geometric patterns." **Step 2: Basic Geometric Patterns** Start with simple patterns, such as concentric circles or triangles, and explain how to construct them using compasses and rulers. Demonstrate the process on the whiteboard. Have students practice constructing these basic patterns. **Step 3: Intermediate Geometric Patterns** Introduce more complex patterns, such as star polygons or tessellations. Explain the construction process step by step, emphasizing symmetry and precision. Provide students with the opportunity to create these intermediate patterns. **Step 4: Creating Personal Patterns** Encourage students to use their creativity to design and construct their unique geometric patterns. Provide guidelines for symmetry, repetition, and precision. Have students share and explain their personal patterns with their peers. **Step 5: Presentation and Discussion** Ask students to present their constructed patterns to the class. Discuss the use of geometric patterns in various cultural contexts and their significance.
Assessment:	Assess students' understanding through their ability to construct geometric patterns, their creativity in designing personal patterns, and their contributions to the class discussion.
Homework:	Assign homework problems that challenge students to create additional geometric patterns using the construction techniques learned in class.

Control Group Lesson Plan

Lesson plan No 1

Class: 6th **Time: 45 mint**

Date: __________ **Subject: Mathematics**

Topic: Exploring Types of Lines

Learning Objectives:	By the end of this lesson, students will be able to identify and understand different types of lines, such as horizontal, vertical, and diagonal lines.B
Instructional Materials:	Chalkboard and chalk, Visual aids (diagrams or pictures), Ruler
Teaching Method:	Traditional Method
Presentation:	**Step 1: Introduction** Begin the lesson by explaining the importance of lines in mathematics and daily life. Mention that lines are fundamental to geometry and are present in various forms around us. **Step 2: Defining Lines** Define a line as a straight path that extends infinitely in both directions. Write this definition on the chalkboard. Explain that lines have no endpoints and continue infinitely. Mention that understanding different types of lines will help us in various mathematical and real-life situations. **Step 3: Types of Lines** Introduce different types of lines: Horizontal Line: A line that runs from left to right, parallel to the horizon. Vertical Line: A line that runs from top to bottom, perpendicular to the horizon. Diagonal Line: A line that slants or inclines. Use visual aids to illustrate each type of line on the chalkboard. Provide real-life examples for each type of line (e.g., horizon, flagpole, ladder). **Step 4: Characteristics** Discuss the characteristics and properties of each type of line: **Step 5: Practical Examples** Present practical examples of each type of line in the students' surroundings. Ask students to identify and describe these lines. **Step 6: Class Discussion** Engage students in a brief class discussion to reinforce their understanding of the types of lines and their characteristics. Encourage them to share any questions or observations about lines.
Assessment:	Assess students' understanding through their participation in the class discussion and their ability to identify and describe different types of lines and their characteristics.
Homework:	Assign homework that involves finding and describing different types of lines in their surroundings and reflecting on their observations.

Lesson plan No 2

Class: 6th **Time: 45 mint**

Date: __________ **Subject: Mathematics**

Topic: Understanding Line Segments and Ray

Learning Objectives:	By the end of this lesson, students will be able to differentiate between line segments and rays, define and identify their components, and understand their significance in geometry.
Instructional Materials:	Chalkboard and chalk, Visual aids (diagrams or pictures), Ruler,
Teaching Method:	Traditional Method
Presentation:	**Step 1: Introduction** Begin the lesson by explaining the importance of understanding line segments and rays in geometry and real-life scenarios. Mention that these concepts help us describe and work with different parts of a line. **Step 2: Defining Line Segments and Rays** Define a Line Segment as a part of a line with two distinct endpoints. Write this definition on the chalkboard. Define a Ray as a part of a line with one endpoint that extends infinitely in one direction. Write this definition on the chalkboard. Explain that both line segments and rays are portions of a line but have different characteristics. **Step 3: Identifying Component** Discuss the components of line segments and rays: Line Segment: It has two endpoints (start and end points) that define its length. Ray: It has one endpoint (starting point) and extends infinitely in one direction. Use visual aids to illustrate the components and differences between line segments and rays on the chalkboard. **Step 4: Significance and Real-Life Examples** Explain the significance of line segments and rays in geometry and beyond: Line segments are used to measure distances between two points. Rays represent directions or paths that extend indefinitely. Provide real-life examples to illustrate the use of line segments (e.g., measuring a bookshelf) and rays (e.g., a flashlight beam). **Step 5: Class Discussion** Engage students in a brief class discussion to reinforce their understanding of line segments and rays, their components, and their applications. Encourage students to share any questions or examples they can think of.
Assessment:	Assess students' understanding through their participation in the class discussion and their ability to define, identify, and differentiate between line segments and rays.
Homework:	Assign homework problems that require students to identify line segments and rays in various diagrams, draw examples of each, or measure distances using line segments.

Lesson plan No 3

Class: 6th **Time: 45 mint**

Date: __________ **Subject: Mathematics**

Topic: Introduction to Surface Area and Volume

Learning Objectives:	By the end of this lesson, students will be able to understand the basic concepts of surface area and volume and how to calculate them for simple geometric shapes.
Instructional Materials:	Chalkboard and chalk, Visual aids (diagrams or pictures), Ruler,
Teaching Method:	Traditional Method
Presentation:	**Step 1: Introduction** Begin the lesson by explaining the importance of understanding surface area and volume in mathematics and real-life applications. Mention that these concepts help us quantify the space occupied by three-dimensional objects. **Step 2: Defining Surface Area and Volume** Define Surface Area as the total area of all the surfaces (faces) of a three-dimensional object. Write this definition on the chalkboard. Define Volume as the amount of space enclosed by a three-dimensional object. Write this definition on the chalkboard. Explain that surface area deals with the outer covering of an object, while volume deals with the space it occupies. **Step 3: Examples and Visual Aids** Present examples of simple geometric shapes (e.g., cubes, rectangular prisms) and their surface area and volume. Use visual aids and diagrams to illustrate how to calculate surface area and volume for these shapes. **Step 4: Surface Area Calculation** Discuss the formulae for calculating surface area of common shapes, such as cubes, rectangular prisms, and cylinders. Write these formulae on the chalkboard and explain how to use them. **Step 5: Volume Calculation** Discuss the formulae for calculating volume of common shapes, such as cubes, rectangular prisms, and cylinders. Write these formulae on the chalkboard and explain how to use them. **Step 6: Class Discussion:** Engage students in a brief class discussion to reinforce their understanding of surface area and volume, their definitions, and formulae. Encourage students to ask questions if anything is unclear.
Assessment:	Assess students' understanding through their participation in the class discussion and their ability to explain the concepts and formulae for surface area and volume.
Homework:	Assign homework problems that involve calculating the surface area and volume of simple geometric shapes.

Lesson plan No 4

Class: 6th **Time: 45 mint**

Date: __________ **Subject: Mathematics**

Topic: Applying Surface Area and Volume

Learning Objectives:	By the end of this lesson, students will be able to apply their knowledge of surface area and volume to solve real-life problems involving everyday objects.
Instructional Materials:	Chalkboard and chalk, Visual aids (diagrams or pictures), Ruler,
Teaching Method:	Traditional Method
Presentation:	**Step 1: Introduction** Begin the lesson by discussing the practical applications of understanding surface area and volume, such as calculating materials needed for construction or packing items in boxes. **Step 2: Real-Life Examples** Present pictures of everyday objects (e.g., cereal boxes, swimming pools, paint cans) and explain how surface area and volume are relevant to those objects. Discuss how these concepts can be applied to solve problems related to those objects. **Step 3: Problem Solving** Provide students with a set of word problems that involve calculating surface area and volume of various objects. Walk through the solution of one problem as an example, emphasizing the steps and formulae used. Ask students to work on the remaining problems individually or in pairs. **Step 4: Class Discussion and Review** Engage students in a class discussion to review the solutions to the word problems. Clarify any doubts or questions they may have.
Assessment:	Assess students' problem-solving skills and their ability to apply their knowledge of surface area and volume to real-life situations through their participation in the class discussion and the accuracy of their solutions.
Homework:	Assign homework problems that involve additional real-life scenarios where students must calculate surface area and volume to solve practical problems.

Lesson plan No 5

Class: 6th **Time: 45 mint**

Date: __________ **Subject: Mathematics**

Topic: Understanding Angles

Learning Objectives:	By the end of this lesson, students will be able to identify and understand different types of angles and their measurements.
Instructional Materials:	Chalkboard and chalk, Visual aids (diagrams or pictures), Ruler,
Teaching Method:	Traditional Method
Presentation:	**Step 1: Introduction** Begin the lesson by explaining the importance of understanding angles in mathematics and everyday life. Mention that angles help us describe turns and directions. **Step 2: Types of Angles** Define an angle as the figure formed by two rays with a common endpoint called the vertex. Write this definition on the chalkboard. Introduce different types of angles: Acute Angle: An angle less than 90 degrees. Obtuse Angle: An angle greater than 90 degrees but less than 180 degrees. Right Angle: An angle of exactly 90 degrees. Straight Angle: An angle of exactly 180 degrees. Use visual aids and diagrams to illustrate these types of angles on the chalkboard. **Step 3: Angle Measurements** Discuss how to measure angles using a protractor. Explain how to align the protractor correctly and read the angle measurement in degrees. Provide examples of measuring different angles and demonstrate with a protractor if available. **Step 4: Practical Examples** Present practical examples of angles in real-life situations (e.g., clock hands, the corners of a book). Ask students to identify and measure these angles using their knowledge of angle types and measurements. **Step 5: Class Discussion** Engage students in a class discussion to reinforce their understanding of angles, their types, and measurements. Encourage them to share real-life examples of angles they encounter.
Assessment:	Assess students' understanding through their participation in the class discussion and their ability to identify, classify, and measure angles.
Homework:	Assign homework problems that involve identifying, classifying, and measuring angles in various diagrams and real-life scenarios.

Lesson plan No 6

Class: 6th **Time: 45 mint**

Date: __________ **Subject: Mathematics**

Topic: Exploring Symmetry

Learning Objectives:	Objective: By the end of this lesson, students will be able to recognize and understand symmetry in geometric shapes.
Instructional Materials:	Chalkboard and chalk, Visual aids (diagrams or pictures), Ruler,
Teaching Method:	Traditional Method
Presentation:	**Step 1: Introduction** Begin the lesson by discussing the concept of symmetry and its importance in art, design, and mathematics. Mention that symmetry is a form of balance and harmony. **Step 2: Defining Symmetry** Define symmetry as a balanced arrangement of parts on either side of a centerline or axis. Write this definition on the chalkboard. Explain that symmetric shapes have a line or axis where one side is a mirror image of the other side. **Step 3: Identifying Symmetry** Present pictures or diagrams of geometric shapes and objects with lines of symmetry. Discuss how to identify lines of symmetry and ask students to identify them in the provided examples. Explain that some shapes have multiple lines of symmetry, while others have none. **Step 4: Symmetrical Art** Encourage students to create their symmetrical designs on paper. Ask them to fold the paper along a line to create a mirror image. Allow them to experiment and be creative in designing symmetrical shapes and patterns. **Step 5: Class Discussion** Engage students in a brief class discussion to reinforce their understanding of symmetry and share their symmetrical art creations. Encourage them to discuss their creative processes.
Assessment:	Assess students' understanding through their participation in the class discussion and the creativity and quality of their symmetrical art.
Homework:	Assign homework problems that involve identifying lines of symmetry in various geometric shapes and objects found at home or in their surroundings.

Lesson plan No 7

Class: 6th **Time: 45 mint**

Date: __________ **Subject: Mathematics**

Topic: Introduction to Geometrical Constructions

Learning Objectives:	By the end of this lesson, students will be able to understand the basic principles of geometrical construction and use a straightedge and compass to construct fundamental geometric figures.
Instructional Materials:	Chalkboard and chalk, Visual aids (diagrams or pictures), Ruler,
Teaching Method:	Traditional Method
Presentation:	**Step 1: Introduction** Begin the lesson by explaining the importance of geometrical construction in mathematics and its relevance to real-life applications. Mention that construction allows us to create accurate geometric shapes. **Step 2: Basic Tools** Introduce the basic tools used in geometrical construction: Straightedge: A ruler without markings used for drawing straight lines. Compass: A tool for drawing circles and arcs. Explain how to use these tools safely and effectively. **Step 3: Constructing a Line Segment** Demonstrate how to construct a line segment of a given length using a straightedge and compass. Show the step-by-step process on the chalkboard and have students follow along. **Step 4: Constructing an Equilateral Triangle** Demonstrate how to construct an equilateral triangle using a straightedge and compass. Explain the steps involved, including the use of the compass to create equal sides. Have students try to construct an equilateral triangle themselves. **Step 5: Class Discussion** Engage students in a class discussion to review the construction steps and tools used. Encourage them to ask questions if anything is unclear.
Assessment:	Assess students' understanding through their participation in the class discussion and their ability to successfully construct a line segment and an equilateral triangle.
Homework:	Assign homework problems that involve constructing various geometric shapes, such as angles and perpendicular bisectors, using a straightedge and compass.

Lesson plan No 8

Class: 6th **Time: 45 mint**

Date: __________ **Subject: Mathematics**

Topic: More Geometrical Constructions

Learning Objectives:	By the end of this lesson, students will be able to apply their knowledge of geometrical construction to create additional geometric figures, such as perpendicular bisectors and angles.
Instructional Materials:	Chalkboard and chalk, Visual aids (diagrams or pictures), Ruler,
Teaching Method:	Traditional Method
Presentation:	**Step 1: Review** Begin the lesson by briefly reviewing the basic principles of geometrical construction introduced in the previous lesson. **Step 2: Constructing Perpendicular Bisectors** Demonstrate how to construct a perpendicular bisector of a line segment using a straightedge and compass. Show the step-by-step process on the chalkboard and have students follow along. Explain the concept of a perpendicular bisector and how it divides a line segment into two equal parts. **Step 3: Constructing Angles** Introduce the concept of constructing angles, including right angles and other angle measures. Demonstrate how to construct a right angle using a straightedge and compass. Have students try to construct right angles and other specified angles themselves. **Step 4: Class Discussion** Engage students in a class discussion to review the construction steps for perpendicular bisectors and angles. Encourage them to ask questions and share their experiences. **Step 5: Practical Applications** Discuss the practical applications of geometrical construction in fields like architecture and engineering. Mention how construction techniques can be used to create accurate diagrams and blueprints.
Assessment:	Assess students' understanding through their participation in the class discussion and their ability to successfully construct perpendicular bisectors and angles.
Homework:	Assign homework problems that involve constructing various geometric figures, including perpendicular bisectors and specified angles, using a straightedge and compass.

Annexure 2

Pretest Result of Experimental Group

Pretest result of Govt High School, Dherai Talash, Lower Dir

Name of the students	Roll number	class	age	Mcqs (40)	Question (10)	Marks
Maaz Ullah	1	6	13	38	4	42
Hamid Ullah	2	6	12	42	6	48
Ijaz Ahmad	3	6	12	32	6	38
Adil Faraz	4	6	12	44	8	52
Ahmad Ullah	5	6	14	54	6	60
Wahab Khan	6	6	14	33	0	33
Mustafa Khan	7	6	13	19	6	25
Saad Khan	8	6	12	32	0	32
Usman Ahmad	9	6	13	34	8	42
Azhar Uddin	10	6	14	38	6	44
Yaseen Ali	11	6	12	52	4	56
Mansoor Ahmad	12	6	12	36	5	41
Mushtaq Ahmad	13	6	13	36	5	41
Muhammad Haroon	14	6	12	44	4	48
Rahat Ullah	15	6	12	42	8	50
Fazl Urrahman	16	6	12	48	4	52
Weqar Ahmad	17	6	15	52	5	57
Saqib Ali	18	6	13	43	6	49
Mustafeez Khan	19	6	14	0	0	Absent
Muhmmad Khan	20	6	14	40	0	40
Ishaq Ali	21	6	14	50	4	54
Shamsher Shah	22	6	12	43	4	47
Nawaz Shah	23	6	16	28	0	28
Naseer Uddin	24	6	12	33	6	39
Kamil Ali	25	6	15	46	4	51
Aimal Khan	26	6	16	20	4	24
Darya Tajik	27	6	13	38	3	41
Shah Saood	28	6	15	0	0	Absent
Muhammad Salman	29	6	16	46	4	50
Muhammad Amir	30	6	12	31	4	35

Posttest Result of Experimental Group

Posttest result of Govt High School, Dherai Talash, Lower Dir

Name of the students	Roll number	class	age	Mcqs (40)	Question (10)	Marks
Maaz Ullah	1	6	13	60	8	68
Hamid Ullah	2	6	12	44	16	60
Ijaz Ahmad	3	6	12	62	10	72
Adil Faraz	4	6	12	0	0	Absent
Ahmad Ullah	5	6	14	70	10	80
Wahab Khan	6	6	14	56	8	64
Mustafa Khan	7	6	13	49	8	57
Saad Khan	8	6	12	56	4	62
Usman Ahmad	9	6	13	72	13	85
Azhar Uddin	10	6	14	54	12	66
Yaseen Ali	11	6	12	50	12	62
Mansoor Ahmad	12	6	12	0	0	Absent
Mushtaq Ahmad	13	6	13	50	8	58
Muhammad Haroon	14	6	12	51	10	61
Rahat Ullah	15	6	12	42	10	58
Fazl Urrahman	16	6	12	58	12	70
Weqar Ahmad	17	6	15	55	14	69
Saqib Ali	18	6	13	0	0	Absent
Mustafeez Khan	19	6	14	56	6	62
Muhmmad Khan	20	6	14	60	15	75
Ishaq Ali	21	6	14	64	16	80
Shamsher Shah	22	6	12	66	14	80
Nawaz Shah	23	6	16	40	8	48
Naseer Uddin	24	6	12	56	12	68
Kamil Ali	25	6	15	62	10	72
Aimal Khan	26	6	16	44	10	54
Darya Tajik	27	6	13	60	14	74
Shah Saood	28	6	15	0	0	Absent
Muhammad Salman	29	6	16	58	14	72
Muhammad Amir	30	6	12	54	10	57

Pretest Result of Control Group

Pretest Result Govt High School, Dherai Talash, Lower Dir

Name of the students	Roll number	class	age	Mcqs (40)	Question (10)	Marks
Muhsin Khan	1	6	12	38	4	42
Esa Ahmad	2	6	13	44	3	47
Muhammad Hayan	3	6	12	20	4	24
Muhammad Muzammil	4	6	13	30	2	32
Muhammad Hammas	5	6	13	28	0	28
Rehan Uddin	6	6	13	40	4	44
Sohail Tanveer	7	6	14	28	2	30
Muhammad Hayyan Khan	8	6	14	11	2	13
Abdul Basit	9	6	12	0	0	Absent
Muhammad Talha	10	6	13	30	4	34
Azhar Uddin	11	6	12	0	0	Absent
Usama Khan	12	6	14	30	6	36
Abbas Ahmad	13	6	13	44	8	52
Farooq Khan	14	6	13	40	0	40
Arshad Khan	15	6	12	30	6	36
Riaz Iqbal	16	6	12	8	2	10
Adnan Ahmad	17	6	14	20	4	24
Nasir Khan	18	6	15	28	4	32
Muhammad Mustafa	19	6	15	0	0	Absent
Atal Khan	20	6	13	36	7	43
Muzaffar Said	21	6	14	48	6	54
Ashfaq Ahmad	22	6	12	50	8	58
Tariq Ali	23	6	16	40	4	44
Imran Ullah	24	8	12	28	2	30
Ihsan Khan	25	8	15	40	6	46
Kaleem Khan	26	8	16	30	4	34
Muhammad Dawood	27	8	13	44	6	50
Muhammad Ali	28	8	15	36	4	40
Ikram Ullah	29	8	16	0	0	Absent
Muhammad Musab	30	8	12	22	0	22

Posttest Result of Control Group

Posttest Result Govt High School, Dherai Talash, Lower Dir

Name of the students	Roll number	class	age	Mcqs (40)	Question (10)	Marks
Muhsin Khan	1	6	12	40	12	52
Esa Ahmad	2	6	13	46	14	60
Muhammad Hayan	3	6	12	36	6	42
Muhammad Muzammil	4	6	13	40	6	46
Muhammad Hammas	5	6	13	36	4	40
Rehan Uddin	6	6	13	48	8	56
Sohail Tanveer	7	6	14	30	10	40
Muhammad Hayyan	8	6	14	24	6	30
Abdul Basit	9	6	12	28	8	36
Muhammad Talha	10	6	13	0	0	Absent
Azhar Uddin	11	6	12	37	2	39
Usama Khan	12	6	14	40	4	44
Abbas Ahmad	13	6	13	35	6	41
Farooq Khan	14	6	13	36	10	46
Arshad Khan	15	6	12	40	8	48
Riaz Iqbal	16	6	12	24	1	25
Adnan Ahmad	17	6	14	18	4	22
Nasir Khan	18	6	15	22	8	30
Muhammad Mustafa	19	6	15	36	10	46
Atal Khan	20	6	13	38	7	45
Muzaffar Said	21	6	14	42	13	55
Ashfaq Ahmad	22	6	12	38	14	52
Tariq Ali	23	6	16	40	10	50
Imran Ullah	24	8	12	29	6	35
Ihsan Khan	25	8	15	38	4	42
Kaleem Khan	26	8	16	32	8	40
Muhammad Dawood	27	8	13	38	12	50
Muhammad Ali	28	8	15	30	6	36
Ikram Ullah	29	8	16	0	0	Absent
Muhammad Musab	30	8	12	34	6	40