EFFECT OF HANDS ON LEARNING ON THE DEVELOPMENT OF SCIENTIFIC SKILLS IN FIRST GRADERS

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IN THE NAME OF ALLAH THE MOST BENEFICIENT THE MOST GRACIOUS

SUPERVISOR'S CERTIFICATE

The thesis titled "EFFECT OF HANDS ON LEARNING ON THE DEVELOPMENT OF SCIENTIFIC SKILLS IN FIRST GRADERS" submitted by Mr. Malik Shoukat Ali Reg. No. 191-FSS/PHDEDU/F20 in partial fulfilment of PhD degree in Educational Leadership and Management, has been completed under my guidance and supervision. I am satisfied with the quality of student's research work and allow him to submit this for further process as per IIUI rules and regulation.

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APPROVAL SHEET

EFFECT OF HANDS ON LEARNING ON THE DEVELOPMENT OF SCIENTIFIC SKILLS IN FIRST GRADERS

By

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AUTHOR’S DECLARATION

I, Mr. Malik Shoukat Ali Reg. No. 191-FSS/PHDEDU/F20, a student of PhD in Educational Leadership and Management at International Islamic University Islamabad, hereby declare that the thesis entitled “EFFECT OF HANDS ON LEARNING ON THE DEVELOPMENT OF SCIENTIFIC SKILLS IN FIRST GRADERS”, submitted for partial fulfilment of PhD in Educational Leadership and Management is my original work, except where otherwise acknowledged in the text. This work has not been submitted, published, or presented by me for obtaining any degree from this or any other university or institution.

Malik Shoukat Ali

DEDICATION

This research work is dedicated to my late grandfather ***Muhammad Hussain****, my loving grandmother* ***IQBAL BAGUM,*** *my caring and loving father* ***MALIK MUHAMMAD ALI*** *and loving mother* ***ZEENAT KOUSAR*** *for their unconditional love, care and guidance they always gave me right from my childhood. I especially thanks to my family for their spiritual, emotional and physical support I needed to grow up and maintain and sustain myself in life by means of the education they painfully financed. They have always been and will always be my heroes.*

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ABSTRACT

Mathematics is a fundamental subject that plays a vital role in students' lives. So, if it is taken at early stages, its effect will be long life. Hands on learning is a teaching method that promotes mathematical learning and develops students' scientific skills in Mathematics at early stages. This study investigated the effect of Hands on Learning on the development of scientific skills in first graders. The objectives of the study were; 1). to measure the effect of Hands on Learning on the development of scientific skills in terms of numerical skills, 2). to examine the effect of Hands on Learning on the development of scientific skills in terms of spatial skills, 3).to evaluate the effect of Hands on Learning on the development of scientific skills in terms of mathematical thinking, 4). to measure the effect of conventional method on the development of scientific skills in terms of numerical skills, 5). to examine the effect of conventional method on the development of scientific skills in terms of spatial skills, 6). to evaluate the effect of conventional method on the development of scientific skills in terms of mathematical thinking, and 7). to compare the effect of Hands on Learning (experimental group) with conventional method (control group) on the development of scientific skills. The study was true experimental in nature. Pretest posttest equivalent group design was used to conduct the study. In the present study, the target population of the study was first grader students of district Kotli who were studying Mathematics. Government Boys High School Hatli Kotli was selected randomly as a sample. From this school, 72 Mathematics Students of first graders were chosen for the study and divided into two groups such as Group- A (Experimental Group) and Group-B (Control Group). These both groups were formed through randomization and each group consisted of 36 students. Experimental group was taught by Hands on Learning and control group was taught by conventional method and the duration of the study was eight weeks. Subject achievement test (Pre-test and post-test) of 100 marks was used as research instrument and it was validated by educational experts. Pilot testing was executed on fifteen Mathematics students of Grade-1 in Government Boys Higher secondary School Andrla Nar. Cronbach's Alpha (α) was used to test the reliability of subject achievement test and its value was 0.83. Thirty-two (32) lessons were planned for this study. Data were collected in the form of pretest before treatment and posttest after treatment from both groups and results were collected. The data were analyzed by using both descriptive statistics (Mean, SD) and inferential statistics (Paired sample t-test, Independent Sample t-test, One Way ANCOVA and Eta-test) through SPSS 25 software. Descriptive statistics were used to evaluate the marks of pre-test and post-test and to compare the means scores of both groups. Inferential statistics were used to find the significant difference and effect size of Hands on Learning and conventional method on the development of students' scientific skills. The findings of the study showed a positive effect of Hands on Learning on the development of scientific skills in terms of numerical skills, spatial skills and mathematical thinking in first graders. On the basis of findings, it was concluded that Hands on Learning was more effective method than conventional method in developing students' scientific skills in terms of numerical skills, spatial skills and mathematical thinking. It is recommended that Hands on Learning may be implemented in mathematics classroom for developing scientific skills at the very early stages. It is also recommended that further researches may be conducted for the validation and improvement of this study.

Keywords: Hands on Learning, Conventional Method, Scientific Skills, Numerical Skills, Spatial Skills, Mathematical thinking.

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LIST OF ABBREVIATIONS

AJ&K	Azad Jammu and Kashmir
ANCOVA	Analysis of Co Variance Analysis
CPA	Concrete, Pictorial and Abstract
DDS	Divisional Director School
DEOs	District Education Officers
DPI	Director Public Instruction
ERQs	Extended Response Questions
FNIRS	Functional Near-Infrared Spectroscopy
GBL	Game Based Learning
GCETs	Government College for Elementary Teachers
HoL	Hands on Learning
ICT	Information Communication and Technology
IED	Institute for Educational Development
MCQs	Multiple Choice Questions
NAT	National Achievement Test
NCM	National Curriculum of Mathematics
NEAS	National Education Assessment System
OECD	Organization for Economic Co-operation and Development
PBL	Problem Based Learning
PISA	Program for International Student Assessment
RRQs	Restricted Response Questions
SDG	Sustainable Development Goal
SNC	Single National Curriculum
STEM	Science, Technology, Engineering and Mathematics
SPSS	Statistical Packages for Social Sciences
TIMSS	Trends in International Mathematics and Science Study

CHAPTER 1

INTRODUCTION

Mathematics is known as queen of all subjects and its effect is in the whole life of students. It develops the mental abilities of an individual through solving mathematical problems (DeLegge & Kaur, 2023). It is a discipline that promotes logical thinking and provide us tools to describe abstract ideas in quantitative terms and intelligent fashion. It contributes in the performance of daily life activities of every individual, and provides basis for the development of different subjects in natural and social sciences (Cirneanu & Moldoveanu, 2024). According to Parviainen (2019) revolutionary development in different fields of life is direct or indirect result of mathematics because mathematics develops accuracy, concentration, reasoning, analytical thinking, creative thinking, critical thinking and intellectual independence. Behlol et al., (2018) stated that nature can be communicated by using symbols of mathematics that helps to understand and explain the things in the universe. If a country wants to produce men and women who can create knowledge for the development and progress, then it must make sure that the proper basis may be provided at early childhood through the study of mathematics. In this respect, mathematics teacher plays very important role, and facilitate students to think, reflect and think about thinking (Kooloos et al., 2022).

1.1 Background of the Study

Education is a conscious effort to impart knowledge in order to achieve certain ends and goals. Various disciplines in the school curriculum serve as distinct tools to realize these objectives. With regard to mathematics, it is utilized to enhance capability rather than simply accumulate knowledge. Thus, it is more about mastering the art of learning. The understanding gained through analytical reasoning leads to the revelation of new truths (DeLegge & Kaur, 2023). All children viewed as having an ability to solve mathematical problems, discover new facts, make sense of the world using mathematics, and communicate their mathematical thinking (Li & Disney, 2023). This shift in perspective demands a change in pedagogy – in particular it puts the teaching-learning relationship at the heart of mathematics. It is impossible to think about good mathematics pedagogy for children aged 3–8 years without acknowledging that much early mathematical learning occurs in the context of children's different classroom activities (Clements & Sarama, 2020). Teachers need to understand how mathematics learning is promoted by young children. The only way to promote mathematics learning in students is to engage them in different activities by using activity-based pedagogies. (Nwoke, 2021).

According to Acton (2020) there are a numbers of teaching pedagogies that are used for teaching mathematics at early stages. Expository method is used for teaching mathematics at the early stage. It is a fast and efficient way of giving information. This method was also favoured by Robertson in 2013 for the teaching mathematics Hankeln (2020) stated that Singapore mathematics learners learn through manipulation of real objects first, without any internal representation of the objects. Learners interact with the world by exploring and manipulating objects. Laboratory method, simulation, problem solving method are also used for teaching of mathematics at early levels in Europe. Students may learn mathematics by cooperative learning and guided learning (Warsah et al., 2021).

According to Udofia and Uko (2018) modern mathematical teaching emphasized that mathematical knowledge should be taught by problem-solving, hands-on activities, interactive learning experiences, project method and demonstration method. Another method of learning mathematics at early level is Game based learning which is first used in Africa (Hwa, 2018). Learner centered and play way methods, Hands on Learning can also be used for teaching of mathematics because they give learner opportunity to handle, observe and do. Among these methods, Hands on Learning is used in Europe, Singapore and China for teaching of mathematics at early stages. It is a very good method of teaching mathematics because it helps students becoming more engaged in learning (Chikuni, 2018).

According to Li (2023) the concept of hands-on learning was introduced by American philosopher Dewey in 1938 and gained widespread popularity in the early 1950s, supported by prominent psychologists Lewin in 1943 and Piaget in 1952. Dewey implemented this approach by establishing the University of Chicago Laboratory School. It emphasizes active student engagement through activities that involve using materials and objects to manipulate ideas. This method involves learning through direct experience rather than solely relying on books, lectures, or other traditional approaches. According to Miller and Cutright (2022) Hands-on learning has greater retention of material, enhances creativity, more enjoyable, develops a sense of achievement and also develops critical thinking. It guided the students to gain knowledge by experience. This means giving the students the opportunity to manipulate the objects they are studying for instance, mathematical instruments, calculators, rulers, mathematical set, and shapes comprehension. It plays an important role in developing students' mathematical concept, critical thinking and their mathematical skills.

According Fakaruddin et al. (2024) Hands on Learning can be used for developing mathematical thinking and scientific skills in Mathematics at early stages including numeracy, representation, spatial thinking skill, reasoning, manipulation, critical thinking, analytical thinking and problem-solving skills.

According to Parviainen (2019) these skills are further divided into sub skills such as number sense (symbolic and non-symbolic), counting skills (knowledge of quantities and number symbols, number word sequence and enumeration), basic skills in arithmetic (addition, subtraction and arithmetic combinations) and 'understanding mathematical relations' (mathematical-logical principles, arithmetic principles, mathematical symbols, place- value and base-ten system).

A number of scientific skills in Mathematics suggested for students at early ages included spatial reasoning, geometrical awareness and sense of time and require mathematical thinking and reasoning skills are (Sarama & Clements, 2020). A cluster of mathematical thinking and reasoning skills such as reasoning, solving problems and learning analytical thinking and mathematical-logical thinking are essential components of early scientific skills in Mathematics (Larkin & Karp, 2023).

The National Curriculum of Pakistan 2006 recommended that the students of grade-I in mathematics subject must have the scientific skills of demonstrating different attributes of objects and their engagement in pattern making. They also have counting skills, simple number operations, recognizing different shapes and developing an understanding of comparing objects (Yoon et al., 2019).

According to Parviainen (2019), the basic scientific skills in Mathematics at the early stage are numerical skills (number sense, counting skills, basic arithmetic skills), spatial skills (spatial sense, geometrical awareness and sense of time) and mathematical thinking.

A study conducted by Jahanzaib et al. (2021) highlighted the scientific skills in Mathematics for grade-I students from the Single National Curriculum of Pakistan that was given in 2020 which demonstrated different attributes of objects and their classification on one / two attributes, counting skills 0-100, basic operation of 1-20, geometrical awareness, developing an understanding of measurements, spatial sense and critical thinking.

1.2 Research Gap

To gain insights regarding the topic being researched, the researcher reviewed the literature from the perspective of teaching mathematics, scientific skills and students' performance in mathematics. During the review of literature, it was found that scientific skills of students in Mathematics were very week and their performance in Mathematics subject was also very low. They had no base in mathematics. They had the ability only to memorize formula or contents but could not utilize those concepts in their daily life (Mullis & Martin, 2020).

According to Mullis and Martin (2020) the result of Trends in International Mathematics and Science Study (TIMSS) in 2019, Pakistan ranked second to last in mathematics among 58 countries. Only 27 percent of Pakistani Children met the low international benchmark (Addition, subtraction, multiplication and Division) in mathematics. Only 8 percent of Pakistani children met the intermediate benchmark (whole numbers, negative numbers, fractions, decimals, ratio, two dimensional shapes, graphs) in mathematics and 1 percent met the high benchmark (two step word problem, number line, operation with fraction and decimal, properties of shapes and angles, interpreting and using data in tables and graphs) in mathematics.

According to the World Bank's report (2021) learning outcomes in Pakistan are generally low, with a considerable percentage of students failing to reach minimum proficiency standards in fundamental subjects such as mathematics and reading. This indicates systemic issues in educational quality throughout the nation, particularly in mathematics, where foundational knowledge and problem-solving abilities are essential.

A study conducted by Azeem (2021) on 5th grade students' achievement in mathematics told us the performance of students in written papers of math was less than 45% and overall (both written and multiple choice) in mathematics was 57% since 2015 while 8th grade students' performance in written papers and overall (both written and multiple choice) of math was less than or almost equal to 50% since 2015. Assessment Data of National Education Assessment System (NEAS) and results of TIMSS 2019 also aligned with these results.

Another study conducted by Bhutta and Rizvi (2022) in the Agha khan University's Institute for Educational Development (IED) Pakistan which reported that more than 90 percent of the primary and lower secondary students across Pakistan were weak or lack basic understanding of Mathematics. The study also found that only one in 50 students had the basic ability to convert numbers written in words to numeric forms. The average mathematics score of the student was 27 out of 100. They were also weak in mathematical operations.

There are numbers of studies that depicted the reasons of students' low performance in mathematics. Students' performance in mathematics was low because students were feeling fear in learning mathematics and they were not satisfied by the teachers' method. Teachers' rigid style while teaching mathematics was also a major cause of poor achievement in mathematics (Mullis & Martin, 2020).

According to the Amin and Mariani (2017) teachers were using the question-and-answer method. This method was not helpful for engaging students in mathematics class. A study conducted in West Indies also highlights poor learner's performance in mathematics and the factor behind this low performance in mathematics was teacher centered method applied in the classroom (Mbatha, 2018).

A study conducted by Makondo and Makando (2020) also showed students low performance in mathematics was because of methodology used by teachers. According to them teachers were not using proper methods for teaching mathematics. 100% teachers used question and answer method and lecture method while teaching mathematics which were not helpful for improving their performance in mathematics.

According to the previous studies and research reports, it was found that the performance of Pakistani's students in mathematics was very low. The reason was the use of improper teaching method by the teacher such as question- and-answer method, teacher centered method and lecture method (Amin & Mariani, 2017; TIMSS, 2019, Makondo and Makondo, 2020; Azeem, 202; Bhutta & Rizvi, 2022). According to them, these methods were not helpful for developing students' scientific skills in Mathematics. So, it was found imperative to use those methods for teaching of mathematics at the very early stage that were activity based and helpful for developing students' scientific skills in Mathematics. In order to meet this problem, it was found that the best method for teaching of mathematics at grade-I was Hands on Learning as it promotes students' learning in Mathematics through direct experiences or by practical activities. Therefore, the focus of the study was to investigate the effect of Hands on Learning on the development of scientific skills in Mathematics in terms of numerical skills, spatial skills and mathematical thinking in first graders.

1.3 Statement of the Problem

The traditional approach to mathematics education often emphasizes rote memorization of formulas and contents, primarily aimed at passing standardized exams. It has contributed to low students' achievement in Mathematics, as evidenced by the TIMSS (2019) results. To improve students' performance in Mathematics, it is essential to transform the teaching and learning process by fostering active, creative, and intellectual engagement. Hands-on Learning (HoL) offers a promising approach by enabling students to learn through direct experiences, thereby enhancing retention and long-term understanding (Li, 2023). While HoL has been effectively employed in teaching Science, Chemistry, Engineering, and Mathematics in regions such as Pakistan, Europe, and Canada, its specific impact on scientific skills in Mathematics development remains underexplored. Thus, the intent of the present study was to measure the effect of Hands on Learning on the development of scientific skills in first graders.

1.4 Significance of the Study

This study may provide a sound knowledge to policy makers, curriculum developers and educational experts to make policies, contents and plans for enhancing conceptual understanding of Mathematics in first graders. They may suggest for including those contents in curriculum that can be taught by Hands on Learning (HoL). In addition, the findings of this study may be fruitful for Director Public Instruction (DPI) schools, Divisional Director School (DDS) and District Education Officers (DEOs). They may motivate their teachers to apply HoL in classroom setting. Moreover, its results may help the head teachers who are responsible of all educational activities of an institution. They may motivate their teachers to apply HoL for mathematics students because it is an activity-based learning. Further, the findings of the study are beneficial for teachers. By the findings of this study, the teachers may be able to know which mathematics' method is more effective for first graders. Moreover, this study is directly beneficial for students. A number of Hands-on activities can be performed by the teacher in mathematics classroom in order to develop scientific skills of students. Furthermore, this study may pave the way to other researchers to investigate the effectiveness of this method for the teaching of mathematics at other levels. It may be a new addition in the existing literature.

1.5 Objectives of the Study

The objectives of the study were;

1. To measure the effect of Hands on Learning on the development of scientific skills in terms of numerical skills.
2. To examine the effect of Hands on Learning on the development of scientific skills in terms of spatial skills.
3. To evaluate the effect of Hands on Learning on the development of scientific skills in terms of mathematical thinking.
4. To measure the effect of conventional method on the development of scientific skills in terms of numerical skills.
5. To examine the effect of conventional method on the development of scientific skills in terms of spatial skills.
6. To evaluate the effect of conventional method on the development of scientific skills in terms of mathematical thinking.
7. To compare the effect of Hands on Learning (experimental group) with conventional method (control group) on the development of scientific skills.

1.6 Research Hypotheses

The research hypotheses of the study were;

$H_0$1: There is no significant effect of Hands on Learning on students' number sense.

$H_0$2: There is no significant effect of Hands on Learning on students' counting skills.

$H_0$3: There is no significant effect of Hands on Learning on students' basic arithmetic skills

$H_0$4: There is no significant effect of Hands on Learning on students' numerical skills.

$H_0$5: There is no significant effect of Hands on Learning on students' spatial sense.

$H_0$6: There is no significant effect of Hands on Learning on students' geometrical awareness.

$H_0$7: There is no significant effect of Hands on Learning on students' sense of time.

$H_0 8$: There is no significant effect of Hands on Learning on students' spatial skills.

$H_0 9$: There is no significant effect of Hands on Learning on students' mathematical thinking.

$H_0 10$: There is no significant effect of conventional method on students' number sense.

$H_0 11$: There is no significant effect of conventional method on students' counting skills.

$H_0 12$: There is no significant effect of conventional method on students' basic arithmetic skills

$H_0 13$: There is no significant effect of conventional method on students' numerical Skills.

$H_0 14$: There is no significant effect of conventional method on students' spatial sense.

$H_0 15$: There is no significant effect of conventional method on students' geometrical awareness.

$H_0 16$: There is no significant effect of conventional method on students' sense of time.

$H_0 17$: There is no significant effect of conventional method on students' spatial skills.

$H_0 18$: There is no significant effect of conventional method on students' mathematical thinking.

$H_0 19$: There is no significant difference in the development of students' number sense taught by Hands on Learning and those taught by conventional method.

$H_0 20$: There is no significant difference in the development of students' counting skills taught by Hands on Learning and those taught by conventional method.

$H_0 21$: There is no significant difference in the development of students' basic arithmetic skills taught by Hands on Learning and those taught by conventional method.

$H_0$22: There is no significant difference in the development of students' numerical skills taught by Hands on Learning and those taught by conventional method.

$H_0$23: There is no significant difference in the development of students' spatial sense taught by Hands on Learning and those taught by conventional method.

$H_0$24: There is no significant difference in the development of students' geometrical awareness taught by Hands on Learning and those taught by conventional method.

$H_0$25: There is no significant difference in the development of students' sense of time taught by Hands on Learning and those taught by conventional method.

$H_0$26: There is no significant difference in the development of students' spatial skills taught by Hands on Learning and those taught by conventional method.

$H_0$27: There is no significant difference in the development of students' mathematical thinking taught by Hands on Learning and those taught by conventional method.

$H_0$28: There is no significant effect of Hands on Learning on the development of students' scientific skills.

$H_0$29: There is no significant effect of conventional method on the development of students' scientific skills.

$H_0$30: There is no significant difference in the development of students' scientific skills taught by Hands on Learning and those taught by conventional method.

1.7 Delimitations of the Study

The study was delimited to:

1. Government Boys Higher Secondary School Hatli Kotli Azad Kashmir.
2. Mathematics textbook of AJ&K Textbook Board, Muzaffarabad.
3. Contents: Unit 1 (Concept of Whole Numbers), Unit 2 (Number Operations), Unit 3 (Measurement), Unit 5 (Time) and Unit 6 (Geometry).
4. Scientific Skills in Mathematics in terms of numerical skills, spatial skills and mathematical thinking.

1.8 Operational Definitions of Key Terms

The operational definitions of key terms are as under:

Hands on Learning

Hands on Learning guided the students to gain knowledge by experiences or by doing rather than learning from books or lectures. It is designed by teacher which requires from the students to use materials and objects to understand ideas and earn experiences from dealing with objects.

Conventional Method

The conventional method of teaching is a method in which a teacher directs students to learn through memorization and recitation techniques thereby not developing their critical thinking problem solving and decision-making skills.

Scientific Skills

Scientific skills refer to measurable and observable abilities used in the process of scientific enquiry including observation, measurement, experimentation, data analysis and critical thinking.

Scientific Skills in Mathematics

Scientific skills in mathematics refer to the measurable and observable abilities that enable individuals to apply logical reasoning, critical thinking, and problem-solving techniques in mathematical contexts to solve given mathematical problems.

Numerical Skills

Numerical skills, in terms of scientific skills in mathematics refer to the foundational abilities that enable young learners to understand, recognize, and work with numbers systematically.

Number Sense

Number sense refers to a student's intuitive understanding of numbers and their relationships, which forms the foundation for logical reasoning and problem-solving. It involves recognizing numbers, their quantities, and how they relate to each other through concepts such as more, less, and equal.

Counting Skills

Counting skills refer to the ability to systematically identify, sequence, and manipulate numbers to understand quantity and order. These skills include counting forward and backward, skip counting by 2s, 5s, and 10s, and understanding the relationship between numbers in a sequence.

Basic Arithmetic Skills

Basic arithmetic skills refer to the foundational abilities to perform simple mathematical operations such as addition and subtraction. These skills involve understanding the concepts of combining and separating quantities, using strategies like counting on, using number lines, or manipulating objects to solve problems.

Spatial Skills

Spatial skills, in terms of scientific skills in mathematics refer to the ability to understand, interpret, and manipulate shapes, positions, and relationships in space.

Spatial Sense

Spatial sense refers to the ability to understand and interpret the positions, shapes, and relationships of objects in space. It involves recognizing and naming basic geometric shapes, such as circles, squares, triangles, and rectangles, and understanding their properties.

Geometrical Awareness

Geometrical awareness refers to the ability to recognize, describe, and analyze shapes, structures, and their properties. It involves identifying basic geometric shapes such as circles, squares, triangles, and rectangles, and understanding their attributes, like the number of sides or corners

Sense of Time

Sense of time refers to the ability to understand and measure the passage of time using basic concepts and tools. It involves recognizing units of time such as seconds, minutes, hours, days, weeks, and months, and their relationships to one another.

Mathematical Thinking

Mathematical thinking refers to the ability to approach problems and mathematical concepts with curiosity, creativity, and logical reasoning. It involves recognizing patterns, making connections between numbers, shapes, and operations, and using these observations to solve problems.

1.9 Conceptual Framework of the Study

The study was based on the development of scientific skills in Mathematics by using Hands on Learning in first graders. Hands on Learning is the independent variable and Scientific skills in Mathematics including numerical skills, spatial skills and mathematical thinking were dependent variable. Hands on Learning was used for developing scientific skills of students in Mathematics at grade-1. Following conceptual framework was used for the current study:

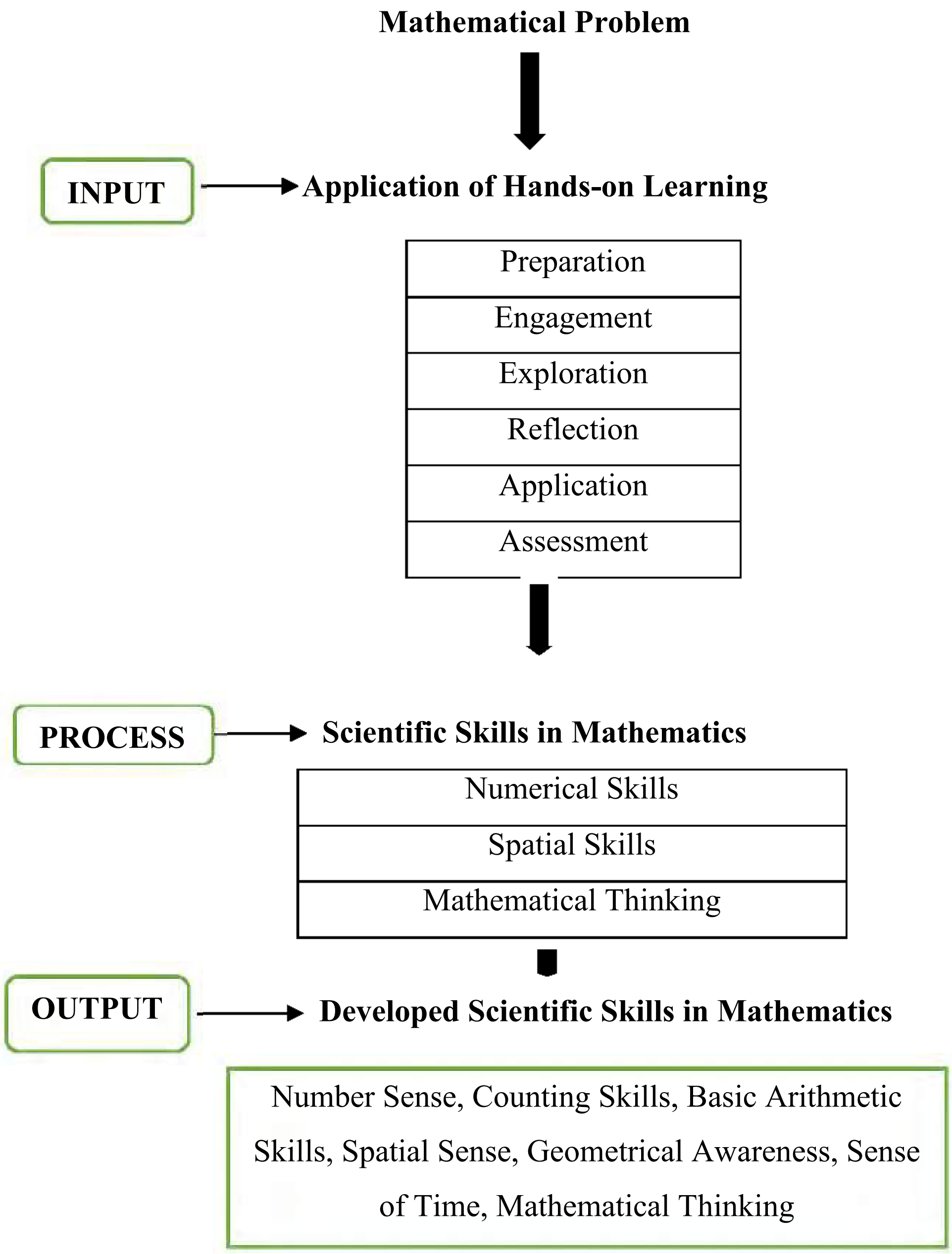

Figure 1.1: Conceptual Framework of the Study

CHAPTER 2

LITERATURE REVIEW

Hands-on learning has been widely recognized as an effective approach for enhancing students' scientific skills in Mathematics including numerical skills, spatial skills and mathematical reasoning and thinking skills particularly in the early grades. In connection with the significance of the Hands on Learning, the present study was designed to investigate the effect of Hands on Learning on the development of scientific skills in first graders. The literature review of the present study includes:

- Concept of Mathematics
- Characteristics of Mathematics
- Importance of Mathematics
- Curriculum of Mathematics in Pakistan at Early Stages
- Curriculum 2006 of Mathematics in Pakistan at Early Stages
- Single National Curriculum 2020 of Mathematics in Pakistan at Early stages
- Single National Curriculum 2020 of Mathematics for Grade-1 in Pakistan
- Teaching of Mathematics
- Methods of Teaching Mathematics
- Conventional Method
- Hands on Learning
- Hands on Learning Activities in Mathematics
- Scientific Skills
- Scientific Skills in Mathematics
- Numerical Skills
- Spatial Skills
- Mathematical Reasoning and Thinking Skills
- International Reports on Learning of Mathematics
- Major reasons of Failure in Mathematics
- Researches Related to Hands on Learning in Mathematics
- Summary

2.1 Concept of Mathematics

The term mathematics is derived from two Greek words "Manthanein" which means "learning" and "Techne" which means an "art" (or) "technique". Therefore, Mathematics means the art of learning related to disciplines (or) facilities. The dictionary meaning of mathematics refers as the science of number and space or the science of measurement, quantity and magnitude (Latafat, 2024). It is a human activity, a social phenomenon, part of human culture, historically evolved, and intelligible only in a social context. It is viewed not only as useful and as a way of thinking, seeing and organizing the world, but also as aesthetic and worthy of pursuit in its own right (Reyes, 2022).

According to Whitehead (2017) Mathematics is considered as the science of quantity, measurement and spatial relations. It is a systematized, organized and exact branch of science. It deals with quantitative facts, relationships as well as with problems involving space and form. It is a logical study of shape, arrangement, and quantity.

Mathematics is defined in different ways by different authors. Let us examine a few of them.

- Mathematics is the science and study of quality, structure, space, and change" (Parker, 2019).
- Mathematics is the logical study of abstract structure" (Stewart, 2020).
- Mathematics is a field of study that deals with the logical and abstract properties of numbers, quantities, shapes, and patterns" (Harris & Smith, 2021).
- Mathematics is the discipline studying quantities, forms, and the relationships between them" (Cohen & Browne, 2022).
- Mathematics is a study of patterns, structures, and logical relationships, emphasizing precision, abstraction, and generalization" (Riley, 2023).

In conclusion, Mathematics is the logical and systematic study of abstract structures, quantities, patterns, relationships, and spatial configurations. It employs systematic techniques to analyze the properties and interactions of numbers, shapes, and other mathematical structures. It involves the use of precise methods to explore the properties of numbers, shapes, and their interconnections. It provides a framework for understanding complex systems and solving problems across a wide range of fields. Its applications span from theoretical studies to practical uses for scientific discovery, technological advancement, and everyday problem-solving.

2.2 Characteristics of Mathematics

According to Clements and Sarma (2023) mathematics learning begins from birth as children explore the world around them. As children progress, they receive support in their educational journeys from those around them. The surroundings serve as a valuable resource for engaging with mathematics, particularly when they offer chances to listen, utilize mathematical terminology, and interact mathematically with daily experiences. With the guidance of others, children's focus and activities are steered in ways that empower them to reason and enhance their capabilities to express themselves mathematically. In doing so, they cultivate a connection with mathematical instruments and derive enjoyment and curiosity from mathematical thinking.

Various scholars identify several characteristics of mathematics. Some of these are listed below:

2.2.1 Objectivity

According to Madden and Connell (2023) objectivity in mathematics is often regarded as one of the more essential qualities for its credibility. The foundational premises suggest that any mathematical representation of nature should be detached from the desires, emotions, or requirements of any single mathematician (or collective group of mathematicians). More fundamentally, nature itself is considered impartial, governed by laws rather than the preoccupations or goals of its inhabitants. Being impartial implies an existence of "global consensus" (or at least a significantly widespread agreement). Everyone concurs that "1 + 1 = 2". Indeed, mathematics may be the only domain where a true sense of global consensus prevails. This universality accounts for mathematics' remarkable efficacy in underpinning the exploration of various distinct fields.

2.2.2 Logical Structure

Mathematics employs an unwavering logical framework. The stages in a problem must be arranged in a coherent order. Each step or assertion to be considered mathematical needs to be substantiated by an appropriate justification. Failing to do so might lead even simple equations to cause misconceptions. In the realm of mathematics, we cannot accept claims that lack sufficient justification. The answer by itself cannot be the sole benchmark. While an answer may be correct, it requires logical reasoning to support it. This training to think in terms of providing a rationale for every assertion will serve individuals well when they encounter challenges in life (Wang & Kim, 2022).

2.2.3 Abstractness

Abstract forms the foundation of mathematics. It's accurate that real-life issues have contributed to the evolution of mathematical theories. However, all mathematical principles rest upon abstraction. Mathematical truths and theories can evolve even in the absence of practical application. Renowned mathematicians of history have been profoundly drawn to this intrinsic quality of mathematics (Reed & Jordan, 2024).

2.2.4 Symbolism

Mathematics possesses a distinctive language of notation. It serves as a technical method for conveying a specific set of ideas in a format conducive to reasoning processes. The mathematical language is relevant to a limited spectrum of ideas with a comparative aspect. It boasts its own clarity, brevity, and precision that are not found in any other form of discourse (Miller & Thompson, 2023).

2.2.5 Applicability

Knowledge transforms into power only when put into action. The knowledge that students gain is predominantly employed to tackle problems. Students can always verify the validity of mathematical principles and relationships by applying them to unfamiliar scenarios. Teachers should continually assist students in applying and validating mathematical concepts. Wherever applicable, the knowledge and its practical applications should be linked to everyday life. Ideas and principles become significantly functional and resonant only when they relate to concrete applications. Such practice enhances the relevance and importance of learning mathematics (Singh & Lee, 2023).

2.2.6 Precision and Accuracy

Mathematics is regarded as a precise science due to its exactness. It may be the only discipline that can assure certainty in its outcomes. In mathematics, results are categorically right or wrong, accepted or rejected. Mathematics can determine the accuracy of its conclusions. Mathematicians can affirm the validity of results and persuade others of their correctness with steadfastness and impartiality. This principle applies not only to the experts but to anyone engaging with mathematics at any level (Tucker & Arnold, 2024).

2.2.7 Universal

According to Lee (2023) Mathematics truths and principals are universal and apply everywhere. Its truths and principles remain consistent regardless of time, place or context.

2.3 Importance of Mathematics

In today's world, mathematics is considered a universal part of human culture. It serves as the instrument and dialect of trade, engineering, and a multitude of sciences, including physics, computing, and biology, among others. It aids us in identifying patterns and grasping the environment around us. It imparts essential life skills. Finding an area of existence untouched by mathematics is challenging (Cohen & Browne, 2022).

Mathematics is vital in the education and growth of learners at various stages. Here are some crucial reasons:

2.3.1 Critical Thinking and Problem-Solving Skills

Mathematics helps learners develop critical thinking and problem-solving skills. It prompts them to examine circumstances, discern patterns, and devise logical solutions. By tackling mathematical concepts and intricate problems, individuals cultivate the capacity to systematically assess situations, discern patterns, and develop reasoned solutions (Sachdeva & Eggen, 2021).

2.3.2 Foundation for STEM Education

Mathematics serves as the cornerstone of science, technology, engineering, and mathematics (STEM) education. Mastery in math is crucial for success in these areas, as mathematics functions as the unifying thread connecting these fields, offering a universal language that promotes precision, accuracy, and the enhancement of knowledge and technological prowess (Mass et al, 2019).

2.3.3 Real-World Applications

Mathematics has myriad practical applications, spanning budgeting and financial strategizing to engineering and technology. It aids learners in establishing links between classroom instruction and real-life experiences. (Agbata et al, 2024).

2.3.4 Enhanced Analytical Skills

Engagement with mathematics enhances analytical capabilities, equipping students to confront issues with a systematic and logical perspective. The journey of grasping and applying mathematical ideas fosters a structured method for deconstructing complex problems into manageable parts (Sachdeva & Eggen, 2021).

2.3.5 Career Opportunities

A strong grasp of mathematics opens doors to a wide array of career opportunities, as numerous professions demand quantitative and analytical expertise.

Many fields, including science, technology, engineering, finance, and data analysis, require a strong mathematical foundation (Mass et al, 2019).

2.3.6 Cognitive Development

Mathematics plays a significant role in cognitive development by immersing individuals in processes that stimulate various cognitive functions. Tackling mathematical challenges necessitates memory usage to recall pertinent formulas and concepts. It demands focus and concentration to comprehend the problem, analyze data, and adhere to logical steps to arrive at a resolution. Mathematical reasoning and analytical thinking advance the development of executive functions, such as planning, organizing, and strategic decision-making (Shing & Starns, 2022).

2.3.7 Global Competitiveness

Nations that place strong emphasis on mathematics education frequently excel in international assessments, significantly enhancing their global competitiveness. A robust mathematical foundation equips individuals with critical analytical and problem-solving capabilities, fostering a skilled workforce essential for innovation and economic progression. This focus also correlates with increased engagement in worldwide research initiatives, encouraging collaboration and elevating a country's position in the global academic landscape (Mullis & Martin, 2020).

2.3.8 Technological Advancements

Mathematics acts as the cornerstone for technological progress, playing a foundational role in the evolution and advancement of various technological sectors. From programming and algorithm development to data analysis and artificial intelligence, mathematical concepts provide the essential groundwork for creating and refining innovative technologies. Mathematical modeling and simulation are vital in engineering, facilitating the design and testing of complex systems prior to the construction of physical prototypes. The interdisciplinary essence of technology and its swift evolution necessitate a solid mathematical basis, emphasizing the unbreakable link between mathematics and the ongoing progression of technology (Mass et al, 2019).

2.3.9 Developing Numerical Skills

Numerical skills, involving the capacity to comprehend and manipulate numerical data, are essential in numerous facets of life and are intimately connected to mathematics instruction. The significance of mathematics in cultivating numerical abilities is highlighted in recent educational research and publications. Mathematics offers a structured and methodical approach to engaging with numbers, promoting the development of numerical fluency and expertise. As students interact with mathematical principles, they improve their capacity to conduct mental computations, estimate amounts, and make informed choices based on quantitative information. Numerical abilities are crucial not only in academic environments but also in daily scenarios, such as budgeting, making financial choices, and interpreting numerical information in the media (Geary & Hoard, 2023).

2.3.10 Fostering Spatial Reasoning Skills

Mathematics is vital in the enhancement of spatial reasoning skills, which pertain to the ability to visualize, comprehend, and mentally manipulate spatial connections. The relevance of mathematics in nurturing spatial reasoning is backed by research and educational publications. Engaging with geometric principles boosts individuals' spatial consciousness and their capacity to mentally manipulate and transform objects in space. A study by the National Research Council titled "Learning to Think Spatially" underscores the importance of spatial reasoning across various fields and illustrates the role of mathematics education in developing these skills (Clements & Sarama, 2023).

2.3.11 Enhancing Mathematical Reasoning and Thinking Skills

Mathematics is essential in fostering and improving mathematical thought and reasoning abilities, which are critical skills that extend beyond simple arithmetic. The growth of these skills is vital for problem-solving, logical thinking, and decision-making. Educational literature stresses the importance of mathematics in nurturing these cognitive abilities. Mathematical thought encompasses the capacity to analyze, synthesize, and apply mathematical concepts, promoting a deeper comprehension of the subject. Reasoning abilities, crucial in daily life and academic endeavors, are refined through the logical processes inherent in mathematical problem-solving (Siegler & Alibali, 2023).

In summary, the significance of mathematics is profound and multifaceted, spanning diverse areas and influencing every aspect of modern life. Its importance cannot be overstated, as it pervades virtually all dimensions of our existence. Beyond its function as an academic subject, mathematics serves as a potent tool that empowers individuals and societies to navigate the complexities of contemporary life. Its emphasis on logical reasoning, problem-solving, numerical abilities, spatial reasoning skills, and critical thinking skills is essential for addressing challenges across various fields.

2.4 Curriculum of Mathematics in Pakistan at Early Stages

The curriculum is a document that outlines a comprehensive educational program including the experiences that individual learners encounter in school. Its purpose is to serve as a guide with distinct goals and precise objectives. These elements are arranged based on a framework or research that exemplifies a professional practice (Smith, 2020). Mathematics is a crucial subject across all educational levels, taught from primary school up to university. In Pakistan, the mathematics curriculum is formulated at the national level (Government of Pakistan, 2006).

Additionally, greater emphasis has been placed on primary mathematics as it lays the groundwork for students' future success as well as the development of their personalities and overall inclusive growth, where foundational skills and attitudes of students are cultivated (Gulzar, & Mahmood, 2019). As a result, modern societies are persistently working to adjust educational systems to fit global standards so that learners—who are 21st-century citizens—exhibit adaptable thinking and demonstrate their ability to comprehend and apply concepts, gaining practical and cognitive experiences in mathematics (Abramovich et al., 2019).

Generally, Mathematics is not liked by Pakistani students due to its challenging, tedious, and difficult nature (Ahmad & Khan, 2021). Students often struggle significantly with math learning. In public sector schools in Pakistan, students commonly cannot perform two-digit addition and subtraction. Only 48% of students are capable of solving basic arithmetic problems (Dubash, 2018). The mathematics curriculum involves conceptual understanding, which necessitates both analytical and logical reasoning. The efforts of students are crucial in the mathematics learning process (Harefa, 2023). However, educators in both public and private institutions have been unable to instill analytical skills in students due to a lack of understanding about the curriculum (Gulzar & Mahmood, 2019).

In Pakistan, mathematics has a well-defined vision for its teaching and objectives. The country initiated its curriculum development and revision efforts in 1975, beginning with the first national curriculum developed during 1975-76 under the guidance of the 1971 Education policy. This curriculum underwent revisions in 1984, followed by updates in 1994, 2000, and 2002 respectively. In pursuit of further enhancement, the mathematics curriculum was revised again in 2006 and this process continues in Pakistan from 1975 to 2006 (Government of Pakistan, 2006).

2.4.1 Curriculum 2006 of Mathematics in Pakistan at Early Stages

The National Curriculum of Mathematics (NCM) 2006 documents are centered on standards, meaning they are founded on the ideology of social efficacy. This ideology emphasizes the skills and specific competencies of individuals. It advocates for education that is performance-based, as it holds the belief that human existence is grounded in the execution of particular abilities. Therefore, education should equip students with these specific skills and competencies (Harb & Thomure, 2020).

In the contemporary era, a curriculum influenced by the ideology of social construction is expected to enhance students' learning outcomes since when students are permitted to shape their understanding of the world around them, their comprehension improves. The ideology of social construction contends that knowledge, skills, and intelligence can be applied to address societal issues for the benefit of society (Kumar, 2019). The goals established in the 2006 curriculum reflected those that were international and followed by many developed nations. A prominent characteristic of this curriculum was its emphasis on content that could facilitate the achievement of diverse objectives. The curriculum 2006 proposed the following topics for students:

- Mathematical concepts were introduced to cultivate a robust conceptual foundation that would empower students to leverage acquired knowledge for deeper understanding in various subjects.
- Mathematical concepts were included to enhance students' abilities to think logically, reason, conjecture wisely, and grasp geometric ideas.
- Mathematical concepts were incorporated that could improve students' skills to visualize and interpret mathematical expressions.
- Topics related to emerging and current technologies were recommended in examples and questions to inform students about them.
- Content addressing real-life issues was integrated into the curriculum (Government of Pakistan, 2006).

To uphold the quality of the National Curriculum for Mathematics 2006, it was structured around five fundamental standards, listed as follows:

- Numbers and Operations
- Algebra
- Measurement and Geometry

- Information Handling
- Reasoning and Logical Thinking (Government of Pakistan, 2006).

Undeniably, the NCM 2006 was founded on academic standards; however, it overlooked the holistic development of students, preventing them from constructing meaning, engaging in critical and logical thinking. This curriculum failed to consider the instructional process across the three domains of learning: cognitive, affective, and psychomotor. The learner's role was passive in the mathematics learning experience. Furthermore, teachers acted as mere transmitters of knowledge instead of facilitating students' meaning-making. Document reviews indicated that mathematics content was not being taught in accordance with the specified curriculum (Yoon et al., 2019). Additionally, the three standards had been somewhat implemented, but two crucial standards; information handling and reasoning were absent at the primary level (Khan et al., 2018).

While the NCM 2006 was a standards-based framework emphasizing skills, it neglected a humanistic viewpoint. It prioritized skills over an understanding of fundamental mathematical concepts, as content was provided through the standard-based program. Nonetheless, the implementation of reasoning and justification skills was lacking in schools. The instructional process primarily aimed at procedural fluency and strategic competency, but there was a deficiency in proper instructional processes in the NCM 2006, and although teaching strategies were mentioned, they were not correctly executed (Yoon et al., 2019).

To address these shortcomings, a new initiative has been introduced in the form of the Single National Curriculum 2020.

2.4.2 Single National Curriculum 2020 of Mathematics in Pakistan at Early Stages

The Single National Curriculum (SNC) 2020 was established with the aim of bridging the gap among three distinct types of education systems: namely public schools, also referred to as state-operated institutions; private schools, often called elite and middle-class establishments; and low-income organizations (Jahanzaib et al, 2021).

The foundation of the Single National Curriculum (SNC) in Pakistan is based on the belief that all students should have equal access to high-quality education throughout the nation, regardless of their socio-economic status, gender, religion, or geographic area (Zaman et al, 2021).

The SNC seeks to establish a standardized and inclusive curriculum that centers on fostering a shared understanding of fundamental knowledge and values among all learners, no matter their backgrounds. It is rooted in principles of fairness, access, quality, and pertinence, and is intended to enhance national unity and social harmony (Irfan, 2021).

Additionally, it highlights the cultivation of critical thinking, problem-solving, creativity, and innovative skills, alongside practical abilities and vocational training. The curriculum is crafted to be student-centered, prompting active involvement and engagement in the educational journey (Government of Pakistan, 2020).

The mathematics curriculum under SNC 2020 is structured around standards, benchmarks, and outcomes for every topic, contrasting with the 2006 curriculum, which did not specify these elements for each field of study. The mathematics content in the SNC has been aligned with the TIMSS curriculum framework (Irfan, 2021).

The mathematics curriculum for grades I-V is elaborated under the following points:

- Concrete, pictorial, and abstract learning techniques are gradually introduced from grades 1 to 5.
- There should be a focus on establishing a solid conceptual foundation supported by robust reasoning.
- Addresses SDG 4 objectives like open discussion, collaboration, and individual initiative in education.
- Linking mathematical concepts to daily life through narratives and illustrations.
- Various engagement-enhancing activities suggested for each subject area.
- Incorporating links to external websites and assigning tasks to students as part of ICT integration.
- Alignment with TIMSS, an international research initiative that monitors educational trends in mathematics and science (Government of Pakistan, 2020; Dilshad et al, 2023).

2.5 Single National Curriculum 2020 of Mathematics for Grade-1 in Pakistan

The mathematics curriculum of grade-I stimulates the logical cognition of students and encourages them to solve real life mathematical situations. It comprised of four strands including Whole Numbers, Number Operations, Measurement, and Geometry. All these contents are underpinned by reasoning and logical thinking. All standards, benchmarks and students' learning outcomes are built around these strands (Government of Pakistan, 2020; Zaman et al, 2021; Ahmad & Naeem, 2022; Dilshad et al, 2023).

2.5.1 Strand No. 1: Whole Numbers (39%weightage of the curricula)

The strand 1 (whole numbers) consisted of 39% weightage of the grade-1 mathematics curriculum. According to Zaman et al (2021), Ahmed and Naeem (2022) and Dilshad et al, (2023) grade 1 mathematics curriculum has the following standards and benchmarks which are shown in the table 2.1

Table 2.1

Whole Numbers

Standards	Benchmarks
a. Identify numbers b. ways of representing numbers c. comparing numbers d. examine real life situations by identifying mathematically valid arguments e. drawing conclusion to enhance their mathematical thinking	The students will be able to: a. Identify, read and write whole numbers up to 100. b. Count forward and backward whole numbers up to 99. c. Identify the place value of the specific digit in a 2-digit numbers d. Identify the position of objects using ordinal numbers. e. Comparing and matching objects f. Identify number of objects in two groups to show "more than" and "less than".

2.5.2 Strand No. 2: Number Operations (25% weightage of the curricula)

The strand 2 (number operations) consisted of 25% weightage of the grade-1 mathematics curriculum. According to Zaman et al (2021), Ahmed and Naeem (2022) and Dilshad et al, (2023) grade 1 mathematics curriculum has the following standards and benchmarks which are shown in the table 2.2

Table 2.2

Number Operations

Standards	Benchmarks
a. comparing numbers b. identify effects of operations in various situations such as addition without carrying and subtraction without borrowing. c. examine real life situations by identifying mathematically valid arguments through number operations. d. drawing conclusion to enhance mathematical thinking	The students will be able to: a. compare numbers from 1 to 20. b. recognize and use symbols of addition (+), subtraction (-) and equality (=). c. add and subtract two 1-digit and 2-digit numbers up to 10. d. add and subtract tens from 2-digit number. e. add and subtract the numbers up to 20 by using real life examples. f. Construct addition and subtraction sentences from given number stories.

2.5.3 Strand No.3: Measurement (24%weightage of the curricula)

The strand 3 (measurement) consisted of 24% weightage of the grade-1 mathematics curriculum. According to Zaman et al (2021), Ahmed and Naeem (2022) and Dilshad et al, (2023) grade-1 mathematics curriculum has the following standards and benchmarks which are shown in the table 2.3

Table 2.3

Measurement

Standards	Benchmarks
a. identify measurable attributes of objects such as long, short, tall high, heavy, light, Pakistan currency and timing. b. Comparing the measurable attributes. c. examine real life situations by identifying mathematically valid arguments through measurable attributes. d. drawing conclusion to enhance mathematical thinking.	The students will be able to: a. use language to compare heights, lengths, masses and capacity of different objects. b. read, recognize and use units of money(rupees) with coins and notes and time (minute and seconds). c. add and subtract in units of money and time for solving real life situations. d. use analogue and digital clock to find time in hours, minutes and seconds. e. use solar and Islamic calendar to find a particular dates/ day.

2.5.4 Strand No. 4: Geometry (12% weightage of curricula)

The strand 4 (Geometry) consisted of 12% weightage of the grade-1 mathematics curriculum. According to Zaman et al (2021), Ahmed and Naeem (2022) and Dilshad et al, (2023) grade-1 mathematics curriculum has the following standards and benchmarks which are shown in the table 2.4

Tabe 2.4

Geometry

Standards	Benchmarks
a. identify and recognize the shapes of objects in daily life. b. analyze characteristics and properties of geometric shapes and develop arguments about their geometric relationships c. examine real life situations by identifying mathematically valid arguments. d. drawing conclusion to enhance mathematical thinking.	The students will be able to: a. Recognize and identify shapes of similar objects. b. Identify basic shapes rectangle, square, circle and rectangle. c. Identifying and distinguishing basic shapes and 2D shapes by considering different attributes and number of sides and corners. d. Identify the shapes in given pattern of 2 or 3 elements. e. Identify whether an object is placed inside, outside, above, below, over, under, far, near, before and after a given object.

2.6 Teaching of Mathematics

` The teaching of Mathematics in the early years is essential as it establishes the groundwork for future mathematical comprehension and achievement. Early childhood education emphasizes cultivating number sense, fundamental arithmetic, and reasoning abilities that learners will expand upon as they advance through their schooling (Clements & Sarama, 2020). Effective pedagogical approaches during this period highlight active participation, experiential learning, problem-solving, and the utilization of tangible materials. By fostering mathematical reasoning from the beginning, instructors can promote a constructive outlook towards mathematics and assist children in acquiring the essential skills to tackle more intricate concepts as they progress in their education (Asad et al., 2021).

Early mathematics' teaching is crucial since it helps children establish a robust basis for future learning. Initial exposure to mathematics encourages an understanding of numerical reasoning, spatial perception, and mathematical connections. Studies indicate that children who receive high-quality math education in their early years are more likely to excel in subsequent academic pursuits, particularly in STEM areas (Lowrie et al., 2019). The 2008 report from the National Mathematics Advisory Panel underscores the significance of early math education and provides evidence showing that foundational mathematical abilities are a strong predictor of future academic success. (National Mathematics Advisory Panel, 2008).

Researches highlight the value of hands-on, interactive learning experiences during the initial phases of math education. Young learners gain from engaging with tangible materials like blocks, counters, and measuring instruments that enable them to investigate mathematical concepts in a tangible manner. Through play-based and experiential tasks, children can discover mathematical ideas in a natural and captivating way (Chen et al., 2020).

Language is a vital factor in fostering mathematical thought, as it allows children to articulate, reason, and deliberate about mathematical concepts. Promoting the use of mathematical terminology from an early age, such as terms related to number operations (addition, subtraction), size, and patterns, enhances children's comprehension and lays a foundation for future academic achievement. Numerical reasoning is a fundamental element of early math development. It encompasses grasping the relative magnitude of numbers, identifying numerical patterns, and cultivating an understanding of operations. Numerical reasoning is not merely about memorization; it involves developing an intuitive grasp of how numbers function and relate to one another. Introducing problem-solving at a young age aids children in honing critical thinking abilities and learning to tackle complex challenges. During early childhood, problem-solving typically involves straightforward tasks that necessitate logical reasoning, such as counting objects in a group or solving basic addition and subtraction problems. As children advance, these tasks become more intricate, demanding higher-order reasoning skills (Erath et al., 2021).

It is crucial that early math education emphasizes fostering conceptual understanding rather than rote memorization. Studies indicate that when young children cultivate a conceptual grasp of mathematical principles, they are better prepared to tackle new problems and apply their knowledge in different situations. Teaching methods that encourage profound understanding focus on helping children comprehend why mathematical concepts function rather than merely memorizing processes (Clements & Sarama, 2020).

Technology can play a significant role in enhancing early math learning. Educational software, applications, and digital games can deliver interactive experiences that reinforce concepts such as counting, recognizing patterns, and identifying shapes. However, it is vital that technology is utilized alongside hands-on activities to promote balanced learning (Chen et al., 2020).

Play is a crucial component of early childhood growth and education, including mathematics. Through play, children acquire foundational skills such as problem-solving, logical reasoning, and numerical comprehension. Structured play activities involving manipulatives and games can foster active engagement and exploration of mathematical concepts in a relaxed environment (Rosli & Lin, 2018).

In conclusion, the instruction of mathematics during early stages is a dynamic activity that lays the groundwork for subsequent mathematical learning. Through active learning, problem-solving, and the development of numerical reasoning, young children start developing the skills necessary for more advanced mathematical reasoning. By integrating play, tangible experiences, and technology, educators can create engaging and effective learning settings. Research consistently supports the importance of cultivating conceptual understanding, hands-on exploration, and critical thinking skills in the early phases of math education.

2.7 Methods of Teaching Mathematics at Early Stages

Effective methods of teaching Mathematics at early stages are essential for assisting students in enhancing their problem-solving skills, logical reasoning, and mathematical proficiency. The choice of suitable methods relies on factors such as the age and developmental level of the students, the particular mathematical material, and the objectives of teaching (Montague-Smith et al., 2017). Following are different methods for teaching mathematics at early stages:

Inquiry-based learning is used at early stages for the teaching of Mathematics. It involves directing students through the process of questioning, exploring, and solving challenges. This approach promotes students to become independent thinkers by engaging in hands-on explorations and forming their understanding through questioning (Montague-Smithet al., 2017).

Problem-based learning (PBL) is also used at early stages for the teaching of Mathematics. It is a technique where learners acquire knowledge by tackling intricate, real-life challenges. In mathematics, PBL requires students to utilize mathematical principles to resolve practical issues, fostering critical thinking and analytical skills. The educator's responsibility is to offer support and facilitate the educational process by presenting demanding problems (Montague-Smithet al., 2017).

Differentiated instruction is a pedagogical strategy that is used at early stages for the teaching of Mathematics. It adjusts teaching to accommodate the varied needs of learners. Differentiation may involve modifying the pace, content, or method of lesson delivery to cater to distinct learning preferences (Dzaldov & Mandelker, 2023).

The flipped classroom method is also used at early stages for the teaching of Mathematics. It entails reversing the conventional teaching approach. Rather than introducing new material during classroom sessions, students initially engage with the content at home through videos or readings. (Lo et al., 2017).

Game-based learning (GBL) is used at early stages for the teaching of Mathematics. It merges play with education by incorporating educational games to strengthen mathematical concepts. Games can inspire students by offering an enjoyable, interactive means to practice and apply their math abilities. (Behnamnia, 2021).

According to Livstorm et al (2019) the Montessori method of teaching mathematics emphasizes hands-on learning resources and promotes independent inquiry. In this method, students receive tangible materials that aid in understanding abstract mathematical concepts. This approach nurtures self-directed learning, allowing students to advance at their own pace while establishing a solid foundation in mathematical comprehension.

The play-based learning is a creative and child-focused educational approach that prioritizes learning through play. It is especially effective in early childhood education, as it corresponds with the innate way young children investigate and comprehend their surroundings. This approach incorporates play into the educational experience, making it captivating, enjoyable, and significant (Rosli & Lin, 2018).

The demonstration method is a teacher-directed instructional strategy where the educator illustrates or showcases a concept, process, or skill to facilitate students' comprehension. This method is particularly beneficial in early childhood education, as young learners thrive on visual and kinesthetic examples (Monye, 2016).

2.8 Conventional Method

Conventional method of teaching mathematics, often referred to as the traditional method, is based on a structured, teacher-centered approach. This method has been widely used for many years and focuses on the teacher delivering the content, with the students primarily acting as passive recipients of information. It emphasizes rote learning, memorization, and repetitive practice (Stephan, 2020).

2.8.1 Key Characteristics of the Conventional Method

Slavin (2019) described the following characteristics of Conventional method:

- In conventional method, the teacher is in charge of delivering knowledge and overseeing the lesson's progression. Learning primarily relies on the educator’s exposition, with students expected to passively absorb information
- The teacher clarifies concepts, offers illustrations, and demonstrates problem-solving methods, particularly in subjects such as mathematics. Lessons are typically structured in a straightforward and sequential manner.
- Its focus is placed on recollection and repetition, often with scant attention to application or analytical thinking. Learners may be evaluated on their capacity to remember facts and procedures rather than on comprehending concepts.
- There is scant interaction or cooperation among learners during lessons. Inquiries from students may be restricted to the teacher’s prearranged activities

2.8.2 Limitation of the Conventional Method

The conventional method of teaching, characterized by a teacher-centered approach, has several limitations that hinder effective learning which are as under:

- One major drawback is limited student involvement. Traditional methods frequently lead to passive learning, where students are merely recipients of information, causing diminished levels of interest and retention (Slavin, 2019).
- This method often lacks personalized learning as it adheres to a rigid curriculum that may not cater to the varied learning styles and paces of students, potentially resulting in disengagement for those who do not conform to the conventional standard (Slavin, 2019).
- Traditional methods often prioritize rote memorization over analytical thinking, leaving students with a shallow understanding that is not easily applicable to real-world situations (Smith & Brown, 2022).
- Another disadvantage is the limited collaboration among students. Unlike more contemporary, interactive approaches, traditional methods often restrict group activities, which research indicates enhance problem-solving abilities and social engagement (Slavin, 2019).
- Furthermore, the teacher-centric nature of this approach can suppress student autonomy and motivation, as the teacher commands most of the authority, diminishing students' capacity to take charge of their learning (Smith & Brown, 2022).
- Lastly, the inflexibility of the traditional approach, with its strict following of a designated curriculum, offers little opportunity for adaptation to students' needs or the inclusion of relevant current issues, which can lessen the effectiveness of the educational experience (Smith & Brown, 2022).

In conclusion, the conventional method of teaching mathematics, which largely relies on rote memorization and repetitive practice, has long been a cornerstone of educational systems. While this approach can be effective in building foundational skills and preparing students for standardized assessments, it often falls short in fostering a deep understanding of mathematical concepts. Students may struggle to apply their knowledge to real-world problems or develop critical thinking skills.

2.9 Hands on Learning

2.9.1 Introduction

Hands-on learning, often referred to as experiential learning, is an educational approach where students engage directly with the learning material through practical activities. Instead of passively receiving information, learners actively participate in exercises that help them grasp concepts more effectively. Hands on Learning help students to handle scientific instruments for manipulating the objects they are learning with. In other words, hands- on learning offers effective realistic, and exciting learning experiences (Bradberry & De Maio, 2019). Numerous studies demonstrate that engaging in hands-on activities results in beneficial motivational effects in education. The hands-on learning method enhances student motivation. It primarily involves topics that are pertinent to students, particularly those with experiential tasks. Consequently, students have the opportunity to carry out experiments or utilize microscopes, which promote a high level of understanding. Moreover, hands-on experiences such as laboratory experiments increase students' interest in their education compared to teaching methods like viewing videos or solely listening to the instructor (Ma, 2023). Hands-on learning can be described as the psychomotor abilities of the learners. Therefore, psychomotor skills can be defined as learners' aptitude for using sensory information and effective motor coordination while performing hands-on tasks. These psychomotor skills are engaged in the regulation of muscles activated by the brain. When students participate in psychomotor tasks, their brains engage with bodily signals, which aids in fostering positive motivation in learning (Thiri & Guirguis, 2024).

2.9.2 Historical Context

According to Li (2023) the concept of experiential learning was introduced by American philosopher Dewey. This concept gained popularity in the early 1950s, supported by well-known psychologists Piaget and Kurt Lewin. This concept came into practice by establishing the University of Chicago Laboratory School. Brodie (2020) stated that HoL is an approach that relies on student engagement in activities that necessitate the use of materials and objects to manipulate ideas. It is achieved through active participation rather than solely through traditional methods like books and lectures. It guided students to acquire knowledge through experience. This entails providing students the chance to handle the objects they are examining, such as mathematical tools, calculators, rulers, geometric sets, and shapes. It has been suggested as a strategy to enhance students' academic performance and comprehension of scientific principles by interacting with objects that can solidify and clarify abstract concepts (Bradberry & De Maio, 2019).

According to Miriam (2021) through experiential learning, students can integrate theory with practice, serving as a cognitive foundation for learning and future reasoning. Moreover, these activities encourage students to observe, inquire, and discover solutions to their own motivational thoughts. Thus, enhancing the manipulability of knowledge can foster both physical and cognitive effectiveness in learning, making experiential engagement more meaningful. Through manipulative learning experiences, students develop manual skills and technical proficiency, finding fulfillment in their education and preparing these skills for future utility. These activities are intellectually enriching (Li, 2023).

2.9.3 Definitions of Hands on Learning

Hands on Learning is acquired by actively participating in activities rather than studying them through textbooks, lectures, etc. It is an excellent way to teach mathematics as it promotes student engagement in the learning process (Pais, 2012). Numerous definitions of Hands on Learning have been put forth by various scholars. Some of these include:

- Hands on Learning is the technique of handling objects which can make abstract concepts more tangible and comprehensible (Barbazette, 2013).
- Hands on Learning leads to improved retention of information, encourages creativity, is more enjoyable, creates a sense of accomplishment, and fosters critical thinking through the manipulation of objects (Al-abasi, 2013).
- Hands on Learning is a methodology that involves engaging students in learning through practical activities (Brodie, 2020).
- Hands on Learning occurs when a student engages in physical tasks or participates in practical projects to better understand the subject matter, as opposed to merely listening to a lecture (Miriam, 2021).

Hands on Learning may be operationally defined as an educational approach that emphasizes active participation and practical engagement to apply theoretical frameworks in real-life or simulated settings, promoting a deeper grasp and retention of ideas.

2.9.4 Components of Hands on Learning

Hands on Learning entails involving students in active, hands-on, and practical tasks to deepen their comprehension and retention of knowledge. This approach is especially impactful in disciplines such as mathematics, where abstract principles can be made tangible through manipulation, experimentation, and exploration. The following is an overview of the described components and their respective contributors:

2.9.4.1 Active Participation

Active participation is fundamental to Hands on Learning, where students are deeply engaged in tasks that require them to interact with materials, solve problems, and actively contemplate concepts. Unlike passive absorption of information, this method encourages learners to partake directly, enhancing their sense of ownership and motivation. For example, first-grade students may utilize number tiles to physically arrange and solve equations, which boosts their understanding of addition and subtraction. In Hands on Learning, active involvement is vital in fostering meaningful educational experiences, especially in mathematics, where tactile and visual interactions can significantly improve comprehension (Miller and Cutright, 2022).

2.9.4.2 Tangible Manipulatives

Tangible manipulatives, such as blocks, counters, and geometric figures, are practical tools that render abstract mathematical ideas more accessible for young learners. These instruments allow students to visualize and handle numbers, promoting a deeper understanding of relationships and operations. For instance, first graders can utilize Cuisenaire rods to investigate fractions, aiding them in visualizing and comparing parts of a whole. Experiential Learning emphasizes that manipulative-based education not only enhances problem solving abilities but also improves long-term retention of mathematical concepts, making it an essential aspect of early education (Carbonneau et al., 2020).

2.9.4.3 Inquiry and Discovery

Inquiry and discovery are core components of experiential learning, as they motivate students to explore problems, evaluate their ideas, and identify patterns independently. This inquiry-driven approach promotes curiosity and critical thinking, which are crucial for honing problem-solving capabilities. For example, first grade students might uncover multiplication patterns by organizing items into grids, fostering an intuitive understanding of repeated addition (Wei et al., 2021).

2.9.4.4 Cooperative Learning

Experiential learning frequently incorporates collaboration, where students team up to tackle problems, exchange ideas, and learn from each other. This cooperative environment helps cultivate communication and social skills while deepening mathematical comprehension. For example, first-grade students might collaborate in groups to solve puzzles or construct shapes using blocks (Kohn et al., 2023).

2.9.4.5 Problem-Centered Approach

A problem-based approach organizes mathematical tasks around practical scenarios, encouraging students to apply their knowledge in meaningful and relevant ways. This strategy not only captures learners' interest but also helps them recognize the importance of mathematics in daily life. For instance, first-grade students can engage in a mock shopping exercise to practice addition and subtraction, reinforcing their understanding of numerical concepts (Tan & Sim, 2023).

2.9.4.6 Reflection and Evaluation

Reflection and evaluation are crucial for solidifying learning during hands-on activities. Students are encouraged to reflect on their experiences, discuss various strategies, and assess their outcomes. Instructors offer constructive evaluation to help clarify understanding and address misunderstandings. For example, after completing a math puzzle, first-grade students may contemplate the methods they employed and converse about alternative strategies with their classmates (Jung and Lee, 2022).

2.9.4.7 Application to Real-Life Scenarios

Application to Everyday Situations Linking mathematical ideas to real-life situations aids students in grasping the practical uses of their studies, making mathematics more understandable and significant. This aspect highlights the importance of utilizing math to tackle everyday challenges, such as measuring components in a recipe or organizing a budget for a mock shopping excursion (Garcia & Schmidt, 2023).

2.9.4.8 Repetitive Learning Cycle

The repetitive learning cycle includes revisiting concepts through stages, such as engagement, exploration, explanation, and extension, to enhance comprehension over time. This cyclical pattern enables students to polish their abilities and expand on prior knowledge through continuous practice. For example, first-grade learners might revisit a geometry challenge using various resources to discover new solutions (Smith & Taylor, 2023).

2.9.5 Steps of Hands on Learning by Robb (2016)

The steps of Hands-On Learning described by Robb (2016) can differ based on the particular framework or model discussed in the book "Hands-on learning: Connecting theory with practice." However, based on the general principles of hands-on learning, the standard steps involved in this approach encompass the following:

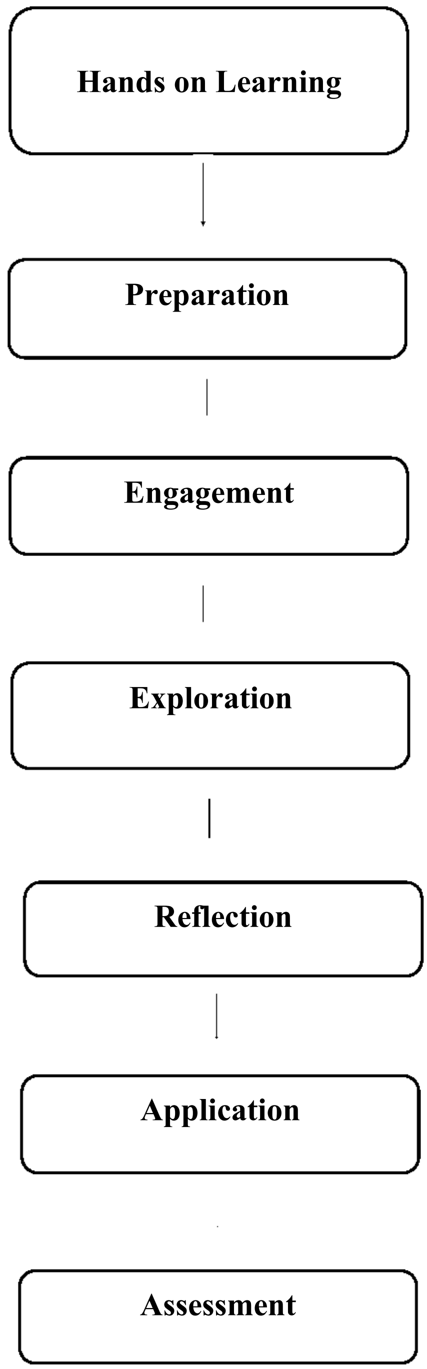

Figure 2.1: Hands on Learning Framework by Robb (2016)

2.9.5.1 Preparation

Preparation entails arranging the environment, establishing learning goals, and coordinating materials and resources. This phase is vital to foster an organized setting that enables students to engage meaningfully with the content. Defined objectives and appropriate resources guarantee a concentrated and effective learning experience. Recent research underscores the significance of well-organized learning environments in boosting student engagement and comprehension. For instance, a study on home laboratories during the COVID-19 pandemic indicated that well-structured hands-on activities positively impacted student motivation and self-belief (Álvarez Ariza, 2022).

2.9.5.2 Engagement

Engagement links students' existing knowledge to new learning through activities or discussions that ignite curiosity. It stresses the importance of capturing students' focus early on and making the content personally relevant to inspire them and establish a purpose for the learning endeavor. As students interact with materials and ideas via hands-on activities, they are more inclined to be motivated and cultivate deeper understandings of the concepts being taught (Robb, 2016).

2.9.5.3 Exploration

Exploration enables students to engage directly with materials and concepts. This hands-on phase promotes experimentation, inquiry, and discovery. It highlights the necessity for learners to actively manipulate materials and ideas, allowing them to construct their own understanding. A 2024 study that integrated hands on experiments with interactive diagrams found that such exploratory activities scaffold primary school students' comprehension of science and technology concepts (Tytler & Prain, 2024).

2.9.5.4 Reflection

Reflection offers students a chance to think critically about their experiences and express their learning. It suggests that structured reflection through discussions or written responses aids learners in connecting the activity to theoretical concepts and internalizing their understanding (Riegle-Crumb et al., 2023).

2.9.5.5 Application

Application centers on extending the learning to real-world contexts or relevant scenarios. It asserts that this stage is essential for reinforcing the importance of the learning and motivating students to apply their knowledge meaningfully. Recent studies highlight that hands-on science education provides numerous advantages for students from all backgrounds, particularly in under-resourced schools, by making learning practical and engaging (National Math and Science Initiative, 2024).

2.9.5.6 Assessment

Assessment involves evaluating the learning process and outcomes to gauge understanding and progress. It advocates for using various assessment strategies, such as observation, discussion, and written tasks, to obtain a comprehensive view of student learning and inform future teaching. A 2024 study on active learning in engineering education discovered that combining hands-on activities with student-created videos offered effective assessment opportunities, enhancing learning and critical thinking (Álvarez Ariza, 2024).

2.9.6 Hands on Learning in Mathematics

Mathematics is a discipline that frequently challenges learners because of its abstract and theoretical aspects. Nevertheless, by incorporating hands-on Learning strategies, teachers can connect theory to practice, rendering these subjects more accessible and interesting for learners (Fuchs & Vaughn, 2019).

Hands-on Learning allows students to visualize mathematical ideas and recognize their real-world relevance. Through construction and building tasks, students can investigate geometric figures, spatial reasoning, and measurement in a practical and concrete way. This tangible experience reinforces their comprehension of mathematical principles and improves their capability to implement these ideas in various situations (Jones & Clark, 2021). Moreover, hands-on education in mathematics offers students chances to enhance their problem-solving abilities. When confronted with a mathematical problem, students are prompted to think critically, examine the issue, and develop innovative solutions. This process not only fortifies their mathematical skills but also fosters their resilience and tenacity (Smith & Green, 2020).

Hands-on Learning in mathematics encourages teamwork among learners. By collaborating on projects and tasks, students learn to communicate effectively, consider differing viewpoints, and contribute their ideas toward a common aim. This cooperative atmosphere nurtures a sense of community and inspires students to value the importance of collaboration. Through construction projects, students can investigate concepts like measurement, proportion, and estimation via hands-on building tasks. For example, when assembling a model bridge, students must accurately measure and cut materials to guarantee the components fit together properly. This necessitates applying measurement skills, grasping proportions, and estimating quantities precisely. By participating in these activities, students attain a deeper insight into mathematical concepts in a practical and significant manner (Lehrer & Schauble, 2019). Construction projects frequently require students to manage budgets and cost estimates. They learn to compute the costs of materials, labor, and other expenditures, acquiring valuable financial literacy skills. This real-world application of mathematics aids students in recognizing the significance of budgeting and making informed choices based on mathematical computations. Apart from measurement and budgeting, building projects present students with the chance to investigate notions like scale, ratio, and spatial reasoning. By handling blueprints and architectural plans, students learn to interpret and manipulate scale models, comprehending the relationship between the tangible world and its representation on paper (Caldwell & Turner, 2022).

Providing students with appropriate tools and materials is crucial for hands-on mathematical learning through construction. Supplying various manipulatives, such as blocks, measuring instruments, and geometric figures, empowers students to explore mathematical concepts more efficiently. When choosing materials, educators ought to select items that are suitable for the age group, safe, and multifunctional. For instance, different varieties of blocks can be utilized to teach measurement, proportions, and geometry. By offering a variety of options, educators can address varying learning styles and provide opportunities for students to tackle mathematical concepts from diverse angles (Chavez & Thompson, 2021).

When evaluating hands-on math learning, educators should extend beyond conventional tests and quizzes. Instead, they can implement a mix of observation, student portfolios, and reflective journals to gauge student progress. By observing students during building activities, educators can gather insights into their problem-solving capacities, critical thinking skills, and grasp of mathematical concepts in real-world scenarios. Furthermore, student portfolios and reflective journals allow students to highlight their educational journey, record their insights and reflections, and express their understanding of mathematical principles (Johnson & Seitz, 2018).

Although hands-on math evaluation provides unique perspectives on student learning, it also brings challenges that educators must confront. One prevalent challenge is the necessity for clear criteria and rubrics to assess student work. By clearly stating expectations and providing students with assessment guidelines, educators can ensure that students comprehend the learning objectives and are aware of how they will be assessed. Additionally, delivering constructive feedback and opportunities for reflection can assist students in their learning and development (Martin & Davis, 2020).

In conclusion, hands-on education is a potent resource for teaching mathematics. By involving students in construction activities, educators can close the gap between abstract ideas and practical uses. Through hands-on learning, students cultivate a deeper understanding, improve their problem-solving capabilities, and develop a passion for mathematics.

2.9.7 Benefits of Hands on Learning in Mathematics

Mathematics can prove to be a daunting subject for many early-stage learners. The intangible essence of numerals and equations can result in dissatisfaction and gaps in comprehension of essential concepts for numerous students. Manipulatives serve as a formidable resource that transforms the manner in which students perceive and engage with math (Fuchs & Vaughn, 2019). In this regard, the benefits of Hands on Learning are as under:

2.9.7.1 Enhanced Understanding

One of the foremost advantages of Hands on Learning in math is that it nurtures a more profound understanding of mathematical principles. By utilizing physical items like counters, construction blocks, or measuring tools, students can visualize, handle, and manipulate these objects to investigate mathematical concepts (Smith & Green, 2020).

2.9.7.2 Increased Engagement

Hands on activities are naturally more captivating than conventional textbook-oriented learning. Students relish employing their creativity and problem-solving abilities to navigate math obstacles, which renders learning more enjoyable and less daunting (McKenna & Hicks, 2016).

2.9.7.3 Multi-Sensory Learning

Each learner possesses a distinctive learning style, and Hands on activities advocate for differentiation in the classroom. Through touch and sight students can experience math through various sensory channels. This multi-modal strategy aids in making math more approachable for diverse learners (Chavez & Thompson, 2021).

2.9.7.4 Practical Application

Hands-on math exercises form a connection to the real world, illustrating the practical uses of mathematical principles. For example, measuring ingredients in a cooking activity to grasp fractions or calculating the area of a garden helps learners recognize the relevance of math in their daily lives. This not only enhances the interest in learning math but also demonstrates its practicality beyond the classroom (Jones & Clark, 2021).

2.9.7.5 Enhanced Retention

Hands on Learning frequently leads to improved preservation of information. When students engage actively in hands-on tasks, they retain concepts more efficiently because they've processed them through firsthand experiences. This retention can have a lasting effect on a student's mathematical knowledge and problem-solving capabilities, bolstering future success in math (Li, 2023).

2.9.7.6 Cooperation and Communication

Hands-on learning promotes teamwork and dialogue among students. Collaborative projects, games, and interactive tasks encourage cooperation and the sharing of ideas. Students not only acquire math skills but also hone vital social emotional and communication abilities that are indispensable in both educational and real-world situations (Lehrer & Schauble, 2019).

2.9.7.7 Reduced Math Anxiety

Math anxiety represents a prevalent issue among elementary students, potentially leading to avoidance of math-related tasks. Hands on Learning can mitigate this anxiety, providing a less intimidating and more accessible approach to engaging with math. As students build confidence through interactive experiences, their apprehension towards math diminishes (Smith & Green, 2020).

2.9.7.8 Facilitates Differentiated Instruction

Hands-on learning enables personalized and differentiated teaching strategies. Educators can readily modify activities to cater to the distinct needs of individual students, offering additional assistance to those in need and further challenges to those who excel. This ensures that every student can advance at their own pace (Chavez & Thompson, 2021).

In conclusion, Hands on Learning is a critical method for teaching Mathematics at foundational levels. By incorporating tangible, engaging experiences into the curriculum, educators can render math more concrete, understandable, captivating, and enjoyable for young learners. The advantages of hands-on learning extend far beyond mathematical skills (Li, 2023).

2.10 Hands on Learning Activities in Mathematics:

There are several activities related to Hands on Learning. Here are Hands on Learning activities related to scientific skills in Mathematics including numerical skills, spatial skills and mathematical reason and thinking skills.

2.10.1 Counting Collections

In this activity, the teacher provides learners with small items such as buttons, beads, or blocks. Instruct them to count the items in sets of 10, then combine the sets to calculate the overall total. This activity aids students in practicing counting by ones and tens, introduces grouping concepts, and reinforces their comprehension of place value (Brown & Green, 2023).

2.10.2 Roll and Add

In this activity, the teacher supplies students with a pair of dice and a recording sheet. They roll the dice, count the dots, and write the corresponding addition equation (e.g., 3 + 5 = 8). For an additional challenge, introduce three dice or incorporate subtraction. This activity assists students in practicing addition, counting, and number composition (Harris & Thomas, 2024).

2.10.3 Matching Number Cards

In this activity, the educator prepares a set of cards with numbers on one set and matching illustrations (e.g., apples or stars) on another. Students pair the numeral to the correct quantity. This straightforward activity helps reinforce number recognition and the connection between numbers and quantities (Fisher & Martinez, 2023).

2.10.4 Build a Tower

In this activity, utilizing blocks or interlocking cubes, the educator challenges the students to construct towers representing different numbers. For instance, they can build a tower of 8 by stacking 8 cubes. This activity enhances counting, comparison, and number sense (Jenkins & Patel, 2023).

2.10.5 Spin and Add/Subtract

The teacher creates a spinner divided into sections with numbers 1–6. Students spin twice, add or subtract the numbers, and document their answer. This activity combines an element of chance with numerical practice, making it engaging while reinforcing basic operations (Walker & Young, 2023).

2.10.6 Sorting Numbers

The teacher provides cards with numbers printed on them. Have students organize the cards in ascending or descending order. You can extend this activity by including odd and even numbers or sorting by tens and ones. This reinforces the order of numbers and categorization abilities of students (Ross & Kim, 2023).

2.10.7 Number Bingo

Play Bingo using numbers instead of traditional Bingo patterns. Call out numbers, and students cover the matching numbers on their cards. For an added challenge, use addition or subtraction problems, and students must solve them to find the number to cover. This activity strengthens number recognition and simple calculation skills of students (Mitchell & Dempsey, 2023).

2.10.8 Building with Blocks

Constructing with blocks is an enjoyable and interactive activity that supports Grade 1 students in developing spatial reasoning. Provide a variety of blocks and ask students to replicate simple structures or create their own designs. This activity allows children to explore concepts such as balance, symmetry, and spatial arrangement. They can also use terms like “above,” “below,” and “next to” to describe their constructions, enhancing their spatial vocabulary (Jones & Evans, 2023).

2.10.9 Tangram Puzzles

Tangram puzzles are an excellent way to engage students in spatial thinking. Provide each child with a tangram set, and guide them to form specific shapes, such as animals or houses, by arranging the pieces. For beginners, templates can be used to assist in matching shapes to a design. As students gain confidence, they can create their own figures. This activity reinforces geometric concepts, encourages creativity, and teaches students how shapes can be flipped, rotated, and combined (Clark & Tannenbaum, 2022).

2.10.10 Paper Folding (Origami)

Origami is a hands-on activity that enhances both spatial and fine motor skills. Start with simple projects, like folding a square piece of paper into a triangle or creating basic shapes like boats and hats. As students fold and transform the paper, they learn about symmetry and how shapes change through manipulation. This activity also improves hand-eye coordination and focus, making it both educational and relaxing for young learners (Harris & Greenfield, 2024).

2.10.11 Create a Shape Collage

Shape collages inspire creativity while teaching spatial relationships and geometry. Provide students with cutouts of various shapes, such as circles, squares, and triangles, in different sizes and colors. Ask them to arrange and glue the shapes onto paper to create scenes, like a house or a rocket. This activity helps students recognize how shapes interconnect and overlap while also introducing concepts like size comparison and Page 1 of 2 layering (Johnson & Lee, 2023).

2.10.12 Puzzle Assembly

Jigsaw puzzles are a classic activity to develop visual-spatial reasoning. Provide puzzles suitable for Grade 1 students, beginning with simpler designs featuring fewer pieces. As they work to complete the puzzles, students practice identifying patterns, matching shapes, and employing problem-solving strategies. Discussing techniques, such as locating edge pieces first, helps foster their logical thinking and collaboration if conducted in pairs or groups (Carter & Kelly, 2023).

2.10.13 Resolving Basic Word Problems

Introducing word problems serves as an effective method to enhance mathematical reasoning among Grade 1 learners. Present scenarios that reflect daily life, such as "If you have 3 apples and you pick up 2 more, how many do you have altogether?" This exercise develops their capability to link math concepts to real situations, boosts critical thinking, and promotes problem-solving abilities (Andrews & Brown, 2023).

2.10.14 Guess the Number Challenge

Engage students in a game where they deduce a concealed number within a specified range (e.g., 1 to 20) based on hints. For instance, "The number is higher than 10 but lower than 15." Students utilize logical reasoning to narrow down the options. This activity hones deductive reasoning, reinforces numerical understanding, and introduces ideas of comparison and sequencing (Newton & West, 2023).

2.10.15 Math Stories with Pictures

Encourage students to invent their own math problems utilizing drawings and brief narratives. For example, they might illustrate 4 ducks in a pond and 2 more arriving, then write, "How many ducks are present now?" This activity fosters creativity, reinforces addition and subtraction principles, and enhances their capacity to reason through challenges (Hanson & Walton, 2024).

2.10.16 Logical Puzzle Games

Provide simple puzzles like arranging three differently sized circles from smallest to largest or determining who possesses what in a "Who has the red hat?" puzzle with clues. These types of logic riddles cultivate reasoning abilities, introduce problem-solving techniques, and teach students to assess various possibilities (Brown & Cooper, 2023).

2.10.17 Find the Mistake

Present learners with a basic incorrect math statement, such as "2 + 2 = 5," and ask them to identify and amend the error. Discuss why the answer is incorrect and how to rectify it. This exercise encourages students to think analytically, assess mathematical statements, and develop meticulousness (Riley & Westbrook, 2024).

In conclusion, Hands-on learning activities in mathematics provide students with an interactive and engaging approach to understanding mathematical concepts. These activities often use physical tools such as blocks, counters, geometric shapes, and measuring instruments, enabling learners to explore abstract ideas through tangible experiences. By manipulating objects and visualizing concepts, students can develop a deeper comprehension of topics like geometry, algebra, and arithmetic. Hands-on methods encourage active participation and collaborative learning, helping students build connections between theoretical knowledge and practical applications. This approach enhances not only understanding but also retention, as learners are more likely to remember concepts they have explored experientially. In addition to physical tools, hands-on activities often incorporate real-world problem-solving scenarios and group projects to make mathematics relevant and relatable. For instance, tasks like designing a structure, analyzing data, or calculating costs in simulated situations allow students to apply mathematical concepts in meaningful ways. These activities also nurture essential skills such as critical thinking, creativity, and teamwork. By making learning more dynamic and student-centered, hands-on methods reduce math anxiety and build confidence, creating a positive attitude toward the subject.

2.11 Scientific Skills

Scientific skills, in the context of Mathematics, refer to a set of competencies that enable individuals to explore, analyze, and solve mathematical problems using systematic methods, logical reasoning, and tools for experimentation and verification. These skills help students develop a deep understanding of mathematical concepts and the ability to apply them to real-world situations.

Different scholars have defined scientific skills in relation to mathematics, focusing on reasoning, problem-solving, experimentation, and the application of mathematical methods.

Here are a few definitions and explanations of scientific skills in mathematics according to different scholars:

- The capacity to effectively convey mathematical concepts and arguments both orally and in writing in scientific way is called scientific skills in mathematics. These abilities include effectively communicating mathematical thinking, providing logical reasons to support findings, and describing solutions in a style that is understandable to others (Oco & Oco, 2023).
- The ability to solve problems using critical thinking and the application of mathematical concepts and procedures is known as scientific skills in mathematics. These abilities include not just carrying out mathematical computations but also interpreting and assessing mathematical issues, formulating plans of action, and considering potential remedies (Cai et al., 2022).
- The ability to investigate and question mathematical ideas in both formal and informal contexts is known as scientific skills in mathematics. Students actively formulate mathematical questions, formulate hypotheses, and test them via experimentation and logical reasoning as part of their inquiry-based learning method (Larkin & Karp, 2023).

Scientific skills may be operationally defined as the proficiencies that empower individuals to investigate, question mathematical principles and utilize mathematical ideas, logical reasoning, problem-solving strategies, and analytical thinking in both theoretical scenarios and practical applications. These abilities encompass the capacity to analyze, model, evaluate theories, and convey mathematical concepts efficiently.

2.12 Scientific Skills in Mathematics

There are several scientific skills in Mathematics according to different scholars. Some of them are as under:

2.12.1 Number Sense

Number sense is an essential ability in mathematics for novice learners, encompassing the capacity to comprehend the size and interplay of numbers. It aids students in identifying numbers, their characteristics, and their interrelations. An early grasp of numerical relationships lays the groundwork for subsequent arithmetic and mathematical tasks (Siegler et al., 2023).

2.12.2 Problem Solving Skills

Scientific problem-solving skills entail students applying mathematical reasoning to tackle genuine issues. This process involves recognizing the challenge, strategizing a solution, and reflecting on the approach to confirm the outcome. At this stage, problem-solving activities are generally linked to simple addition and subtraction scenarios (Charlesworth & Lind, 2023).

2.12.3 Metacognitive Skills

Metacognition in mathematics signifies the awareness and management of one's cognitive processes during mathematical problem resolution. This encompasses planning a strategy to tackle a problem, overseeing progress, and modifying tactics when needed. Metacognitive abilities assist students in not just arriving at answers but also comprehending the methods employed, fostering more profound learning (Adinda et al., 2023).

2.12.4 Mathematical Abstraction

Mathematical abstraction indicates the skill to generalize particular mathematical instances into broader principles and to apply these abstracted ideas in various environments. Scientific abilities in mathematics transcend merely solving specific problems; they also involve discerning patterns and developing generalizations applicable across diverse mathematical contexts (Stewart et al., 2022).

2.12.5 Basic Operations

Basic Operations is an important skill in mathematics for young learners that enhances proficiency in addition and subtraction within 20. They come to grasp techniques such as making ten, using doubles facts, and decomposing numbers to resolve problems effectively (Van de Walle et al., 2023).

2.12.6 Place Value Understanding

Understanding place value enables students to grasp the notions of tens and ones, which underpins arithmetic operations. Instruction often incorporates interactive activities with base-ten blocks and number lines (Fuson, 2023).

2.12.7 Spatial Awareness

Spatial awareness involves the ability to recognize shapes, understand their characteristics, and learn how to manipulate them. First graders delve into basic geometry concepts, such as recognizing and constructing two dimensional shapes, which bolsters spatial reasoning development (Clements & Sarama, 2023).

2.12.8 Measurement

Measurement skills encompass comparing lengths, comprehending units of measurement, and utilizing tools like rulers. Learners become adept at measuring objects by iterating length units and contrasting measurements (Smith & Tylor, 2023).

2.12.9 Pattern Recognition

Pattern recognition is an essential competency in mathematics for young learners that enables students to identify, extend, and create patterns using numbers, shapes, and objects. This skill lays the groundwork for algebraic reasoning. For instance, first graders recognize repeating patterns (ABAB, AABB) and increasing patterns (2, 4, 6, 8) (Mulligan & Mitchelmore, 2023).

2.12.10 Comparison and Classification

Comparison and classification are vital skills in mathematics for young learners that involve sorting items into categories based on attributes like size, color, or shape, and contrasting numbers using terms such as greater than, less than, or equal to (Ginsburg et al., 2023).

2.12.11 Data Interpretation

Data interpretation is an emerging skill in mathematics for young students where they start to gather, organize, and analyze simple data. They create and interpret bar graphs, pictorial graphs, and tally charts, establishing the foundation for future statistical reasoning (Siegler et al., 2023).

2.12.12 Critical Thinking

Critical thinking represents a fundamental mathematical skill for young learners, involving the analysis and assessment of information to make sound judgments. This skill is crucial for problem-solving and evaluating the validity of proofs in mathematics (Facione, 2023).

2.12.13 Numerical Skills

Numerical skills serve as the cornerstone of mathematical education for young learners, focusing on the understanding and manipulation of numbers (Fisher et al., 2023).

2.12.14 Spatial Skills

Spatial skills are essential mathematical capacities for young learners, which include visualizing and manipulating objects in space, crucial for grasping geometric concepts and for problem-solving (Lozano et al., 2023).

2.12.15 Mathematical Reasoning

Mathematical reasoning encompasses logical deduction, problem-solving abilities, and the skill to apply mathematical principles to practical situations for young learners (Lee & Ginsburg, 2024).

2.13 Numerical Skills

Numerical skills are scientific skills in Mathematics. These skills are foundational for developing mathematical proficiency and are often considered crucial for students' success in both academic and real-world problem-solving contexts. These skills involve number sense, counting skills and basic arithmetic skills (Parviainen, 2019).

2.13.1 Sub Skills of Numerical Skills

2.13.1.1Number Sense

Number Sense Number sense encompasses the skill to grasp numbers, their interactions, and how they can be manipulated for problem-solving in daily life. It stresses that number sense involves more than just recognizing what numbers signify; it also includes comprehending how numbers react when combined or adjusted. This concept involves identifying numbers along with their relationships, appreciating the magnitude of numbers, and applying these ideas in varied mathematical situations. Cultivating number sense is vital for students' success in mathematics, as it lays the groundwork for more sophisticated mathematical reasoning, problem solving, and algebraic thinking (Van de Walle et al., 2021).

2.13.1.2 Counting Skills

Counting skills refer to the capacity to track objects sequentially, grasp the cardinality of a collection, and acknowledge the one-to-one correspondence between numbers and items. These are crucial for mathematical growth, especially in early education. Such skills involve the capability to count items, appreciate the order of numbers, and utilize counting in diverse contexts. Counting skills serve as the fundamental elements for subsequent mathematical ideas like addition, subtraction, and complex problem solving (Gelman, R., & Gallistel, 2022).

2.13.1.3 Basic Arithmetic Skills

Basic arithmetic skills comprise the competence to carry out the four basic operations: addition, subtraction, multiplication, and division accurately and effectively. These skills form the cornerstone for more intricate mathematical reasoning and problem-solving (Van de Walle et al., 2021).

2.13.2 Development of Numerical Skills

The development of numerical skills is a vital component of early childhood education and cognitive advancement. These abilities denote the capacity to recognize, understand, and manipulate numbers, as well as apply them to tackle problems and make choices. The cultivation of numerical skills generally begins in early childhood and expands through the school years. It serves as the foundation for grasping more complicated mathematical concepts in the future. Here's a comprehensive detail of the development of numerical skills:

2.13.2.1 Early Number Recognition

At the initial phase, children begin to develop an appreciation for numbers as symbols that signify quantities. The main emphasis is on number recognition, wherein children start to identify and articulate numbers. Engaging in activities such as counting objects, singing number songs, and reading books focused on numbers aids children in forming links between numerals (like "3" or "5") and their corresponding quantities (Gelman & Gallistel, 2023).

2.13.2.2 Counting and Cardinality

Following the attainment of number recognition, children start to cultivate cardinality, which is the awareness that the last number in a counting sequence denotes the total amount of items. This is the moment when children truly comprehend that numbers represent quantities, rather than mere labels (Bower & Bower, 2023).

2.13.2.3 Understanding Number Patterns

At this stage, children begin to grasp more abstract mathematical notions. They start identifying number patterns such as counting by twos or fives and can recognize simple relationships between numbers (e.g., even versus odd numbers). This is critical for nurturing fluency in addition and subtraction (Fuson, 2023).

2.13.2.4 Developing Mental Math

As children advance in their education, they begin to cultivate mental math abilities, enabling them to carry out straightforward arithmetic operations (like addition and subtraction) without relying on physical items or visual aids. At this point, students comprehend the principles of place value, the commutative property of addition, and can utilize these concepts to tackle fundamental arithmetic problems with greater efficiency (Jordan & Levine, 2022).

2.13.2.5 Applying Numerical Skills to Word Problems

Children start utilizing their numerical skills for more intricate word problems and real-life scenarios. This involves grasping how numbers can be implemented in various contexts and employing mathematical reasoning to resolve practical issues (Siegler et al., 2023).

2.13.2.6 Building Numerical Skills for Advanced Concepts

Students continue to refine their numerical abilities, applying them to advanced mathematical principles, such as multiplication, division, fractions, and decimals. At this juncture, the advancement of numerical fluency; the capability to perform calculations swiftly and accurately is highlighted. Students also begin to perceive the connections between numbers and abstract mathematical principles, establishing the foundation for algebra (Geary & Hoard, 2023).

2.14 Spatial Skills

2.14.1 Introduction

Spatial skills encompass various cognitive abilities that allow an individual to visualize, manipulate, and understand objects in space. These skills are essential for tasks that require the understanding of shapes, sizes, distances, and orientations, and they are strongly linked to mathematical reasoning, particularly in areas such as geometry, measurement, and problem-solving. These skills involve spatial sense, geometrical awareness and sense of time (Parviainen, 2019).

2.14.2 Subskills of Spatial Skills

2.14.2.1 Spatial Sense

Spatial Sense is the capacity to perceive, comprehend, and reason about the spatial relationships between objects and their surroundings. It encompasses various cognitive skills, including spatial orientation, mental rotation, and visualization, forming the bedrock for grasping and solving geometric challenges, as well as employing mathematical principles in real-life applications (Clements & Sarama, 2023).

2.14.2.2 Geometrical Awareness

Geometrical awareness involves the ability to identify, grasp, and reason about the attributes, relationships, and transformations of shapes and figures in the environment. It requires recognizing geometric shapes, comprehending spatial relationships, visualizing geometric figures, and applying geometric principles to tackle problems. Geometric understanding is a core element of mathematics education and significantly contributes to the enhancement of spatial reasoning and problem-solving capabilities (Clements & Sarama, 2023).

2.14.2.3 Sense of Time

Sense of time encompasses the ability to perceive, understand, and mentally organize the flow of time, incorporating concepts like duration, sequence, and timing. It is critical for grasping time-related principles in mathematics, such as time measurement, estimation, and sequencing events. The perception of time can affect a student's problem-solving skills, task management, and their relationship with temporal concepts in everyday scenarios (Nicolson & Fawcett, 2023).

2.14.3 Development of Spatial Skills

Development of spatial skills signifies the process through which individuals acquire the skills to comprehend and manipulate objects and shapes in a spatial context. These abilities are vital across numerous domains, including mathematics, science, engineering, and everyday tasks. Spatial abilities consist of the capacity to visualize and mentally rotate objects, understand spatial relationships, and interpret diagrams or maps (Shing & Starns, 2022). Here is a summary of the enhancement of spatial skills:

2.14.3.1 Cultivating Cognitive Skills

Spatial abilities denote the cognitive competencies that empower individuals to perceive and manipulate objects in their thoughts. These competencies encompass mental rotation, spatial visualization, and the capacity to grasp relationships among objects in space (Shing & Starns, 2022).

2.14.3.2 Recognizing Spatial Relationships

Spatial abilities begin their development in early childhood, frequently through exploration and interaction with objects. Children cultivate an understanding of spatial relationships as they engage with their environment. Activities like constructing with blocks, categorizing shapes, and manipulating puzzles assist children in grasping spatial concepts such as size, shape, direction, and distance (Noor & Yusuf, 2022).

2.14.3.3 Grasping and Tackling Mathematical Challenges

Spatial skills are fundamental for grasping and addressing mathematical challenges, especially in geometry, measurement, and algebra. Students with strong spatial reasoning skills are better positioned to visualize geometric forms, tackle problems involving spatial transformations (like rotations and reflections), and comprehend abstract mathematical concepts. These abilities are particularly crucial in learning and applying ideas such as symmetry, area, volume, and scale (Noor & Yusuf, 2022).

2.14.3.4 Practice and Focused Training

Spatial skills can be enhanced through practice and focused training. Activities such as working with 3D puzzles, using construction blocks, sketching shapes, and participating in spatial games are effective ways to improve spatial reasoning. Educational programs that integrate these activities can markedly boost students' spatial capabilities and aid their achievements in mathematics and STEM fields (Lee & Lim, 2020).

2.15 Mathematical Reasoning and Thinking Skills

2.15.1 Introduction

Mathematical Reasoning and Thinking Skills are critical components of mathematical understanding that enable individuals to approach, solve, and interpret mathematical problems. These skills involve logical thinking, problem-solving, pattern recognition, and the ability to apply mathematical concepts in varied contexts. Mathematical reasoning and thinking encompass both deductive and inductive reasoning, where one uses known facts, logic, and strategies to arrive at conclusions or generalizations.

2.15.2 Development of Mathematical Reasoning and Thinking Skills

According to Parviainen (2019) the development of Mathematical Reasoning and Thinking Skills entails the progressive acquisition and honing of competencies that empower individuals to tackle, assess, and resolve mathematical challenges. This journey starts in early childhood and persists throughout formal education, incorporating the enhancement of both logical reasoning and problem-solving techniques.

2.15.2.1 Initial Stages of Mathematical Reasoning

In early childhood, the genesis of mathematical reasoning initiates with the establishment of fundamental principles like number sense, patterns, and basic operations. Children first cultivate reasoning through tactile activities that promote exploration of numbers and shapes (Baroody, 2022).

2.15.2.2 Importance of Pattern Recognition in Mathematical Reasoning

The ability to recognize patterns is a fundamental skill that supports mathematical reasoning. Children initially recognize simple patterns. Identifying patterns allows students to formulate generalizations, a vital dimension of reasoning, laying the groundwork for more advanced mathematical cognition (Siegler & Alibali, 2023).

2.15.2.3 Progression of Problem-Solving Skills

Problem-solving is pivotal to mathematical reasoning. As children develop, they transition from addressing straightforward arithmetic problems to tackling more complicated assignments that involve multi-step operations, abstract reasoning, and conceptual comprehension. They acquire the ability to implement strategies such as trial and error, logical inference, and the use of visual tools (like diagrams or graphs) to facilitate problem resolution. Problem-solving also encompasses the capacity to contemplate and validate their solutions (Polya, 2021).

2.15.2.4 Contribution of Deductive and Inductive Reasoning in Mathematical Thinking

As children advance through their education, their reasoning skills mature from concrete thought to more abstract reasoning. Deductive reasoning empowers students to apply universal principles to specific circumstances, while inductive reasoning allows them to draw generalizations from particular observations or examples. (Hershkowitz & Schwarz, 2022).

2.15.2.5 Development of Abstract Thought in Mathematics

Students grow, their reasoning transitions from concrete problem-solving to more abstract types of mathematical thought. At this juncture, students begin to interact with symbolic representations of numbers, geometric shapes, and algebraic expressions. Abstract thought is vital for comprehending algebra, calculus, and other sophisticated areas of mathematics requiring manipulation of symbols and concepts disconnected from physical objects (Siegler & Alibali, 2023).

2.16 International / National Reports on Mathematics Achievement in Pakistan

Pakistan has participated in several international assessments that provide valuable insights into the state of mathematics achievement in the country. The most notable of these assessments include the Trends in International Mathematics and Science Study (TIMSS), The World Bank's Learning Poverty Report and National Achievement Tests (NAT). Here's a summary of Pakistan's performance based on available data from these reports:

2.16.1 Trends in International Mathematics and Science Study (TIMSS)

TIMSS stands as one of the most extensive and all-encompassing global assessments, concentrating on student accomplishments in mathematics and science. Pakistan took part in TIMSS 2015 and 2019 (Mullis & Martin, 2020).

TIMSS 2015: In TIMSS 2015, Pakistan's results were below the international average. In mathematics, Pakistani pupils achieved a score of 421 points, markedly lower than the global average of roughly 500 points. Pakistan was positioned second last among the 39 participating countries at the Grade 4 tier. Similarly, at the Grade 8 level, the results were dismal (Mullis et al., 2016).

TIMSS 2019: In 2019, Pakistan's performance showed no substantial enhancement. The nation ranked toward the bottom among participating countries in both mathematics and science. For Grade 4, Pakistan’s average mathematics score was 434, and for Grade 8, it was 415. This denotes that, although there were minor improvements in scores, performance remains inadequate compared to other nations (Mullis & Martin, 2020).

2.16.2 World Bank's Learning Poverty Report

The World Bank's Learning Poverty report serves as a crucial source of information regarding global education quality, including that of Pakistan. This report focuses on the proportion of children unable to read and comprehend a simple text by age 10, while also providing insights on the broader educational framework, including mathematics. According to the World Bank's report (2021), learning outcomes in Pakistan are generally low, with a considerable percentage of students failing to reach minimum proficiency standards in fundamental subjects such as mathematics and reading. This indicates systemic issues in educational quality throughout the nation, particularly in mathematics.

2.16.3 National Achievement Tests (NAT) and Other Local Assessments

Besides international assessments, Pakistan has executed national achievement evaluations, including the National Assessment of Student Achievement (NASA). These assessments regularly reveal that students in Pakistan, especially in rural regions, encounter substantial difficulties in mathematics education, characterized by low proficiency rates (Ministry of Federal Education and Professional Training, 2020). Key Findings and Insights are as under:

2.16.3.1 Low Achievement Levels

In both TIMSS and local assessments, Pakistani students consistently score beneath the international average in mathematics, with notably poor outcomes at the Grade 8 level (Mullis & Martin, 2020).

2.16.3.2 Lack of Improvements

Despite attempts to enhance the education system, there has been marginal progress in elevating achievement levels in mathematics. The findings from TIMSS indicate that educational reforms and investments in teaching quality are imperative (Mullis et al., 2016).

2.16.3.3 Geographic Disparities

A significant divide exists in education quality between urban and rural locales, with rural students, particularly in underdeveloped provinces, facing heightened challenges in attaining even basic mathematical proficiency (UNESCO, 2021).

2.16.3.4 Quality of Teaching

A major issue identified in both TIMSS and local evaluations is the scarcity of qualified instructors, insufficient teaching resources, and ineffective pedagogical strategies in mathematics (World Bank, 2021).

International reports, especially those from TIMSS, underscore critical challenges in mathematics achievement for students in Pakistan. Although there have been slight advancements, Pakistan still trails behind numerous countries concerning student performance in mathematics. These results stress the need for thorough educational reforms, improved teacher training, and increased investment in the education system to boost students' mathematical capabilities. Pakistan would benefit from engaging in international assessments like PISA, which would yield further data to guide educational policy and practices (OECD, 2023).

2. 17 Reasons for Failure in Mathematics Achievement

There are several reasons of failure of students in Mathematics. Some important are as under:

2.17.1 Ineffective Teaching Methods

One of the primary reasons for low mathematics achievement in Pakistan is the lack of effective teaching methodologies. Traditional rote learning and memorization-based teaching dominate most classrooms. This technique fails to nurture critical analysis, problem-solving abilities, or conceptual insight. Global evaluations like TIMSS have highlighted that students in Pakistan are frequently instructed to retain formulas and methods without fully grasping the foundational principles. This results in fragile mathematical reasoning skills, crucial for tackling more intricate problems (Mullis & Martin, 2020).

2.17.2 Shortage of Qualified Teachers

The standard of education poses a considerable challenge in Pakistan's schooling system. Numerous instructors, especially in rural and isolated regions, lack proper qualifications or specialized knowledge required to effectively instruct mathematics. International analyses, such as those conducted by the World Bank, have noted that many teachers do not possess sufficient training in teaching methods or subject matter. In certain instances, educators are assigned to teach subjects outside their expertise, further diminishing the quality of mathematics instruction (World Bank, 2021).

2.17.3 Insufficient Resources and Infrastructure

Schools in Pakistan, particularly in rural locales, frequently struggle with poor infrastructure and limited resources. International evaluations like TIMSS have brought attention to the dire resource shortages within classrooms, including a lack of textbooks, educational materials, and access to technology. Such resource deficiencies hinder the application of interactive and engaging teaching styles that could aid students in understanding complex mathematical ideas (UNESCO, 2021).

2.17.4 Socio-economic Obstacles

Socio-economic conditions significantly influence students' poor performance in mathematics. A considerable number of students, particularly those from underprivileged backgrounds, encounter difficulties such as inadequate nutrition, absence of educational resources, and insufficient support at home for learning. Reports from the World Bank highlight that children from low-income households tend to achieve lower educational results, which is aggravated by their limited access to quality education and additional learning opportunities (World Bank, 2021).

2.17.5 Low Student Motivation and Engagement

Student motivation and engagement are essential elements affecting academic achievement in mathematics. According to global reports, Pakistani students often exhibit low motivation levels to learn mathematics, possibly due to a lack of real-world relevance to the subject. Many regards mathematics as abstract and irrelevant to their everyday experiences, leading to disinterest. Furthermore, the stress associated with high stakes assessments that primarily emphasize rote memorization can undermine critical thinking and problem solving, which are fundamental for mastering mathematics (Mullis et al., 2016).

2.17.6 Gender Inequalities

Gender disparities in education are another vital aspect that hinders performance in mathematics, especially in rural regions. International reports, including those from UNESCO, indicate that girls in Pakistan frequently encounter more significant educational barriers than boys, particularly in conservative areas. These challenges include early marriage, limited school access, and societal standards that prioritize male education. Consequently, many girls miss out on adequate mathematical education, affecting their overall performance and subsequent opportunities in the field (UNESCO, 2021).

2.17.7 Curriculum Challenges

The mathematics curriculum in Pakistan is often criticized for being outdated and excessively geared towards memorization rather than promoting critical thinking and problem-solving abilities. International evaluations like TIMSS have found that the curriculum does not effectively foster a deep understanding of mathematics or the application of mathematical concepts to real-life situations. As a result, students develop a superficial understanding of mathematics, impacting their performance in evaluations that require practical application and reasoning (Mullis & Martin, 2020).

2.17.8 Insufficient Early Support and Intervention

Early intervention is crucial for addressing learning challenges in mathematics, but Pakistan's educational framework frequently lacks the resources and structures to deliver targeted assistance to struggling learners. International reports indicate that students who lag behind in the early grades do not receive the necessary help to catch up, leading to cumulative learning deficiencies. This lack of support persists throughout their educational journey, particularly in mathematics, where foundational knowledge is essential for future achievement (World Bank, 2021).

2.17.9 Overcrowded Classrooms

Overcrowded classrooms represent another critical issue within Pakistan's education framework. Reports from the World Bank and various educational studies indicate that large class sizes impede teachers' ability to offer personalized attention to students. In congested classrooms, educators struggle to identify and cater to individual student needs, resulting in disengagement and subpar academic performance, especially in subjects like mathematics that necessitate tailored support (World Bank, 2021).

2.17.10 Insufficient Focus on Critical Thinking

The education system in Pakistan often prioritizes memorization and rote learning over critical thinking and problem-solving skills. International reports, such as those from TIMSS, emphasize the importance of fostering mathematical reasoning skills. However, in Pakistan, the focus is predominantly on passing exams, which discourages students from developing the logical and analytical thinking required to solve real-life mathematical problems. This limits their ability to apply mathematical concepts to new and unfamiliar situations (Mullis et al., 2016).

In conclusion, the failure of students in Mathematics in Pakistan is a complex issue influenced by multiple factors, including ineffective teaching methods, lack of qualified teachers, limited resources, socio-economic barriers, and systemic curriculum issues. International reports, particularly from TIMSS and the World Bank, highlight the need for substantial reforms in the education system to address these challenges. To improve mathematics achievement, Pakistan must focus on teacher training, updating the curriculum to emphasize problem-solving, and addressing socio-economic disparities in education access. Additionally, increasing student engagement and motivation through real-world applications of mathematics and early intervention programs could significantly improve outcomes.

2.18 Researches related to Hands on Learning in Mathematics

Some notable research studies related to Hands-on Learning in Mathematics, which emphasize the benefits of using interactive, tactile, and experiential methods to enhance students' understanding of mathematical concepts areas under. These studies cover various educational settings and highlight the impact of hands-on learning activities on mathematical achievement and student engagement.

2.18.1 Effectiveness of Manipulatives in Mathematics Learning by Karp and Bunker (2015)

The study "The Influence of Manipulatives on Achievement in Mathematics" by Karp and Bunker (2015) investigates the effects of employing physical manipulatives, like blocks, cubes, and geometric shapes, on students' comprehension of mathematical principles. The study concluded that the integration of manipulatives within a hands-on learning approach significantly enhances student performance in mathematics, particularly for those who experience difficulties with abstract reasoning.

2.18.2 Constructivist Approach and Hands-On Learning in Mathematics by Menon and Sharma (2016)

The study "Effects of Hands-On Learning in Mathematics" by Menon and Sharma (2016) employs a constructivist perspective to hands-on learning within mathematics classrooms. The study revealed that when students participated in hands-on activities such as exploring geometric shapes, utilizing interactive tools, and creating real-world models of mathematical concepts, they could establish links between theoretical knowledge and practical application. It was concluded that hands-on learning aligns effectively with constructivist principles and promotes a deeper grasp and retention of mathematical concepts.

2.18.3 Impact of Hands-On Learning on Early Mathematics Education by Walker and Ross (2017)

The study "Hands-On Learning and Its Influence on Early Mathematics Achievement" by Walker and Ross (2017) focused on the impact of hands-on learning activities on early elementary school learners, particularly in mathematics. The study implemented activities like shape construction, using physical counters for addition and subtraction, and engaging in group-based math games. It found that students who took part in hands-on activities exhibited improved math fluency, higher engagement levels, and better retention of fundamental mathematical skills. The study concluded that early exposure to hands-on learning activities is essential for developing foundational mathematical abilities and nurturing a positive attitude toward mathematics.

2.18.4 Hands-On Learning and Student Engagement in Mathematics by Cunningham and Horton (2018)

The study "Hands-On Learning in Mathematics and Its Influence on Student Engagement" by Cunningham and Horton (2018) explored the connection between hands-on learning activities and student involvement in mathematics classrooms. It discovered that hands-on learning elevated student participation, motivation, and interest in the subject. Activities such as interactive math games, utilizing real-world objects for problem-solving, and cooperative group work were especially effective in sustaining high engagement and enthusiasm for learning. It was concluded that integrating hands-on learning strategies can significantly enhance student engagement, particularly in subjects like mathematics, where abstract concepts can pose challenges.

2.18.5 Collaborative Hands-On Learning and Mathematical Discourse by Smith and Johnson (2019)

The study "Collaborative Hands-On Learning and Its Effect on Mathematical Discourse" by Smith and Johnson (2019) investigated the impacts of collaborative hands-on learning activities on mathematical discourse among students. It found that when students collaborated on hands-on tasks, they could articulate their reasoning, negotiate ideas, and learn from their peers. The collaborative aspect of hands-on learning facilitated students' expression of their mathematical thinking, making it easier to confront misconceptions and deepen their understanding. It was concluded that collaborative hands-on learning encourages mathematical discourse, which is vital for developing problem-solving skills and conceptual insight.

2.18.6 Using Technology for Hands-On Learning in Mathematics by Lee and Lim (2020)

The study "The Role of Technology in Hands-On Mathematics Education" by Lee and Lim (2020) explored the application of digital tools and virtual manipulatives in the mathematics classroom. The study emphasized how technology can enhance hands-on learning by providing interactive simulations of mathematical concepts, such as geometry or algebra. Students could manipulate virtual objects, explore patterns, and visualize complex problems in a more engaging and accessible manner. The study indicated that technology-based hands-on learning not only improved students' understanding of mathematics but also made learning more enjoyable. It was concluded that technology, when utilized effectively, can enhance hands-on learning experiences and facilitate a deeper understanding of mathematical concepts.

2.18.7 Realist Hands-On Learning Approach in Solid Geometry by Noor and Yusuf (2022)

The study "Realist Hands-On Learning Approach in Solid Geometry: Conceptual Understanding and Problem-Solving Skills" by Noor and Yusuf (2022) examined the application of a realist hands-on learning Page 1 of 2 approach and its contributions to optimizing students' conceptual understanding and problem-solving abilities in solid geometry. The findings suggest that hands-on activities can improve learners' comprehension and skills in this domain.

2.18.8 Assessing the Effectiveness of Hands-On Games for Understanding Probability Concepts by James and Sanders (2023)

The study "Assessing the Effectiveness of Hands-On Games for Understanding Probability Concepts in Mathematics Education" by James and Sanders (2023) explored how pre-service mathematics teachers utilize teaching and learning materials (TLMs) in lessons, underscoring the importance of effectively employing TLMs to create an engaging mathematics learning atmosphere. The study found that hands-on games can enhance understanding of probability concepts in mathematics education.

2.18.9 Improving Middle School Students' Geometry Problem-Solving Ability through Hands-On Experience by Liu and Zhang (2023)

The study “Improving middle school students' geometry problem-solving ability through hands-on experience” by Liu and Zhang (2023) used a learning-test paradigm and Functional Near-Infrared Spectroscopy (FNIRS) to compare differences in geometry reasoning involved in solving well-structured and ill-structured problems. Behavioral results showed that hands-on experience promoted students' performances in geometry problem-solving, with students of lower academic levels benefiting more from hands-on experience.

2.19 Summary of Chapter 2

Mathematics is a discipline that fosters critical thinking, logical reasoning, and problem-solving skills. It is distinguished by its accuracy, universality, and capacity to address issues in the actual world. The study of mathematics helps students to acquire critical abilities that are necessary for both scientific research and technological development, such as numerical proficiency, spatial awareness, and mathematical reasoning. Pakistan's 2006 mathematics curriculum placed a strong emphasis on thinking, problem-solving, and applying mathematical ideas in practical contexts. However, there were issues with its execution, including a lack of resources and inadequate training for teachers. By incorporating contemporary pedagogical practices, including as technology and hands-on learning, to improve students' comprehension of mathematics and standardizing content across provinces, the Single National Curriculum (SNC) 2020 sought to close these disparities. Effective teaching of mathematics plays a crucial role in enhancing student participation and comprehension. Traditional teaching techniques, which rely on memorization and repetitive tasks, often do not promote a profound grasp of the subject. Conversely, Hands on Learning incorporates interactive experiences, hands-on tools, and real-life applications to bridge abstract ideas with real-world relevance. Studies highlight the benefits of HoL in boosting students' involvement, conceptual clarity, and memory retention. HoL in mathematics particularly fosters the cultivation of scientific abilities, including quantitative skills, spatial awareness, and mathematical reasoning. By actively involving students in activities such as constructing models, examining patterns, and addressing real-world challenges, experiential methods enhance critical analysis and problem-solving skills. International reports, such as TIMSS and World Bank evaluations, consistently show low achievement levels in mathematics among Pakistani students. Major factors include ineffective instructional techniques, insufficient teacher preparation, lack of resources, and socio-economic obstacles. Numerous studies affirm the beneficial effects of Hands on Learning on scientific abilities. Researches show that Hands on Learning improved students' quantitative skills, spatial awareness, and capacity to apply mathematical principles in various contexts. This highlights the necessity for incorporating HoL in education to promote a deeper comprehension of mathematics and address the disparities in learning outcomes.

CHAPTER 3

RESEARCH METHODOLOGY

The main purpose of the study was to measure the effect of Hands on Learning on the development of scientific skills in Mathematics including numerical skills, spatial skills and mathematical thinking in first graders. The study was experimental in nature. In this study, two types of instructional methods (Hands on Learning and Conventional Method) were used. The methodology and procedure of the present study is described under the following headings:

- Research design
- Population and sample of the study
- Procedure of the study
- Research instruments
- Variables of the study
- Control on internal threats
- Control on external threats
- Data collection
- Data analysis
- Ethical consideration

3.1 Research Design

Research design refers to the overall strategy and plan for conducting research, including the methods and techniques used to collect and analyze data (Creswell, 2022; Kumar, 2022; Saunders & Lewis, 2022). It refers to the overall strategy and plan for conducting research, including the methods and techniques used to collect and analyze data. It involves several key elements, such as research approach (qualitative, quantitative, or mixed methods), data collection methods (surveys, interviews, experiments, etc.), sampling strategy (probability or non-probability sampling) and data analysis techniques (statistical analysis, thematic analysis, etc.) (Williamson, 2023).

In the present study, True Experimental Research Design: the pretest-posttest equivalent group was used. It is the most rigorous research design which allowed researchers to establish cause-and-effect relationships between variables. It involves a control group, an experimental group, and random assignment of participants to groups, enabling researchers to draw causal inferences (Cresswell, 2022).

In pure sciences like Physics, Chemistry and Mathematics, this design is more efficient as compared to other experimental designs, because it manages to exclude extraneous variables, and other irrelevant sources of variation. It is considered a robust approach in mathematics education research, allowing researchers to establish cause-and-effect relationships between variables (Kilpatrick et al., 2022).

In mathematics studies, true experimental designs can help investigate the effectiveness of different teaching methods, interventions, or materials (Moore et al., 2023). The present study was conducted by using one experimental group and one control group. The sample of 72 students was divided into two groups by giving them the names A and B. These both groups were formed through randomization. Group A was experimental group whereas Group B was control group. Group was taught by Hands on Learning and Group B was taught by Conventional Method and its duration was eight weeks.

In the present study, the following research design was used.

Experimental	R	O1	X	O2
Control	R	O3	C	04

Where,

R stands for Randomization, X stands for Treatment, C stands for Control Group, O_1 stands for Pre-test of experimental group, O_2 stands for Post-test of experimental group, O3 stands for Pre-test of control group and O_4 stands for Post-test of control group.

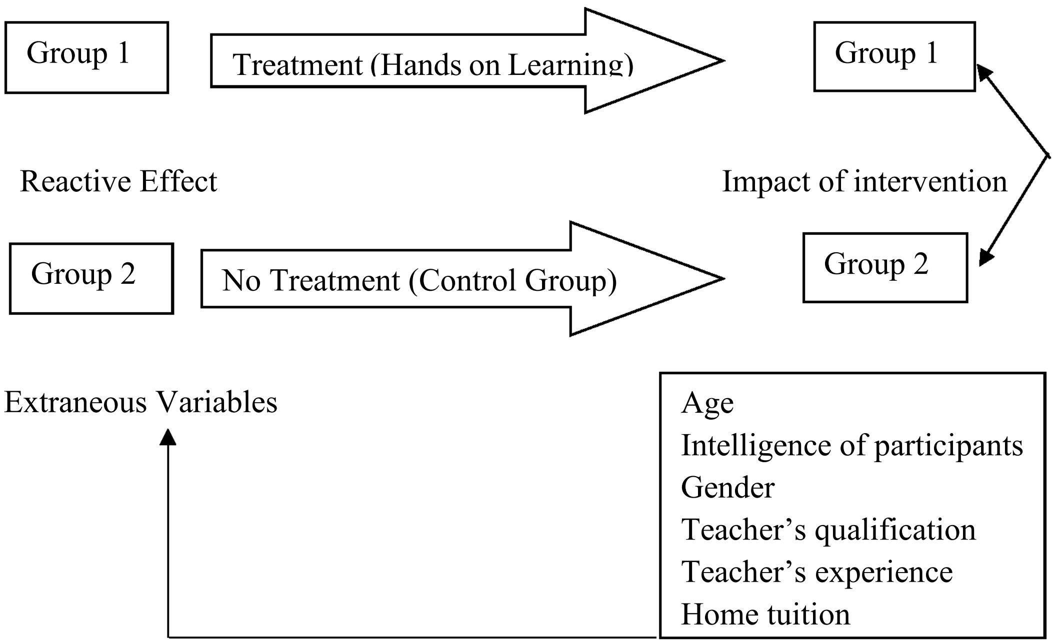

Figure-3.1: Conceptual Framework of the Research Design

3.2 Population and Sample of the Study

The large group of individuals, organizations, or cases that a researcher wants to understand, and from which a sample may be drawn is called population (Frankfort-Nachmias & Nachmias, 2022). A subset of individuals or cases selected from a larger population, used to represent the population in a research study is called sample (Cresswell, 2023). In the present study, the target population of the study was first grader students of district Kotli who were studying Mathematics. Government Boys High School Hatli Kotli was selected randomly as a sample. From this school, 72 Mathematics Students of first graders were chosen which were divided into two groups such as Group- A (Experimental Group) and Group-B (Control Group) through randomization. Each group consisting of 36 students. The sample of the study was shown in figure-3.2. and Table-3.1.

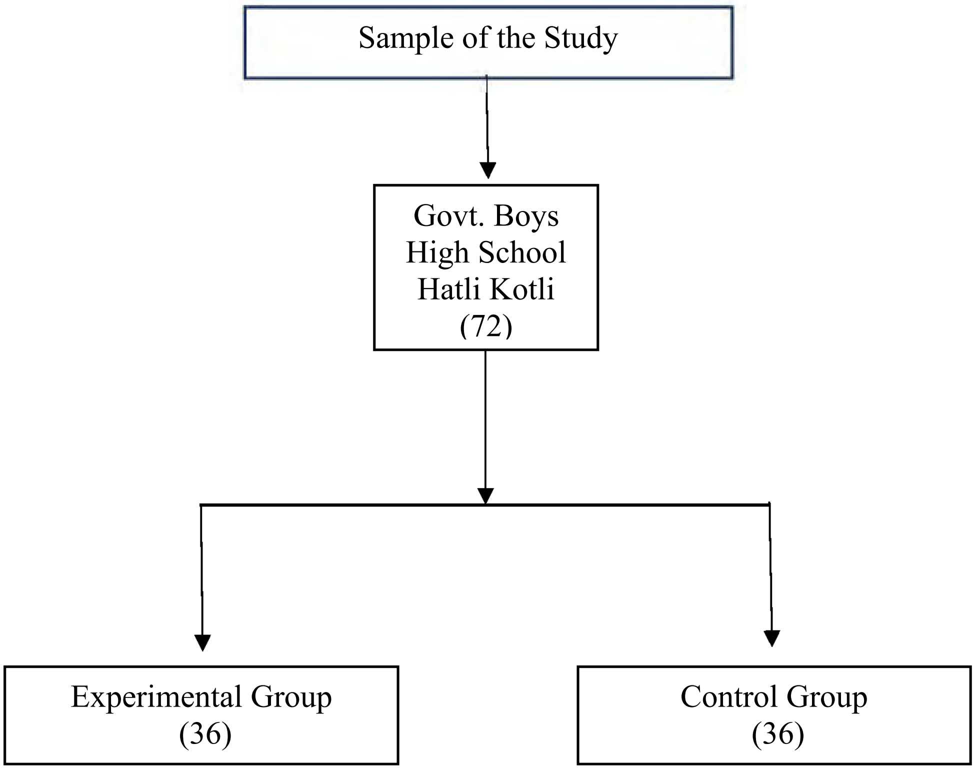

Figure-3.2: Sample of the Study

Table-3.1

Sample of the study

Participants	Sample	Group-A	Group-B
Govt. Boys High School Hatli Kotli	72	36	36

3.3 Procedure of the Study

Following procedure was used in the study.

3.3.1 Formation of experimental and control group

3.3.1.1 Distribution of marks for groups formation on Pre-test

Pre-test of 100 marks was administrated with 72 mathematics students of first grade. On the basis of marks obtained, they were divided into four sampling frames for randomization. This sampling frame was considered favorable for dividing students in groups and to minimize external threats (Mehmood, 2014).

Table-3.2

Distribution of marks for groups formation on the basis of pre-test

Groups	Less than 40 Marks	40-49 Marks	50-59 Marks	60+ Marks
Number of students	18	28	18	08
Selected respondents for each group (Proportionately)	9+9	14+14	9+9	4+4

3.3.1.2 Formation of Experimental Group and Control Group for Treatment and Post-test

On the basis of pre-test scores and distribution of marks for groups formation proportionate numbers of students were randomly selected and hence two groups were formed. The selected two groups were named two sections of routine classes (Section-A and B). The Section-A was treated as Experimental group, while Section-B was treated as control group. Each group had 36 students.

Table-3.3

Formation of Experimental and Control Group

Name of School	Experimental Group	Control Group
Govt. Boys HS Hatli Kotli	9+14+9+4= 36	9+14+9+4= 36

3.3.2 Selection of Contents for Experiment

The contents for the experiment were selected form the mathematics' textbook of grade-I written by Dr. Shazia Naeem and Miss Saba Rafique of Azad Jammu & Kashmir Textbook Board, Muzaffarabad in the year 2021. Five units (Unit 1: Concept of Whole Numbers, Unit 2: Number Operations, Unit 3: Measurement, Unit 5: Time and Unit 6: Geometry) from the mathematics' textbook were selected. The selection of units and topics were done in consultation with the educational experts and Mathematics teachers. The committee (Appendix-xiv) approved that the selected units and topics were important, and represented the whole course and scientific skills in terms of Numerical skills (number sense, counting skills and basic arithmetic skills), Spatial Thinking Skills (spatial sense, geometrical awareness and sense of time) and Mathematical Thinking Skills. The detail of units with topics are as under:

Unit No-1: Concept of whole Number

- Numbers 0-9
- Numbers 10-20
- Numbers 21-50
- Numbers 51-100
- Concept of Place Value in Two (2) Digit Numbers
- Comparison of One (1) and Two (2) Digit Numbers
- Concept of Cardinal and Ordinal Numbers up to 10

Unit-2: Number Operations

- Concept of More, Addition and Equality
- Construction of Addition Sentences
- Addition of One (1) Digit Numbers
- Addition of Two (2) Digit Numbers
- Addition of Numbers up to 20 by Mental Calculations
- Concept of Less and Subtraction
- Subtraction of One (1) Digit Numbers
- Subtraction of Two (2) Digit Numbers
- Subtraction of Numbers up to 20 by Mental Calculations

Unit No-3: Measurement

- Concept of Long, Longer and Longest
- Concept of Short, Shorter and Shortest

- Concept of Tall, Taller and Tallest
- Concept of High, Higher and Highest
- Concept of Heavy, Heavier and Heaviest
- Concept of Light, Lighter and Lightest

Unit-5: Time

- Measuring Time & Concept and Drawing of Analogue Clock
- Measuring Time & Concept and Drawing of Digital Clock

Unit-6: Geometry

- Concept & Drawing of Triangle
- Concept & Drawing of Circle
- Concept & Drawing of Square
- Concept & Drawing of Rectangle
- Patterns of Objects
- Patterns of 2-D Shapes

3.3.3 Preparation of Lessons Plan for Experimental Group and Control Group

The lesson plans for this study were prepared from the Grade 1 Mathematics textbook in consultation with the educational experts and subject specialists of Mathematics. The teaching materials / aids were used for teaching mathematics through Hands on Learning and conventional method. Researcher planned thirty- two lessons on Hands on Learning according to the six steps of Hands on Learning including Preparation, Engagement, Exploration, Reflection, Application and Assessment given by Robb in 2016 (Appendix-xi). Thirty-two lessons on conventional method were also Planned by the researcher (Appendix-xii).

3.3.4 Implementation Strategy of Lesson Planning

Both experimental group and control group were taught same units and same topic in order to develop their scientific skills including numerical skills, spatial skills and mathematical thinking. Both experimental group and control group were taught according to the lesson planning based on Hands on Learning and conventional method respectively by the researcher. The timing of lesson delivering for the experimental group was 9:30 am -10:30 am, and for the control group, it was 11:30 am-12:30 pm for the first four weeks. However, the timing was reversed for the last four weeks, with the experimental group receiving lessons from 11:30 am -12:30 pm and the control group from 9:30 am-10:30 am.

3. 4 Research Instruments

In order to equate the experimental group and control group, Subject achievement test (pre-test) (Appendix-I) was administered before allocating students in experimenting group and control group. After the completion of treatment, subject achievement test (post-test) (Appendix-II) was administered on both groups. Both pre-test and post-test have the same items but post-test was developed after changing the order of the test items.

3.4.1 Construction of Pre-test

Pre-test was of 100 marks consisting of three sections:

Section-A: Objective (40 Marks)

This section consisted of four types of items:

MCQs, Fill in the blanks, True / False, Matching Columns.

Section-B: Restricted Response Questions (36 Marks)

This section consisted of short answer items

Section-C: Extended Response Questions (24 Marks)

This section consisted of open-ended items having performance task. The items included in pre-test with marks is described under the following table.

Table-3.4

Distribution of Test Items with Marks

Sr. No.	Sections	Items	Frequency	Marks Per Item	Toal Marks
1.	**A** Objective Items	MCQs	20	1	20
		Fill in the blanks	10	1	10
		True / False	5	1	5
		Matching columns	5	1	5
2.	**B** Restricted Response Questions	Short answer items	18	2	36
3.	**C** Extended Response Questions	Open ended item with performance tasks	6	4	24

3.4.2 Table of Specification

For the construction of pre-test, two tables of specification (Unit wise and Objectives wise) were developed as shown in table-3.5(a & b) and table-3.6.

Table-3.5 (a)

Table of Specification (Unit Wise) Mathematics Grade-1 (Section-A)

Section-A (Objective Items) 40 Marks							
Sr. No.	Units	Items	K	C	A	Total Items	Total Marks
1.	Whole Number	MCQs	01	02	02	05	5*1=5
		Completion	01	01	-	02	2*1=2
		Matching Columns	-	-	01	01	1*1=1
		True & False	01	-	01	02	2*1=2
2.	Number Operations	MCQs	01	02	02	05	5*1=5
		Completion	-	02	-	02	2*1=2
		Matching Columns	-		01	01	1*1=1
		True & False	-	-	01	01	1*1=1
3.	Measurement	MCQs	01	02	02	05	5*1=5
		Completion	01	-	-	01	1*1=1
		Matching Columns	01	-	-	01	1*1=1
		True & False	-	-	-	-	-
4.	Time	MCQs	-	-	-	-	-
		Completion	1	2	-	03	3*1=3
		Matching Columns	-	1		01	1*1=1
		True & False	1	-	-	01	1*1=1
5.	Geometry	MCQs	01	01	03	05	5*1=5
		Completion	02	-	-	02	2*1=2
		Matching Columns	01	-		01	1*1=1
		True & False	-	-	01	01	1*1=1
	Total items		13	13	14	40	40
	%age		32.5 %	32.5 %	35 %	100%	100%

Table-3.5 (b)

Table of Specification (Unit Wise) Mathematics Grade-1 (Section-B & C)

Section-B &C (RRQs & ERQs) 60 Marks							
Sr. No.	Units	Items	K	C	A	Total Items	Total marks
1.	Whole Number	Short Questions	02	02	01	05	5*2=10
		Long Questions	-	-	01	01	1*4=04
2.	Number Operations	Short Questions	01	02	02	05	5*2=10
		Long Questions	-	01	01	02	2*4=08
3.	Measurement	Short Questions	01	-	01	02	2*2=04
		Long Questions	01	-	-	01	1*4=04
4.	Time	Short Questions	-	01	-	01	1*2=2
		Long Questions	-	-	01	01	1*4=4
5.	Geometry	Short Questions	01	02	02	05	5*2=10
		Long Questions	-	-	01	01	1*4=04

Table-3.6

Table of Specification (Research Objectives Wise) Mathematics Grade-1

Sr. No.	Variables	Test Items	No. of Items	Marks per Item	Total Marks
Objective 1: Numerical Skills (33 Marks)					
1.	Number Sense	MCQs	3	1	3
		Completion	1	1	1
		Matching Columns	1	1	1
		True & False	-	-	-
		RRQs	3	2	6
		ERQs	-	-	-
2.	Counting Skills	MCQs	2	1	2
		Completion	1	1	1
		Matching Columns	-	-	-
		True & False	2	1	2
		RRQs	1	2	2
		ERQs	1	4	4
3.	Basic Arithmetic Skills	MCQs	1	1	1
		Completion	-	-	-
		Matching Columns	-	-	-
		True & False	-	-	-
		RRQs	3	2	6
		ERQs	1	4	4
Objective 2: Spatial Skills (34 Marks)					
1.	Spatial Sense	MCQs	5	1	5
		Completion	-	-	-
		Matching Columns	1	1	1
		True & False	-	-	-
		RRQs	1	2	2
		ERQs	1	4	4
2.	Geometrical Awareness	MCQs	2	1	2
		Completion	2	1	2
		Matching Columns	1	1	1

		True & False	-	-	-
		RRQs	3	2	6
		ERQs	-	-	-
3.	Sense of Time	MCQs	-	-	-
		Completion	3	1	3
		Matching Columns	1	1	1
		True & False	1	1	1
		RRQs	1	2	2
		ERQs	1	4	4
Objective 3: Mathematical Reasoning and Thinking Skills (33 Marks)					
1.	Mathematical Thinking	MCQs	7	1	7
		Completion	3	1	3
		Matching Columns	1	1	1
		True & False	2	1	2
		RRQs	6	2	12
		ERQs	2	4	8
	Total Marks				100

3.4.3 Rubric for Short Answer Test Items and Open-ended Test Items

In the present study, rubric for short test items and open-ended test items were used. The focus of rubric for two marks of test items was on whether the response is: fully correct, partially correct, or incorrect / not attempted and the focus of rubric for four marks of test items was on correct, correct with minor error, partially correct, minimal correct and incorrect / not attempted (Appendix-xiii).

3.4.4 Validity of Research Instruments

Subject achievement test (Pre-test and Post-test) as research instrument was prepared on the basis of proper specification but to ensure its validity. Research instrument was validated by educational experts of International Islamic University Islamabad, Women University of Bagh AJ&K, International Ibadat University Islamabad, University of Kotli, Principal GCET (Male) Kotli, Subject Specialist of Mathematics and Head Examiner of Mathematics BISE AJ&K (Appendix-xv). In the light of their suggestions, some test items were eliminated and some were revised.

3.4.5 Pilot Testing

Pilot testing is a key step in research study. It refers to the process of testing a research instrument on a small group before it can be used in the main study (Malmqvist et al., 2019). In the present study, it was conducted on fifteen Mathematics students of Grade-1 in Government Boys Higher secondary School Andrla Nar Kotli AJ&K in order to test the readability and usability of research instrument. After getting feedback and consulting with supervisor, the tests were improved by eliminating and modifying test items. Two (2) test items related to Numerical Skills were modifying, one (1) test item related to spatial skills was eliminated and six (6) test items were modified and two (2) test items were eliminated related to Mathematical thinking.

3.4.6 Reliability of Research Instrument

The reliability of the research instrument plays a prominent role in research study. It assures that results are consistent, dependable, error-free, trustworthy and not forged. It also increases the confidence of the researcher that obtained result is accurate and should be used for valid conclusion (Surucu, 2020). In the present study, Cronbach's Alpha (α) was used to test the reliability of research instrument (pre-test and post-test). The value of Spearman-Brown's was 0.83 which shows that research instrument was reliable and consistent.

3.5 Variables of the Study

The present study consisted of the following variables:

3.5.1 Independent Variable

Independent variable is intentionally changed or manipulated by the researcher to observe its effect on the dependent variable. It is under the control of the researcher, and is used to measure its impact on the outcome variable (Kumar, 2023). In the present study, Hands on Learning was the independent variable. It is also known as the treatment or cause variable.

3.5.2 Dependent Variable

The variable being measured or observed in response to changes made to the independent variable. The dependent variable is a variable that is being measured or observed in a study (Bryman, 2022). In the present study, scientific skill was the dependent variable of the study. It is also known as outcome variable.

3.5.3 Extraneous Variables

An extraneous variable is a variable that may influence the outcomes of an experiment, even though it is not the focus of the experiment. It can affect the outcome of a study, but is not related to the research question or hypothesis (Creswell, 2022). Temperature, mood and intelligence of participants, age and gender were the extraneous variables. These extraneous variables were control by using randomization, using true experimental design and by using One Way ANCOVA.

3.5.4 Intervenor Variables

An intervenor variable is a hypothetical variable which is used to explain causal links between other variables. It cannot be observed in an experiment (Creswell, 2023). In this study contents, tactics, management of instructional material and teaching environment were the intervenor variables. These intervenor variables were control by the researcher by identifying and measuring them.

3.5.5 Chance Variable

Chance variable is a variable that is beyond the control of the researcher and can affect the outcome of a study (Kumar, 2022). In the present study, the population (First Graders' Mathematics students of District Kotli AJ&K) and research instruments (pre-test & post-test) were the chance variables.

3.6 Control on Internal Threats

Internal threats to validity in experimental research refer to factors within the study that may compromise the causal relationship between the independent and dependent variables. They may include history, testing, instrumentation, statistical regression, selection bias and maturation. In the present study, these internal threats were controlled by the following ways:

- True experimental research design was used which helped to control the internal threat.
- Randomization was used for groups formation and balancing age, experience, or other relevant factors across groups.
- Research instruments were pilot tested, validated and reliability was checked before administering the test and Post-test was administered as a general test. It was based on contents not on text. The students were kept unconscious about the post-test in order to control the internal threats.

3.7 Control on External Threats

External threats to validity are factors that limit the generalizability of a study's findings to other populations, settings, or times. They may include population validity, interaction of pre-test treatment, interaction of selection and treatment, specificity of the variable and researcher effect. These external threats were controlled by the following ways:

- Researcher used random sampling by ensuring that sample was chosen from target population.
- Content based and conceptual pre-test was used. It was a new and unknown for the participants. The same post-test as a general test was administered but changing its order to control the external threats related to test treatment interaction.
- Randomization was used for groups formation for treatment.
- Clearly defined, constructed and validated measurement tools were used to ensure reliability and consistency.
- Standardize instructions and procedures were used to minimize researcher influence on the study.

3. 8 Data Collection

Data were collected in the form of pretest and posttest from both experimental and control group by the researcher. Pre-test was administered among 72 students of grade-1 before teaching mathematics. After pre-test, two groups were formed and they were given name Group-A (Experimental Group) and Group-B (Control Group). The students who were taught by Hands on Learning were in Group-A (Experimental Group) and the students who were given instructions through Conventional Method were in Group-B (Control Group). After eight (8) weeks treatment, post-test was administered from both groups and result was collected.

3. 9 Data Analysis

Data were analyzed by using descriptive statistics and inferential statistics through SPSS Version 25. Descriptive statistics i.e., Mean and SD were used to measure the general trends and distribution of data for the achievement scores of students in Scientific Skills such as Numerical Skills, Spatial Skills and Mathematical Reasoning and Thinking skills. It was also used to compare the means and to present the standard deviation of students' achievement in both the control and experimental groups. Inferential statistics i.e., paired sampled t-test, independent sample t-test and One Way ANCOVA were used to make the analyses more valid and reliable and determining whether there are significant differences in the development of scientific skills of the students exposed to teach with Hands on Learning and those who were taught through conventional method. Eta test was also used to test the effect of Hands on Learning on outcome variables. Data were also analyzed by using bar graph.

3.10 Ethical Consideration

The researcher conducted the research in a fair manner. Data were collected from the participants after taking permission from the head of the institution where the study was conducted. Ethical issues such as informed consent, confidentiality, anonymity and conflict of interest was considered by the researcher. The work of the researcher is free of plagiarism. The researcher is accurately representing the results that are attained during the study.

3.11 Summary of Chapter 3

This study employed a true experimental research design, specifically a pretest-posttest equivalent group design, to investigate the effect of hands-on learning on the development of scientific skills in first graders. Seventy-two (72) first graders were randomly assigned to either an experimental group (n = 36) receiving instruction through Hands-on Learning or a control group (n = 36) receiving instruction through conventional method. The Mathematics Achievement Test (MAT) was administered as a pretest and posttest to measure scientific skills in Mathematics including numerical skills, spatial skills and mathematical reasoning and thinking skills in first graders and data were analyzed by using descriptive statistics (Mean and SD) and inferential statistics (paired sample t-test, independent sample t-test, One Way ANCOVA and Eta test) to determine the effect of hands-on learning on scientific skills in Mathematics while controlling for pre-existing differences between the groups. The data were also analyzed through bar graph.

CHAPTER 4
DATA COLLECTION AND DATA ANALYSIS

4.1 Introduction

This chapter deals with the presentation and analyses of data. The main purpose of the study was to analyze the effect of Hands on Learning on the development of Scientific Skills in first graders. The study was delimited to scientific skills in Mathematics such as Numerical Skills, Spatial Skills and Mathematical Thinking. The results of the study are presented in alignment with the objectives of the study and research hypotheses. The data were analyzed by using both descriptive and inferential statistics through SPSS 25 software.

Descriptive statistics such as Mean, Standard Deviation and other statistics provide an overview of the data. It also helps to understand the general trends and distribution within the data. In the present study, descriptive analyses were used to measure the general trends and distribution of data for the achievement scores of students in Scientific Skills such as Numerical Skills, Spatial Skills and Mathematical Thinking. It was also used to compare the means and to present the standard deviation of students' achievement in both the control and experimental groups.

Inferential statistics is used for making inferences about the population. It is also used to test hypothesis about a population such as determining whether a new treatment is effective or whether there is a significant difference between two groups. In the present study, paired sampled t-test, independent sample t-test, One Way ANCOVA and Eta test were used to make the analyses more valid and reliable and determining whether there are significant differences in the development of scientific skills of the students exposed to teach with Hands on Learning and those who were taught through conventional method.

In the present study, Paired sample t-test was used to check the achievement scores of students in scientific skills before and after the treatment. Independent sample t-test was used to compare the achievement scores of instructions based on Hands on Learning and conventional method in scientific skills, One Way ANCOVA was used to control covariate (a variable that affects the outcome) and Eta test was used to calculate the effect size of the independent variable (Hands on Learning) on the dependent variable (scientific Skills).

4.2 Effect of Hands on Learning on the Development of Scientific Skills in terms of Numerical Skills (Objective 1)

4.2.1 Descriptive Analysis

Table 4.1

Descriptive Statistics for Hands on Learning on Outcome Variable Numerical Skills

Variable	Test	N	Min.	Max.	Mean	Std. Dev.	Diff.
Number Sense	Pre Test	36	1.00	9.00	6.83	1.935	
	Post Test	36	7.00	11.00	9.86	1.018	3.03
Counting Skills	Pre Test	36	4.00	11.00	8.69	2.352	
	Post Test	36	6.00	11.00	9.97	1.483	1.28
Basic Arithmetic Skills	Pre Test	36	0.00	9.00	3.61	3.101	
	Post Test	36	4.00	11.00	9.64	1.839	6.03

Table 4.1 illustrates that the mean achievement scores of students in number sense was; N=36, M= 6.83 with SD=1.935 on pre-test and N=36, M= 9.86 with SD= 1.018 on post-test which indicates an improvement in number sense taught by Hands on Learning. The mean difference between post-test scores and pre-test scores was 3.03. Furthermore, the mean value of post-test (M=9.86) was greater than that of pre-test (M=6.83). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' number sense. It was found that the mean achievement scores of students in counting skills test was; N=36, M= 8.69 with SD=2.352 on pre-test and N=36, M= 9.97 with SD= 1.483 on post-test which indicates an improvement in counting skills of students taught by Hands on Learning. The mean difference between post-test scores and pre-test scores was 1.28. Furthermore, the mean value of post-test (M=9.97) was greater than that of pre-test (M=8.69). Hence the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' counting skills. It was also found that the mean achievement scores of students in basic arithmetic skills test was; N=36, M= 3.61 with SD=3.101 on pre-test and N=36, M= 9.64 with SD= 1.839 on post-test which indicates an improvement in basic arithmetic skills of students taught by Hands on Learning. The mean difference between post-test scores and pre-test scores was 6.03.

Furthermore, the mean value of post-test (M=9.64) was greater than that of pre-test (M=3.61). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' basic arithmetic skills. Overall, the results present that Hands on Learning demonstrated positive effect on students improvement in all variables of numerical skills (number sense, counting skills and basic arithmetic skills) from pre-test to post-test.

Table 4.2

Descriptive Statistics for Mean Achievement Scores of Hands on Learning on Outcome Variable 'Numerical Skills'

Variable	Test	N	Min.	Max.	Mean	Std. Dev.	Diff.
Numerical Skills	Pre Test	36	6.00	29.00	19.11	5.888	10.33
	Post Test	36	19.00	33.00	29.44	3.418	

Table 4.2 presents that the mean achievement scores of students on numerical skills was; N=36, M= 19.11 with SD=5.888 on pre-test and N=36, M= 29.44 with SD= 3.418 on post-test. The mean difference between pre-test scores and post-test scores was 10.33 which indicates an improvement in numerical skills taught by Hands on Learning. Furthermore, the mean value of post-test (M=29.44) was greater than that of pre-test (M=19.11). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' numerical skills.

4.2.2 Hypotheses Testing (Objective 1)

Following hypotheses were tested to measure the effect of Hands on Learning on the achievement scores of numerical skills:

$H_0$1: There is no significant effect of Hands on Learning on students' number sense.

$H_0$2: There is no significant effect of Hands on Learning on students' counting skills.

$H_0$3: There is no significant effect of Hands on Learning on students' basic arithmetic skills

$H_0$4: There is no significant effect of Hands on Learning on students' numerical Skills.

H_01: There is no significant effect of Hands on Learning on students' number sense.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.3

Paired Sample t-test for Hands on Learning on Outcome Variable 'Number Sense'

Variable	Test	N	M	SD	t-value	df	p-value
Number Sense	Pre Test	36	6.83	1.018	8.220	35	0.000
	Post Test	36	9.86	1.935			

Table 4.3 shows that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=9.86, SD=1.935 as compared to pre-test; N=36, M=6.83, SD=1.018. t (35) = 8.220 and p=0.000 < 0.05. Hence, null hypothesis "H_01: There is no significant effect of Hands on Learning on students' number sense" is rejected. Furthermore, the mean value of post-test (M=9.86) was greater than that of pre-test (M=6.83). Hence the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' number sense.

H_02: There is no significant effect of Hands on Learning on students' counting skills.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.4

Paired Sample t-test for Hands on Learning on outcome variable counting skills

Variable	Test	N	M	SD	t-value	Df	p-value
Counting Skills	Pre Test	36	8.69	2.352	2.839	35	0.007
	Post Test	36	9.97	1.483			

Table 4.4 shows that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=9.97, SD=1.483 as compared to pre-test; N=36, M=8.69, SD=2.352. t (35) = 2.839 and p=0.007 < 0.05. Hence, null hypothesis "H_02: There is no significant effect of Hands on Learning on students' counting skills" is rejected. Furthermore, the mean value of post-test (M=9.97) was greater than that of pre-test (M=8.76). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' counting skills.

H_03: There is no significant effect of Hands on Learning on students' basic arithmetic skills.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.5

Paired Sample t-test for Hands on Learning on 'Basic Arithmetic Skills'

Variable	Test	N	M	SD	t-value	Df	p-value
Basic Arithmetic Skills	Pre Test	36	3.61	3.101	9.736	35	0.007
	Post Test	36	9.64	1.839			

Table 4.5 reveals that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=9.64, SD=1.839 as compared to pre-test; N=36, M=3.61, SD=3.101. t (35) = 9.736 and p=0.007 < 0.05. Hence, null hypothesis "H_03: There is no significant effect of Hands on Learning on students' basic arithmetic skills" is rejected. Furthermore, the mean value of post-test (M=9.64) was greater than that of pre-test (M=3.61). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' basic arithmetic skills.

H_04: There is no significant effect of Hands on Learning on students' numerical skills.

Statistical Tests: Mean, SD, Paired Sample t-test

Table 4.6

Paired Sample T-Test for Hands on Learning on Outcome Variable 'Numerical Skills'

Variable	Test	N	M	SD	t-value	df	p-value
Numerical Skills	Pre Test	36	19.11	5.888	8.779	35	0.000
	Post Test	36	29.44	3.418			

Table 4.6 illustrates that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=29.44, SD=3.418 as compared to pre-test; N=36, M=19.11, SD=5.888. t (35) = 8.779 and p=0.000 < 0.05. Hence, null hypothesis "H_04: There is no significant effect of Hands on Learning on students' numerical skills" is rejected. Furthermore, the mean value of post-test (M=29.44) was greater than that of pre-test (M=19.11). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' numerical skills.

4.3 Effect of Hands on Learning on the Development of Scientific Skills in terms of Spatial Skills (Objective 2)

4.3.1 Descriptive Analysis

Table 4.7

Descriptive Statistics for Hands on Learning on Outcome Variable 'Spatial Skills'

Variable	Test	N	Min.	Max.	Mean	Std. Dev.	Diff.
Spatial Sense	Pre Test	36	4.00	9.00	6.36	1.175	3.45
	Post Test	36	6.00	12.00	9.81	1.305	
Geometrical Awareness	Pre Test	36	1.00	11.00	3.78	2.085	5.00
	Post Test	36	5.00	11.00	8.78	1.514	
Sense of Time	Pre Test	36	1.00	8.00	4.00	1.639	3.31
	Post Test	36	4.00	9.00	7.31	1.283	

Table 4.7 shows that the mean achievement scores of students on spatial sense was; N=36, M= 6.36 with SD=1.175 on pre-test and N=36, M= 9.81 with SD= 1.305 on post-test with mean difference 3.45 which indicates a significant improvement in spatial sense of students taught by Hands on Learning. Furthermore, the mean value of post-test (M=9.81) was greater than that of pre-test (M=6.36). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' spatial sense. It was found that the mean achievement scores of students in geometrical awareness test was; N=36, M= 3.78 with SD=2.085 on pre-test and N=36, M= 8.78 with SD= 1,514 on post-test which indicates a significant improvement in geometrical awareness of students taught by Hands on Learning. The mean difference between post-test scores and pre-test scores was 5.00. Furthermore, the mean value of post-test (M=8.78) was greater than that of pre-test (M=3.78). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' geometrical awareness. It was also found that the mean achievement scores of experimental group on sense of time test was N=36, M= 4.00 with SD=1.639 on pre-test and N=36, M= 7.31 with SD= 1.283 on post-test which indicates a significant improvement in sense of time of students taught by Hands on Learning. The mean difference between post-test scores and pre-test scores was

3.31. Furthermore, the mean value of post-test (M=7.31) was greater than that of pre-test (M=4.00). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' sense of time. Overall, the results present that Hands on Learning demonstrated significant improvements in all variables of spatial skills (spatial sense, geometrical awareness and sense of time) from pre-test to post-test.

Table 4.8

Descriptive Statistics for Mean Achievement Scores of Hands on Learning on Outcome Variable 'Spatial Skills'

Variable	Test	N	Min.	Max.	Mean	Std. Dev.	Diff.
Spatial Skills	Pre Test	36	8.00	24.00	14.14	3.758	11.67
	Post Test	36	19.00	30.00	25.89	2.459	

Table 4.8 presents that the mean achievement scores of students on spatial skills was; N=36, M= 14.22 with SD=3.986 on pre-test and N=36, M= 25.89 with SD= 2.459 on post-test. The mean difference between pre-test scores and post-test scores was 11.67 which indicates an improvement in spatial skills taught by Hands on Learning. Furthermore, the mean value of post-test (M=25.89) was greater than that of pre-test (M=14.22). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' spatial skills.

4.3.2 Hypotheses Testing (Objective 2)

Following hypotheses were tested to examine the effect of Hands on Learning on the achievement scores of spatial skills:

$H_0$5: There is no significant effect of Hands on Learning on students' spatial sense.

$H_0$6: There is no significant effect of Hands on Learning on students' geometrical awareness.

$H_0$7: There is no significant effect of Hands on Learning on students' sense of time.

$H_0$8: There is no significant effect of Hands on Learning on students' spatial skills.

H_05: There is no significant effect of Hands on Learning on students' spatial sense.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.9

Paired Sample t-test for Hands on Learning on Outcome Variable 'Spatial Sense'

Variable	Test	N	M	SD	t-value	Df	p-value
Spatial Sense	Pre Test	36	6.36	1.175	12.686	35	0.000
	Post Test	36	9.81	1.305			

Table 4.9 shows that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=9.81, SD=1.305 as compared to pre-test scores; N=36, M=6.36, SD=1.175. t (35) = 12.686 and p=0.000 < 0.05. Hence, null hypothesis "H_05: There is no significant effect of Hands on Learning on students' spatial sense" is rejected. Furthermore, the mean value of post-test (M=9.81) was greater than that of pre-test (M=6.36). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' spatial sense.

H_06: There is no significant effect of Hands on Learning on students' geometrical awareness.

Statistical Tests: Mean, SD and Sample paired t-test

Table 4.10

Paired Sample t-test for Hands on Learning on 'Geometrical Awareness'

Variable	Test	N	M	SD	t-value	Df	p-value
Geometrical Awareness	Pre Test	36	3.78	2.085	11.225	35	0.000
	Post Test	36	8.78	1.514			

Table 4.10 presents that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=8.78, SD=1.514 as compared to pre-test scores; N=36, M=3.78, SD=2.085. t (35) = 11.225 and p=0.000 < 0.05. Hence, null hypothesis "H_06: There is no significant effect of Hands on Learning on students' geometrical awareness" is rejected. Furthermore, the mean value of post-test (M=8.78) was greater than that of pre-test (M=3.78). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' geometrical awareness.

H_07: There is no significant effect of Hands on Learning on students' sense of time.

Statistical Tests: Mean, SD and Sample paired t-test

Table 4.11

Paired Sample t-test for Hands on Learning on Outcome Variable 'Sense of Time'

Variable	Test	N	M	SD	t-value	Df	p-value
Sense of Time	Pre Test	36	4.00	1.639	9.062	35	0.000
	Post Test	36	7.31	1.283			

Table 4.11 presents that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=7.31, SD=1.283, and pre-test; N=36, M=4.00, SD=1.639. t (35) = 9.062 and p=0.000 < 0.05. Hence, null hypothesis "H_07: There is no significant effect of Hands on Learning on students' sense of time" is rejected. Furthermore, the mean value of post-test (M=7.31) was greater than that of pre-test (M=4.00). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' sense of time.

H_08: There is no significant effect of Hands on Learning on students' spatial skills.

Statistical Tests: Mean, SD and Sample paired t-test

Table 4.12

Paired Sample t-test for Hands on Learning on Outcome Variable 'Spatial Skills'

Variable	Test	N	M	SD	t-value	df	p-value
Spatial Skills	Pre Test	36	14.14	3.758	15.557	35	0.000
	Post Test	36	25.89	2.459			

Table 4.12 reveals that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=25.89, SD=2.459as compared to pre-test scores; N=36, M=14.14, SD=2.459. t (35) = 15.557 and p=0.000 < 0.05. Hence, null hypothesis "H_08: There is no significant effect of Hands on Learning on students spatial skills" is rejected. Furthermore, the mean value of post-test (M=25.89) was greater than that of pre-test (M=14.14). Hence, the students scored more in post-test than pre-test which ultimately means that there was a positive effect of Hands on Learning on students' spatial skills.

4.4 Effect of Hands on Learning on the Development of Scientific Skills in terms of Mathematical Thinking (Objective 3)

4.4.1 Descriptive Analysis

Table 4.13

Descriptive Statistics for Hands on Learning on Outcome Variable 'Mathematical Thinking'

Variable	Test	N	Min.	Max.	Mean	SD	Diff.
Mathematical Thinking	Pre Test	36	7	18	12.53	3.246	9.05
	Post Test	36	14	26	21.58	2.655	

Table 4.13 presents that the mean achievement scores of students on mathematical thinking was N=36, M= 12.53 with SD=3.246 on pre-test and N=36, M= 21.58 with SD= 2.655 on post-test. The mean difference between pre-test scores and post-test scores was 9.05 which indicates a significant improvement in mathematical thinking taught by Hands on Learning. Furthermore, the mean value of post-test (M=21.58) was greater than that of pre-test (M=12.53). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' mathematical thinking.

4.4.2 Hypothesis Testing (Objective 3)

Following hypothesis was tested to evaluate the effect of Hands on Learning on mathematical reasoning and thinking skills.

$H_0$9: There is no significant effect of Hands on Learning on students' mathematical thinking.

$H_0$9: There is no significant effect of Hands on Learning on students' mathematical thinking.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.14

Paired sample t-test for Hands on Learning on Outcome Variable 'Mathematical Thinking'

Variable	Test	N	M	SD	t-value	df	p-value
Mathematical Thinking	Pre Test	36	12.53	3.247	14.180	35	0.000
	Post Test	36	21.58	2.655			

Table 4.14 presents the result of paired sample t-test regarding instruction based on Hands on Learning in mathematical thinking. The results showed that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=21.58, SD=2.655 as compared to pre-test scores; N=36, M=12.53, SD=3.247. $t(35) = 14.180$ and $p=0.000 < 0.05$. Hence, null hypothesis "$H_0$9: There is no significant effect of Hands on Learning on students' mathematical thinking" is rejected. Furthermore, the mean value of post-test (M=21.58) was greater than that of pre-test (M=12.53). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' mathematical reasoning and thinking skills.

4.5 Effect of Conventional Method on the Development of Scientific Skills in terms of Numerical Skills (Objective 4)

4.5.1 Descriptive Analysis

Table 4.15

Descriptive Statistics for Conventional Method on Outcome Variable Numerical Skills

Variable	Test	N	Min.	Max.	Mean	Std. Dev.	Diff.
Number Sense	Pre Test	36	2.00	9.00	6.14	1.869	1.75
	Post Test	36	3.00	11.00	7.89	1.769	
Counting Skills	Pre Test	36	3.00	9.00	6.14	1.397	1.08
	Post Test	36	4.00	11.00	7.22	2.140	
Basic Arithmetic Skills	Pre Test	36	0.00	7.00	2.92	1.713	1.08
	Post Test	36	0.00	11.00	4.00	1.957	

Table 4.15 shows that the mean achievement scores of students on number sense was; N=36, M= 6.14 with SD=1.869 on pre-test and N=36, M= 7.89 with SD= 1.769 on post-test which indicates an improvement in number sense of students taught by conventional method with mean difference 1.75 between post-test scores and pre-test scores. Furthermore, the mean value of post-test (M=7.89) was greater than that of pre-test (M=6.14). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' number sense. It was found that the mean achievement scores of students in the counting skills test was; N=36, M= 7.22 with SD=1.397 on pre-test and N=36, M= 6.14 with SD= 2.140 on post-test with mean difference 1.08 which indicates an improvement in counting skills of students taught by conventional method. Furthermore, the mean value of post-test (M=7.22) was greater than that of pre-test (M=6.14). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' counting skills. It was also found that the mean achievement scores of control group in basic arithmetic skills test was N=36, M= 2.92 with SD=1.713 on pre-test and N=36, M= 4.00 with SD= 1.957 on post-test with mean difference 1.08 which indicates a significant improvement in basic arithmetic skills of students taught by conventional method. Furthermore, the mean value of post-test (M=4.00) was greater than that of pre-test (M=2.92). Hence, the

students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' basic arithmetic skills. Overall, the results present that conventional method demonstrated significant improvements in all variables of numerical skills (number sense, counting skills and basic arithmetic skills) from pre-test to post-test.

Table 4.16

Descriptive Statistics for Mean Achievement Scores of Conventional Method on Outcome Variable 'Numerical Skills'

Variable	Test	N	Min.	Max.	Mean	Std. Dev.	Diff.
Numerical Skills	Pre Test	36	7.00	25	15.17	3.917	3.82
	Post Test	36	10.00	33.00	18.99	4.187	

Table 4.16 presents that the mean achievement scores of students on numerical skills were; N=36, M= 15.17 with SD=3.197 on pre-test and N=36, M= 18.99 with SD= 4.187 on post-test taught by conventional method. The mean difference between pre-test scores and post-test scores was 3.82 which indicate a significant improvement in numerical skills taught by conventional method. Furthermore, the mean value of post-test (M=18.99) was greater than that of pre-test (M=15.17). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' numerical skills.

4.5.2 Hypotheses Testing (Objective 4)

Following hypotheses were tested to measure the effect of Conventional Method on the achievement scores of numerical skills:

$H_0$10: There is no significant effect of conventional method on students' number sense.

$H_0$11: There is no significant effect of conventional method on students' counting skills.

$H_0$12: There is no significant effect of conventional method on students' basic arithmetic skills

$H_0$13: There is no significant effect of conventional method on students' numerical Skills.

$H_0$10: There is no significant effect of conventional method on students' number sense.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.17

Paired Sample t-test for Conventional Method on outcome variable number sense

Variable	Test	N	M	SD	t-value	df	p-value
Number Sense	Pre Test	36	6.14	1.869	10.247	35	0.000
	Post Test	36	7.89	1.769			

Table 4.17 shows that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=7.89, SD=1.769 as compared to pre-test scores; N=36, M=6.14, SD=1.869. t (35) = 10.247 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$10: There is no significant effect of conventional method on students' number sense" is rejected. Furthermore, the mean value of post-test (M=7.89) was greater than that of pre-test (M=6.14). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' number sense.

$H_0$11: There is no significant effect of conventional method on students' counting skills.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.18

Paired Sample t-test for Conventional Method on Outcome Variable 'Counting Skills'

Variable	Test	N	M	SD	t-value	df	p-value
Counting Skills	Pre Test	36	6.14	1.397	3.993	35	0.000
	Post Test	36	7.22	2.140			

Table 4.18 reveals that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=7.22, SD=2.140 as compared to pre-test scores; N=36, M=6.14, SD=1.397. t (35) = 3.993 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$11: There is no significant effect of conventional method on students' counting skills" is rejected. Furthermore, the mean value of post-test (M=7.22) was greater than that of pre-test (M=6.14). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' counting skills.

$H_0$12: There is no significant effect of conventional method on students' basic arithmetic skills.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.19

Paired Sample t-test for Conventional Method on 'Basic Arithmetic Skills'

Variable	Test	N	M	SD	t-value	df	p-value
Basic Arithmetic Skills	Pre Test	36	2.92	1.713	4.638	35	0.000
	Post Test	36	4.00	1.957			

Table 4.19 presents that there was a statistically significant difference in the mean scores of students in pos- test; N=36, M=4.00, SD=1.957 as compared to pre-test scores; N=36, M=2.92, SD=1.713. t (35) = 4.638 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$12: There is no significant effect of conventional method on students' basic arithmetic skills" is rejected. Furthermore, the mean value of post-test (M=9.64) was greater than that of pre-test (M=3.61). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' basic arithmetic skills.

$H_0$13: There is no significant effect of conventional method on students' numerical skills.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.20

Paired Sample t-test for Conventional Method on 'Numerical Skills'

Variable	Test	N	M	SD	t-value	df	p-value
Numerical Skills	Pre Test	36	15.17	3.917	9.761	35	0.000
	Post Test	36	18.89	4.187			

Table 4.20 illustrates that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=18.89, SD=4.187 as compared to pre-test scores; N=36, M=15.17, SD=3.917. t (35) = 9.761 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$13: There is no significant effect of conventional method on students' numerical skills" is rejected. Furthermore, the mean value of post-test (M=18.89) was greater than that of pre-test (M=15.17). Hence, the students scored more in post-test than pre-test which ultimately means that there was a positive effect of conventional method on students' numerical skills.

4.6 Effect of Conventional Method on the Development of Scientific Skills in terms of Spatial Skills (Objective 5)

4.6.1 Descriptive Analysis

Table 4.21

Descriptive Statistics for Conventional Method on Outcome Variable 'Spatial Skills'

Variable	Test	N	Min.	Max.	Mean	Std. Dev.	Diff.
Spatial Sense	Pre Test	36	4.00	10.00	7.39	1.536	1.33
	Post Test	36	6.00	12.00	8.72	1.446	
Geometrical Awareness	Pre Test	36	1.00	8.00	4.69	1.564	1.59
	Post Test	36	2.00	10.00	6.28	1.632	
Sense of Time	Pre Test	36	1.00	8.00	6.67	1.639	0.69
	Post Test	36	4.00	9.00	7.36	1.417	

Table 4.21 shows that the mean achievement scores of students on spatial sense was; N=36, M= 7.39 with SD=1.536 on pre-test and N=36, M= 8.72 with SD= 1.446 on post-test with mean difference 1.33 which indicates a significant improvement in spatial sense of students taught by conventional method. Furthermore, the mean value of post-test (M=8.72) was greater than that of pre-test (M=7.39). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' spatial sense. The results show that the mean achievement scores of students in geometrical awareness test was; N=36, M= 4.69 with SD=1.564 on pre-test and N=36, M= 6.28 with SD= 1.632 on post-test which indicates a significant improvement in geometrical awareness of students taught by conventional method. The mean difference between post-test scores and pre-test scores was 1.59. Furthermore, the mean value of post-test (M=6.28) was greater than that of pre-test (M=4.69). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' geometrical awareness. Moreover, the result show that the mean achievement scores of experimental group on sense of time test was N=36, M= 6.67 with SD=1.639 on pre-test and N=36, M= 7.36 with SD= 1.417 on post-test which indicates a moderate improvement in sense of time of students taught by conventional method. The mean difference between post-test scores and pre-test

scores was 0.69. Furthermore, the mean value of post-test (M=7.31) was more than that of pre-test (M=6.67). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' sense of time. Overall, the results present that conventional method demonstrated significant improvements in all variables of spatial skills (spatial sense, geometrical awareness and sense of time) from pre-test to post-test.

Table 4.22

Descriptive Statistics for Mean Achievement Scores of Conventional Method on Outcome Variable 'Spatial Skills'

Variable	Test	N	Min.	Max.	Mean	Std. Dev.	Diff.
Spatial Skills	**Pre Test**	**36**	**9.00**	**25.00**	**18.81**	**3.963**	**3.55**
	Post Test	**36**	**14.00**	**29.00**	**22.36**	**3.728**	

Table 4.22 presents that the mean achievement scores of students on spatial skills was; N=36, M= 17.78 with SD=4.466 on pre-test and N=36, M= 21.03 with SD= 3.410 on post-test. The mean difference between pre-test scores and post-test scores was 3.25 which indicate a significant improvement in spatial skills taught by conventional method. Furthermore, the mean value of post-test (M=21.03) was greater than that of pre-test (M=17.78). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' spatial skills.

4.6.2 Hypotheses Testing (Objective 5)

Following hypotheses were tested to examine the effect of Conventional Method on the achievement scores of spatial skills:

$H_0$14: There is no significant effect of conventional method on students' spatial sense.

$H_0$15: There is no significant effect of conventional method on students' geometrical awareness.

$H_0$16: There is no significant effect of conventional method on students' sense of time.

$H_0$17: There is no significant effect of conventional method on students' spatial skills.

$H_0$14: There is no significant effect of conventional method on students' spatial sense.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.23

Paired Sample t-test for Conventional Method on Outcome Variable 'Spatial Sense'

Variable	Test	N	M	SD	t-value	df	p-value
Spatial Sense	Pre Test	36	7.39	1.536	9.661	35	0.000
	Post Test	36	8.72	1.446			

Table 4.23 shows that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=8.72, SD=1.446, and pre-test; N=36, M=7.39, SD=1.536. t (35) = 9.661 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$14: There is no significant effect of conventional method on students' spatial sense" is rejected. Furthermore, the mean value of post-test (M=8.72) was greater than that of pre-test (M=7.39). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' spatial sense.

$H_0$15: There is no significant effect of conventional method on students' geometrical awareness of students.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.24

Paired Sample t-test for Conventional Method on 'Geometrical Awareness'

Variable	Test	N	M	SD	t-value	df	p-value
Geometrical Awareness	Pre Test	36	4.69	1.564	10.867	35	0.000
	Post Test	36	6.28	1.632			

Table 4.24 Presents that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=6.28, SD=1.632 as compared to pre-test scores; N=36, M=4.69, SD=1.564. t (35) = 10.867 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$15: There is no significant effect of conventional method on students' geometrical awareness" is rejected. Furthermore, the mean value of post-test (M=6.28) was greater than that of pre-test (M=4.69). Hence, the students scored more in post-test than pre-test which ultimately means that there was a positive effect of conventional method on students' geometrical awareness.

$H_0$16: There is no significant effect of conventional method on students' sense of time.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.25

Paired Sample t-test for Conventional Method on Outcome Variable 'Sense of Time'

Variable	Test	N	M	SD	t-value	Df	p-value
Sense of Time	Pre Test	36	6.67	1.639	4.129	35	0.000
	Post Test	36	7.36	1.417			

Table 4.25 presents that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=7.36, SD=1.417 as compared to pre-test scores; N=36, M=6.67, SD=1.639. t (35) = 4.129 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$16: There is no significant effect of conventional method on students' sense of time" is rejected. Furthermore, the mean value of post-test (M=7.36) was greater than that of pre-test (M=6.67). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' sense of time.

$H_0$17: There is no significant effect of conventional method on students' spatial skills of students.

Statistical Tests: Mean, SD and Paired Sample t-test

Table 4.26

Paired Sample t-test for Conventional Method on Outcome Variable 'Spatial Skills'

Variable	Test	N	M	SD	t-value	Df	p-value
Spatial Skills	Pre Test	36	18.81	3.963	13.095	35	0.000
	Post Test	36	22.36	3.728			

Table 4.26 reveals that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=22.36, SD=3.963, and pre-test; N=36, M=18.81, SD=3.728. t (35) = 13.095 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$17: There is no significant effect of conventional method on students' spatial skills" is rejected. Furthermore, the mean value of post-test (M=22.36) was greater than that of pre-test (M=18.81). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' spatial skills.

4.7 Effect of Conventional Method on the Development of Scientific Skills in terms of Mathematical Thinking (Objective 6)

4.7.1 Descriptive Analysis

Table 4.27

Descriptive Statistics for Conventional Method on Outcome Variable 'Mathematical Thinking'

Variable	Test	N	Min.	Max.	Mean	SD	Diff.
Mathematical Thinking	**Pre Test**	**36**	**2**	**18**	**11.69**	**3.725**	**3.84**
	Post Test	**36**	**7**	**25**	**15.53**	**3.910**	

Table 4.27 presents that the mean achievement scores of students on mathematical thinking was; N=36, M= 11.69 with SD=3.725 on pre-test and N=36, M= 15.53 with SD= 3.910 on post-test. The mean difference between pre-test scores and post-test scores was 3.84 which indicate a significant improvement in mathematical thinking taught by conventional method. Furthermore, the mean value of post-test (M=15.53) was greater than that of pre-test (M=11.69). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' mathematical reasoning and thinking skills.

4.7.2 Hypothesis Testing (Objective 6)

Following hypothesis was tested to evaluate the effect of Conventional Method on mathematical reasoning and thinking skills.

$H_0$18: There is no significant effect of conventional method on students' mathematical thinking.

$H_0$18: There is no significant effect of conventional method on students' mathematical thinking

Statistical Tests: Mean, SD and Sample paired t-test

Table 4.28

Paired sample t-test for Conventional Method on Mathematical Thinking

Variable	Test	N	M	SD	t-value	Df	p-value
Mathematical Thinking	Pre Test	36	11.69	3.725	13.960	35	0.000
	Post Test	36	15.53	3.910			

Table 4.28 presents the result of paired sample t-test regarding instructions based on conventional method in mathematical thinking. The results showed that there was a statistically significant difference in the mean scores of students in post- test; N=36, M=15.53, SD=3.910 as compared to pre-test scores; N=36, M=11.69, SD=3.725. $t(35) = 13.960$ and $p=0.000 < 0.05$. Hence, null hypothesis "$H_0$18: There is no significant effect of conventional method on students' mathematical thinking" is rejected. Furthermore, the mean value of post-test (M=15.53) was greater than that of pre-test (M=11.69). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' mathematical thinking.

4.8 Comparison of Hands on Learning (Experimental Group) with Conventional Method (Control Group) on the Development of Scientific Skills (Objective 7)

4.8.1 Descriptive Analysis

Table 4.29

Descriptive Statistics for comparison of mean differences of Hands on Learning (Experimental group) with Conventional Method (Control group) on Outcome Variable 'Numerical Skills'

Variables	Experimental Group		Diff.	Control Group		Diff.
	Pre-test M	Post-test M		Pre-test M	Post-test M	
Number Sense	6.83	9.86	3.03	6.14	7.89	1.75
Counting Skills	8.69	9.97	1.28	6.14	7.22	1.08
Basic Arithmetic Skills	3.61	9.64	6.03	2.92	4.00	1.08
	Average		3.45			1.30

Table 4.29 presents the means scores of pre-test and post-test for the experimental group and control group in outcome variables of numerical skills such as number sense, counting skills and basic arithmetic skills. The results present that experimental group scored more in all three variables (number sense, counting skills and basic arithmetic skills) from pre-test to post test. The mean scores increased from 6.83 to 9.86 (difference = 3.03) in number sense test, 8.69 to 9.97 (difference = 1.28) in counting skills and 3.61 to 9.64 (difference = 6.03) in basic arithmetic skills. The results also show that control group demonstrated smaller and modest improvement in all three variables (number sense, counting skills and basic arithmetic skills) from pre-test to post test. The mean scores increased from 6.14 to 7.89 (difference =1.75) in number sense test, 6.14 to 7.22 (difference = 1.08) in counting skills and 2.92 to 4.00 (difference = 1.08) in basic arithmetic skills. Furthermore, the experimental group showed significant improvement as compared to that of control group with an average difference of 3.45 (experimental group) versus 1.30 (control group) which ultimately means that there was a positive effect of Hands on Learning (experimental group) on students' numerical skills as compared to conventional method (control group).

Table 4.30

Descriptive Statistics for comparison of mean achievement scores of Hands on Learning (Experimental group) with Conventional Method (Control group) on Outcome Variable 'Numerical Skills'

Variable	Group	N	Pre Test		Post Test		Difference
			M	SD	M	SD	M
Numerical	Exp.	36	19.11	5.888	29.44	3.418	10.33
Skills	Control	36	15.17	3.917	18.89	4.187	3.72
Difference			M= 3.94		M=10.55		

Table 4.30 reveals the overall comparison of numerical skills between experimental group and control group on pre-test and post-test. The results show a significant difference in numerical skills between the two groups. The data shows that the mean scores of experimental group in numerical skills on post-test; M= 29.44 (SD=3.418) was significantly high as compared to pre-test; M= 19.11 (SD=5.888) with the difference of 10.33. The data also show the smaller improvement in numerical skills of control group with post-test scores; M= 18.89 (SD=4.187) and pre-test scores; M= 15.17 (SD=3.917) with the difference of 3.72. Furthermore, the difference in improvement between the experimental group and control group was significant with a mean difference of 3.94 in pre-test scores and 10.55 in post-test scores. Hence, the results of both groups present that there was a positive effect of Hands on Learning (experimental group) on students' numerical skills as compared to conventional method (control group).

Table 4.31

Descriptive Statistics for comparison of mean differences of Hands on Learning (Experimental group) with Conventional Method (Control group) on Outcome Variable 'Spatial Skills'

Variable	Experimental Group		Diff.	Control Group		Diff.
	Pre-test M	Post-test M		Pre-test M	Post-test M	
Spatial Sense	6.36	9.81	3.45	7.39	8.72	1.33
Geometrical Awareness	3.78	8.78	5.00	4.69	6.28	1.59
Sense of Time	4.00	7.31	3.31	6.67	7.36	0.69
	Average		3.92			1.20

Table 4.31 presents the means scores of pre-test and post-test for the experimental group and control group in outcome variables of spatial skills such as spatial sense, geometrical awareness and sense of time. The results present that experimental group scored more in all three variables (spatial sense, geometrical awareness and sense of time) from pre-test to post test. The mean scores increased from 6.36 to 9.81 (difference = 3.45) in spatial sense test, 3.78 to 8.78 (difference = 5.00) in geometrical awareness test and 4.00 to 7.31 (difference = 3.31) in sense of time test. The results also show that control group demonstrated smaller and modest improvement in all three variables (spatial sense, geometrical awareness and sense of time) from pre-test to post test. The mean scores increased from 7.39 to 8.72 (difference = 1.33) in spatial sense test, 4.69 to 6.28 (difference = 1.59) geometrical awareness test and 6.67 to 7.36 (difference = 0.69) in sense of time test. Furthermore, the experimental group showed significant improvement as compared to that of control group with an average difference of 3.92 (experimental group) versus 1.20 (control group) which ultimately means that there was a positive effect of Hands on Learning (experimental group) on students' spatial skills as compared to conventional method (control group).

Table 4.32

Descriptive Statistics for comparison of mean achievement scores of Hands on Learning (Experimental group) with Conventional Method (Control group) on Outcome Variable 'Spatial Skills'

Variable	Group	N	Pre Test		Post Test		Difference
			M	SD	M	SD	M
Spatial	Exp.	36	14.14	3.758	25.89	2.459	11.75
Skills	Control	36	18.81	3.963	22.36	3.728	3.55
	Difference		4.67		3.53		

Table 4.32 illustrates the overall comparison of spatial skills between experimental group and control group on pre-test and post-test. The results show a significant difference in spatial skills between the two groups. The data shows that the mean scores of experimental group in spatial skills on post-test; M= 25.89 (SD=2.459) was significantly high as compared to pre-test; M= 14.14 (SD=3.758) with the difference of 11.75. The results also show the significant improvement in spatial skills between two groups. The data shows that the mean scores of experimental group in spatial skills on post-test scores; M= 22.36 (SD=3.728) was significantly high as compared to pre-test scores; M= 18.81 (SD=3.963) with the difference of 3.55. Furthermore, the difference in improvement between the experimental group and control group was significant with a mean difference of 4.67 in pre-test scores and 3.53 in post-test scores. Hence, the results of both groups present that there was a positive effect of Hands on Learning (experimental group) on students' spatial skills as compared to conventional method (control group) from pre-test to post-test.

Table 4.33

Descriptive Statistics for comparison of mean achievement scores of Hands on Learning (Experimental group) with Conventional Method (Control group) on Outcome Variable 'Mathematical Thinking'

Variable	Group	N	Pre Test		Post Test		Difference
			M	SD	M	SD	
Mathematical Reasoning and Thinking Skills	Exp.	36	12.53	3.247	21.58	2.655	9.05
	Control	36	11.69	3.725	15.53	3.910	3.84
Difference			M= 0.84		M=6.05		

Table 4.33 presents the overall comparison of mathematical thinking between experimental group and control group on pre-test and post-test. The results show a significant difference in mathematical thinking between the two groups. The data shows that the mean scores of experimental group in numerical skills on post-test; M= 21.58 (SD=2.655) was significantly high as compared to pre-test; M= 12.53 (SD=3.247) with the difference of 9.05. The data also show the smaller improvement in mathematical thinking of control group with post-test scores; M= 15.53 (SD=3.910) and pre-test scores; M= 11.69 (SD=3.725) with the difference of 3.84. Furthermore, the difference in improvement between the experimental group and control group was significant with a mean difference of 0.84 in pre-test scores and 6.05 in post-test scores. Hence, the results of both groups present that there was a positive effect of Hands on Learning (experimental group) on students' mathematical thinking as compared to conventional method (control group).

Table 4.34

Descriptive Statistics for comparison of mean differences of Hands on Learning (Experimental group) with Conventional Method (Control group) on Outcome Variable 'Scientific Skills'

Variables	Exp Group Pre-test M	Exp Group Post-test M	Diff.	Control Group Pre-test M	Control Group Post-test M	Diff.
Numerical Skills	19.11	29.44	10.33	15.17	18.89	3.72
Spatial Skills	14.14	25.89	11.75	18.81	22.36	3.55
Mathematical Reasoning and Thinking Skills	12.53	21.58	9.05	11.69	15.53	3.84
Average			10.38			3.70

Table 4.34 presents the means scores of pre-test and post-test for the experimental group and control group on outcome variables of scientific skills such as numerical skills, spatial skills and mathematical reasoning and thinking skills. The results present that experimental group scored more in all three variables (numerical skills, spatial skills and mathematical reasoning and thinking skills) from pre-test to post test. The mean scores increased from 19.11 to 29.44 (difference = 10.33) in numerical skills test, 14.14 to 25.89 (difference = 11.75) in spatial skills test and 12.53 to 21.58 (difference = 9.05) in mathematical reasoning and thinking skills test. The results also show that control group demonstrated smaller and modest improvement in all three variables (numerical skills, spatial skills and mathematical reasoning and thinking skills) from pre-test to post test. The mean scores increased from 15.17 to 18.89 (difference = 3.72) in numerical skills test, 18.81 to 22.36 (difference = 3.55) in spatial skills test and 11.69 to 15.53 (difference = 3.84) mathematical reasoning and thinking skills. Furthermore, the experimental group showed significant improvement as compared to that of control group with an average difference of 10.38 (experimental group) versus 3.70 (control group) which ultimately means that there was a positive effect of Hands on Learning (experimental group) on all three variables of scientific skills (numerical skills, spatial skills and mathematical reasoning and thinking skills) as compared to conventional method (control group).

Table 4.35

Descriptive Statistics for comparison of mean achievement scores of Hands on Learning (Experimental group) with Conventional Method (Control group) on Outcome Variable 'Scientific Skills'

Variable	Group	N	Pre Test		Post Test		Achievement
			M	**SD**	**M**	**SD**	
Scientific	Exp.	36	45.78	9.610	76.94	6.516	31.16
Skills	Control	36	44.64	9.728	56.83	9.866	12.19
Achievement			M=1.14		M=20.11		18.97

Table 4.35 reveals the overall comparison of scientific skills between experimental group and control group on pre-test and post-test. The results show a significant difference in scientific skills between the two groups. The data shows that the mean scores of experimental group in scientific skills on post-test; M= 76.94 (SD=6.516) was significantly high as compared to pre-test; M= 45.78 (SD=9.610) with the difference of 31.16. The data also show the smaller and moderate improvement in scientific skills of control group as compared to experimental group with post-test scores; M= 56.83 (SD=9.866) and pre-test scores; M= 44.64 (SD=9.728) with the difference of 12.19. Furthermore, the difference in improvement between the experimental group and control group was significant with a mean difference of 1.14 in pre-test scores and 20.11 in post-test scores and total achievement difference of 18.97 between both groups. Hence, the results of both groups present that there was a positive effect of Hands on Learning on students' scientific skills as compared to conventional method.

4.8.2 Hypotheses Testing (Objective 7)

Before testing the research hypotheses, independent sample t-test on pre test scores was used to check whether the performance of both groups (Experimental group and Control group) was equal or not before treatment. The variables which had same pre-test scores, independent t-test was used on post-test to test the hypothesis. On the other hand, the variables which had pre-existence difference on pre-test, One Way ANCOVA was used to test the hypothesis. Here, following hypotheses were tested to compare the achievement scores of Hands on Learning (experimental group) with Conventional Method (control group).

$H_0$19: There is no significant difference in the mean scores of students' number sense taught by Hands on Learning and conventional method.

$H_0$20: There is no significant difference in the mean scores of students' counting skills taught by Hands on Learning and conventional method.

$H_0$21: There is no significant difference in the mean scores of students' basic arithmetic skills taught by Hands on Learning and conventional method.

$H_0$22: There is no significant difference in the mean scores of students' numerical skills taught by Hands on Learning and conventional method.

$H_0$23: There is no significant difference in the mean scores of students' spatial sense taught by Hands on Learning and conventional method.

$H_0$24: There is no significant difference in the mean scores of students' geometrical awareness taught by Hands on Learning and conventional method.

$H_0$25: There is no significant difference in the mean scores of students' sense of time taught by Hands on Learning and conventional method.

$H_0$26: There is no significant difference in the mean scores of students' spatial skills taught by Hands on Learning and conventional method.

$H_0$27: There is no significant difference in the mean scores of students' mathematical thinking taught by conventional method and Hands on Learning.

$H_0$28: There is no significant effect of Hands on Learning on students' scientific skills.

$H_0$29: There is no significant effect of conventional Method on students' scientific skills.

$H_0$30: There is no significant difference in students' scientific skills taught by conventional method and Hands on Learning.

$H_0$19: There is no significant difference in the mean scores of students' number sense taught by Hands on Learning and Conventional method

Statistical Test

Mean, SD, Independent Sample t-test (Table 4.36 & 4.37)

Graphical Interpretation

Bar Graph

Table 4.36

Independent Sample t-test for Mean Scores' Difference on Students' Number Sense Taught by Hands on Learning and Conventional Method on Pre-Test

Variable	Group	N	M	SD	t-value	df	p-value
Number Sense	Exp.	36	6.83	1.935	1.549	70	0.126
	Control	36	6.14	1.869			

Table 4.36 shows the result of independent sample t-test for comparing the mean scores of Students' Number Sense taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test. The results showed that there was no statistically significant difference in the mean scores of experimental group; N=36, M=6.14, SD=1.869, and the mean scores of control group; N=36, M=6.83, SD=1.935. $t(70) = 1.549$ and $p=0.126 > 0.05$. Hence, null hypothesis "$H_0$19: There is no significant difference in the mean scores of students' number sense taught by Hands on Learning and Conventional method" is accepted. Furthermore, the mean test scores of experimental group (M=6.83) was almost similar to the mean scores of control group (M=6.14). Hence, the mean scores of both groups in pre-test present that there is no statistically significant difference in the mean scores of students' number sense between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

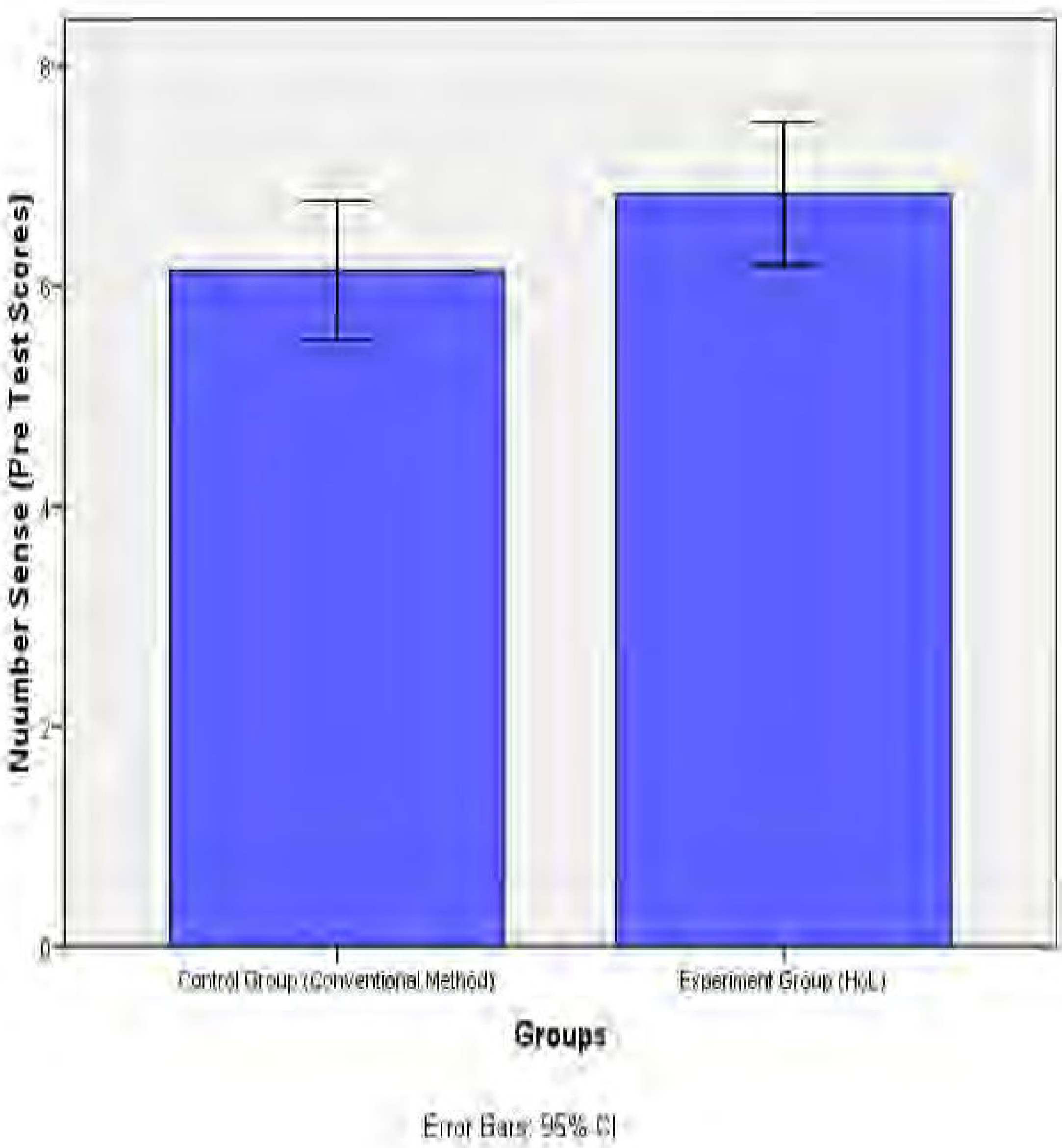

Figure 4.1: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Number Sense on Pre-Test

Figure 4.1 is a graphical view of the results in table 4.36. In figure 4.1, it is observed that both experimental and control groups have almost the same test scores i.e., M=.6.83 & M= 6.14 respectively in number sense which shows that there is no significant difference in the mean scores of students' number sense before treatment. It is also observed that the error bars overlap indicating no significant difference between the mean scores of both groups with p=0.126. The directions of the mean difference between these two groups present that test scores in number sense are almost same before treatment.

Table 4.37

Independent Sample t-test for Mean Scores' Difference on Students' Number Sense Taught by Hands on Learning and Conventional Method on Post-test

Variable	Group	N	M	SD	t-value	df	p-value
Number Sense	Exp.	36	9.86	1.018	5.797	70	0.000
	Control	36	7.89	1.769			

Table 4.37 reveals the result of independent sample t-test for comparing the mean scores of Students' Number Sense taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=9.86, SD=1.018, and the mean scores of control group; N=36, M=7.89, SD=1.769. t (70) = 5.797 and p=0.000 < 0.05. Hence, null hypothesis i.e."$H_0$19: There is no significant difference in the mean scores of students' number sense taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=9.86) was more than to the mean scores of control group (M=7.89). Hence, the mean scores of both groups on post-test present that there is a statistically significant difference in the mean scores of students' number sense between Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test.

Graphical Representation

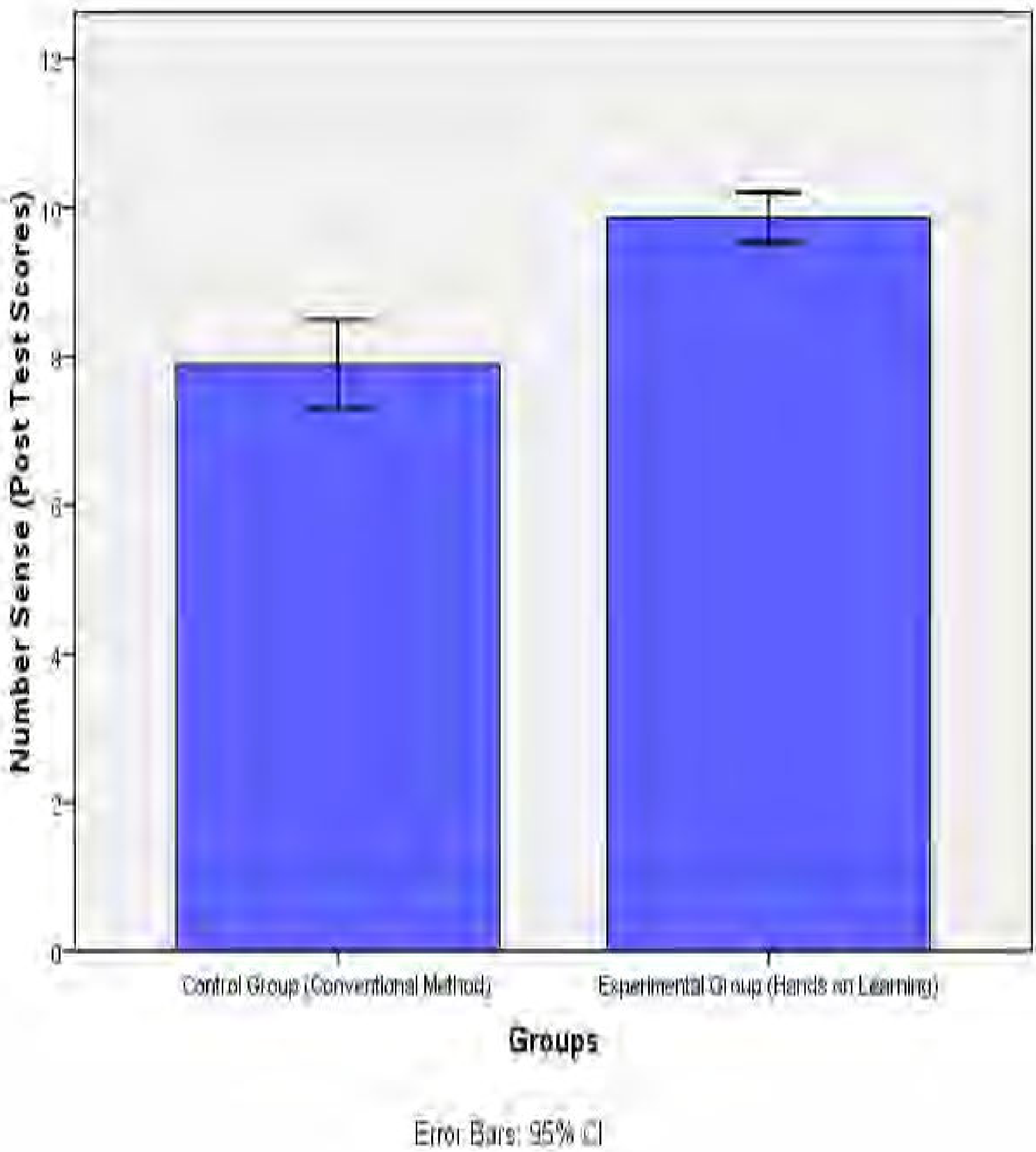

Figure 4.2: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Number Sense on Post-test

Figure 4.2 gives a pictorial view of the results in table 4.37. The graph in the above figure showed that there was a significant improvement in students' number sense (M=9.86) through the instructions based on Hands on Learning as compared to students' number sense (M=7.89) through the instructions based on Conventional Method. It is evident that the error bars do not overlap suggesting a significant difference between the mean scores of both groups. The direction of the mean difference between these two groups present that Hands on Learning is more effective in improving number sense of students as compared to Conventional Method.

$H_0$20: There is no significant difference in the mean scores of students' counting skills taught by Hands on Learning and Conventional.

Statistical Test:

Mean, SD, Independent Sample t-test (Table 4.38)

Mean, SD, One Way ANCOVA, Eta test (Table 4.39)

Graphical Representation:

Bar Graph

Table 4.38

Independent Sample t-test for Mean Scores' Difference on Students' Counting Skills Taught by Hands on Learning and Conventional Method on Pre-Test

Variable	Group	N	M	SD	t-value	df	p-value
Counting Skills	Exp.	36	8.69	2.325	5.605	70	0.000
	Control	36	6.14	1.397			

Table 4.38 shows the result of independent sample t-test for comparing the mean scores of Students' counting skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=8.69, SD=2.325 and the mean scores of control group; N=36, M=6.14, SD=1.397; $t (70) = 5.605$ and $p=0.000 < 0.05$. Hence, null hypothesis "$H_0$20: There is no significant difference in the mean scores of students' counting skills taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=8.69) was more than to the mean scores of control group (M=6.14). Hence, the mean scores of both groups on pre-test present that there is a statistically significant difference in the mean scores of students' counting skills between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

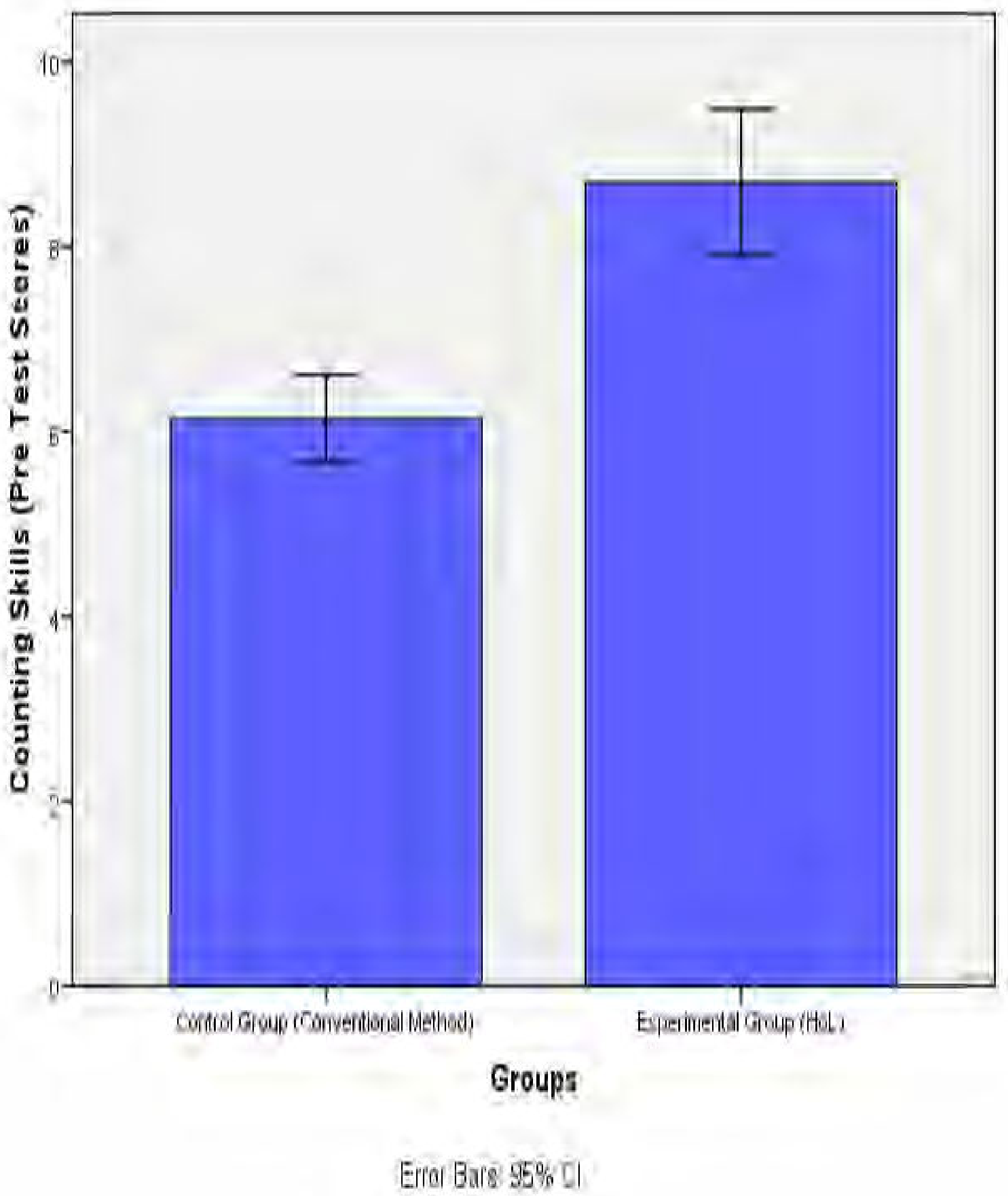

Figure 4.3: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Counting Skills on Pre-test

Figure 4.3 gives a graphical summary of the results in table 4.38. The graph in the above figure showed that there is a significant difference in the mean scores of experimental group (M=8.69) and control group (6.14) before treatment. It is also observed that the error bars do not overlap suggesting a significant difference between the mean scores of both groups. The direction of the mean difference between these two groups present that experimental group has more scores in counting skills test than control group before treatment.

Table 4.39

One Way ANCOVA and Eta-test for Mean Scores' Difference on Students' Counting Skills Taught by Hands on Learning and Conventional Method on Post-Test

Variable	Group	N	M	SD	Df	F-value	p-value	Eta
Counting Skills	Exp.	36	9.97	1.483	1,70	40.173	0.000	0.365
	Control	36	7.22	2.140				

Table 4.39 shows the result of One Way ANCOVA for comparing the mean scores of Students' counting skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test while controlling for the pre-test scores. The results showed that there was a statistical significant difference in the mean scores of experimental group; N=36, M=9.97, SD=1.483, and the mean scores of control group; N=36, M=7.22, SD=2.140; F (1,70)= 40.143 and $p=0.000 < 0.05$. Hence, null hypothesis, "$H_0$20: There is no significant difference in the mean scores of students' counting skills taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=9.97) was more than to the mean scores of control group (M=7.22). Hence, the results show that the instruction based on Hands on Learning is more effective for improving students' counting skills as compared to instructions based on Conventional Method. Moreover, the Eta value (η=0.365) indicates a moderate to strong association between Hands on Learning and counting skills which means that Hands on Learning has significant effect on students counting skills.

Graphical Representation

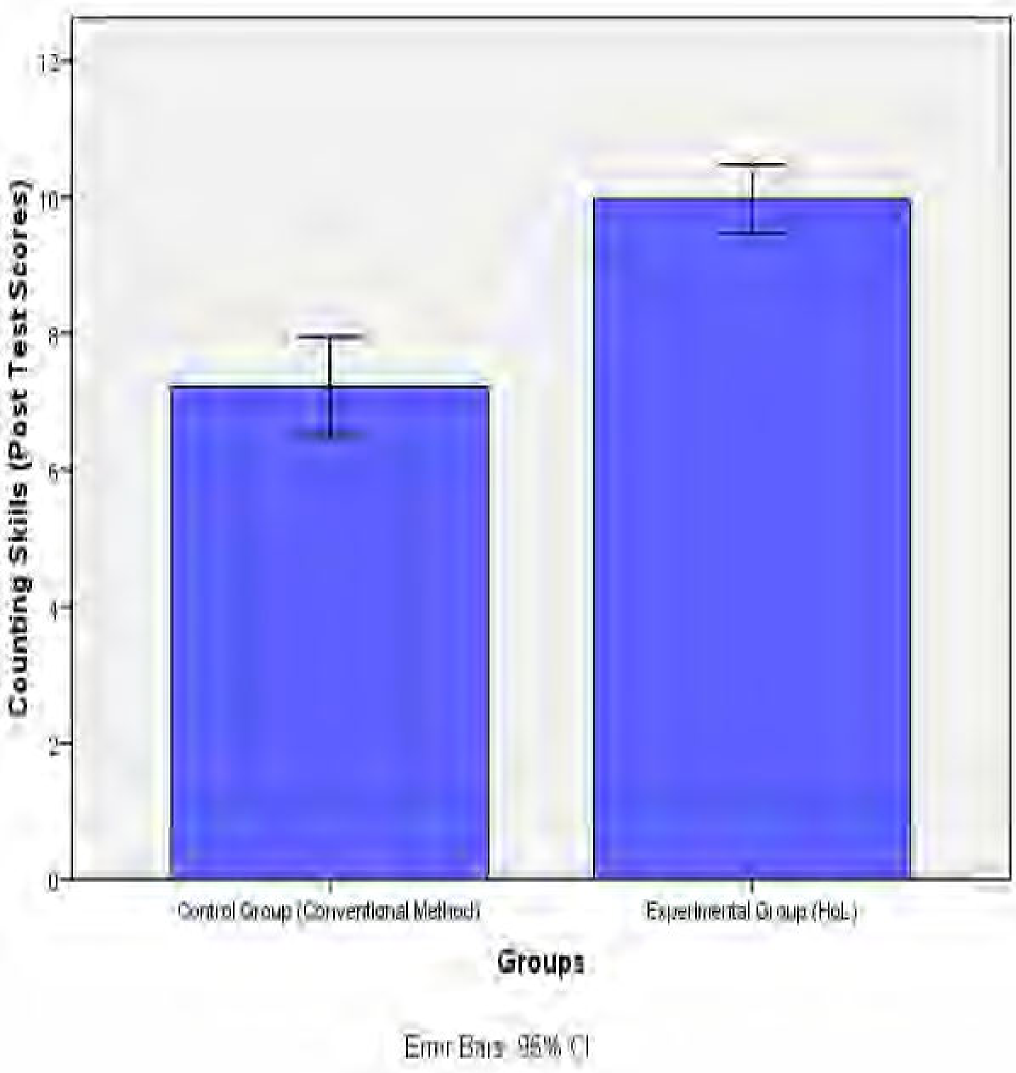

Figure 4.4: Graphical Representation of One Way ANCOVA-test Results for Mean Scores' Difference on Students' Counting Skills on Post-test

Figure 4.4 visually represents the results in table 4.39. The graph in the above figure showed that there is a significant difference in the mean scores of experimental group (M=9.97) and control group (7.22) after treatment. It is also observed that the error bars do not overlap suggesting a significant difference between the mean scores of both groups in improving students' counting skills. The direction of the mean difference between these two groups present that Hands on Learning is more effective in improving students' counting skills as compared to Conventional Method. Moreover, the Eta value (η=0.365) indicates a moderate to strong association between Hands on Learning and counting skills which means that Hands on Learning has significant effect on students' counting skills.

$H_0$21: There is no significant difference in the mean scores of students' basic arithmetic skills taught by Conventional method and Hands on Learning

Statistical Test

Mean, SD, Independent Sample t-test (Table 4.40 & Table 4.41)

Graphical Representation

Bar graph

Table 4.40

Independent Sample t-test for Mean Scores' Difference on Students' Basic Arithmetic Skills Taught by Hands on Learning and Conventional Method on Pre-Test

Variable	Group	N	M	SD	t-value	Df	p-value
Basic Arithmetic Skills	Exp.	36	3.61	3.101	1.176	70	0.245
	Control	36	2.92	1.713			

Table 4.40 shows the result of independent sample t-test for comparing the mean scores of Students' basic arithmetic skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test. The results showed that there was no statistically significant difference in the mean scores of experimental group; N=36, M=3.61, SD=3.101, and the mean scores of control group; N=36, M=2.92, SD=1.713; $t (70) = 1.176$ and $p=0.245 > 0.05$. Hence, null hypothesis "$H_0$21: There is no significant difference in the mean scores of students' basic arithmetic skills taught by Hands on Learning and Conventional method" is accepted. Furthermore, the mean test scores of experimental group (M=3.61) was almost similar to the mean scores of control group (M=2.92). Hence, the mean scores of both groups in pre-test present that there is no statistically significant difference in the mean scores of students' basic arithmetic skills between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

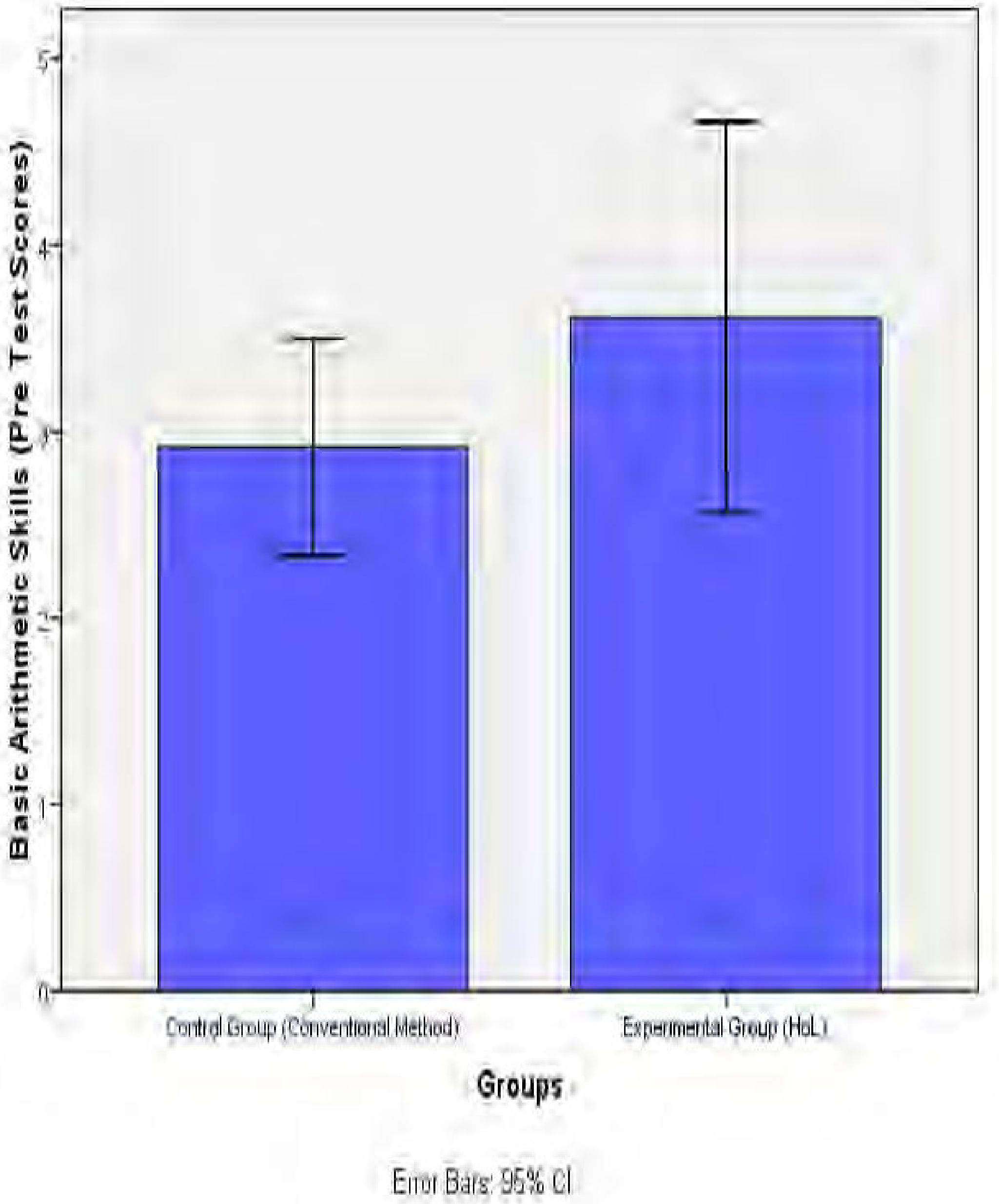

Figure 4.5: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Basic Arithmetic Skills on Pre-test

Figure 4.5 presents a graphical view of the results in table 4.40. The graph in the above figure showed that there the mean scores of experimental group (M=3.61) and control group (M=2.92) are almost equal before treatment. It is also observed that the error bars overlap suggesting no significant difference between the mean scores of both groups with p=0.245. The overlap of the error bars indicates that this difference is likely due to chance. The directions of the mean difference between these two groups present that test scores in basic arithmetic skills are almost before treatment.

Table 4.41

Independent Sample t-test for Mean Scores' Difference on Students' Basic Arithmetic Skills Taught by Hands on Learning and Conventional Method on Post-test

Variable	Group	N	M	SD	t-value	df	p-value
Basic	Exp.	36	9.64	1.839			
Arithmetic	Control	36	4.00	1.957	12.601	70	0.000
Skills							

Table 4.41 shows the result of independent sample t-test for comparing the mean scores of Students' basic arithmetic skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=9.64, SD=1.839 and the mean scores of control group; N=36, M=4.00, SD=1.957; t (70) = 12.601 and p=0.000 < 0.05. Hence, null hypothesis i.e."$H_0$21: There is no significant difference in the mean scores of basic arithmetic skills taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=9.64) was more than to the mean scores of control group (M=4.00). Hence, the mean scores of both groups on post-test present that there is a statistically significant difference in the mean scores of students' basic arithmetic skills between Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test.

Graphical Representation

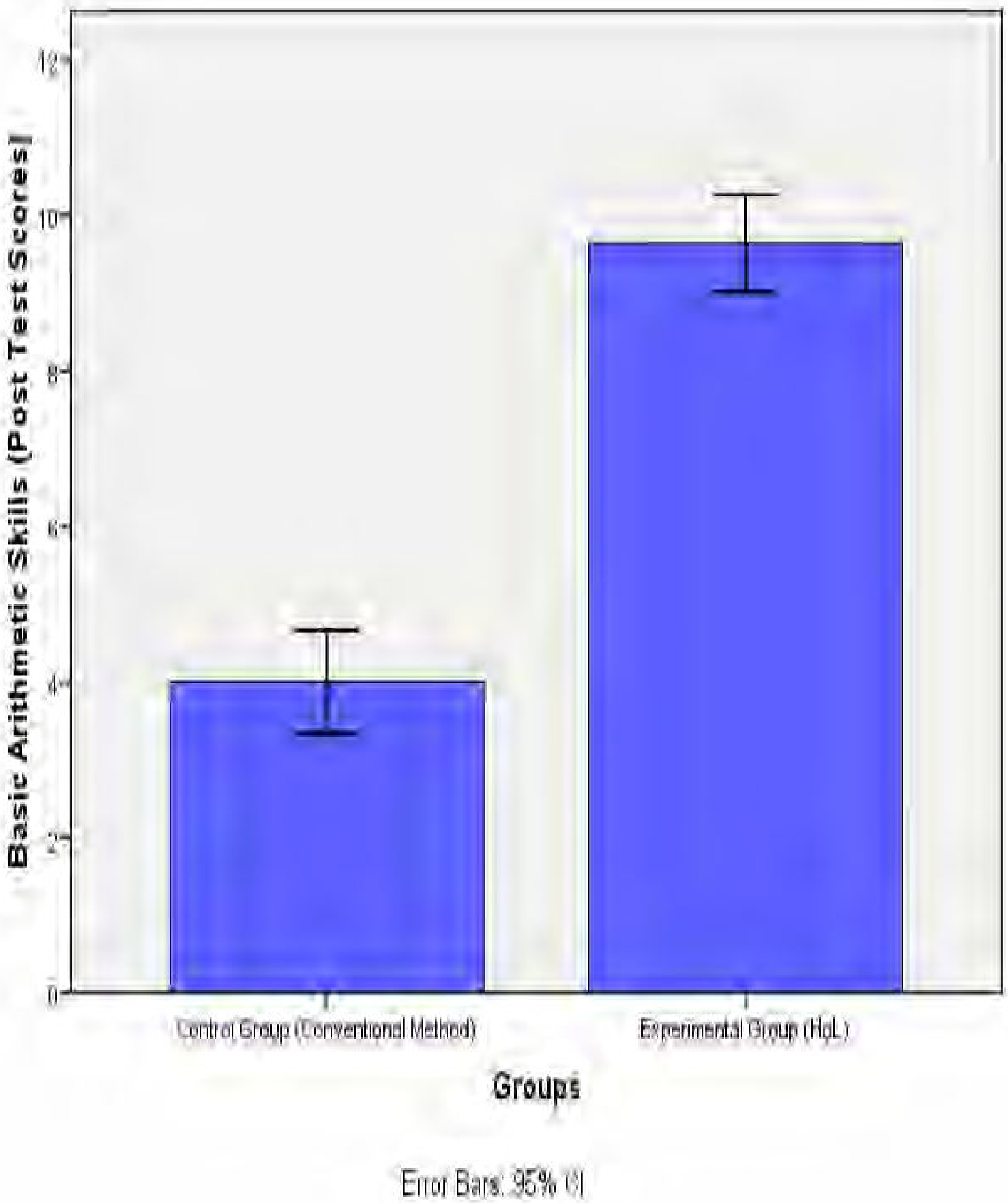

Figure 4.6: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Basic Arithmetic Skills on Post-test

Figure 4.6 shows the results in table 4.41. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=9.64) and control group (4.00) after treatment. It is also observed that the error bars do not overlap suggesting a significant difference between the mean scores of both groups in improving students' basic arithmetic skills. The direction of the mean difference between these two groups presents that Hands on Learning is more effective in improving students' basic arithmetic skills than Conventional Method.

$H_0$22: There is no significant difference in the mean scores of students' numerical skills taught by Conventional method and Hands on Learning

Statistical Test:

Mean, SD, Independent Sample t-test (Table 4.42)

Mean, SD, One Way ANCOVA, Eta test (Table 4.43)

Table 4.42

Independent Sample t-test for Mean Scores' Difference on Students' Numerical Skills Taught by Hands on Learning and Conventional Method on Pre-Test

Variable	Group	N	M	SD	t-value	df	p-value
Numerical Skills	Exp.	36	19.11	5.888	3.346	70	0.001
	Control	36	15.17	3.917			

Table 4.42 shows the result of independent sample t-test for comparing the mean scores of Students' numerical skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=19.11, SD=5.888 and the mean scores of control group; N=36, M=15.17, SD=3.917; $t(70) = 3.346$ and $p=0.001 < 0.05$. Hence, null hypothesis "$H_0$22: There is no significant difference in the mean scores of students' numerical skills taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=19.11) was more than to the mean scores of control group (M=15.17). Hence, the mean scores of both groups on pre-test present that there is a statistically significant difference in the mean scores of students' numerical skills between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

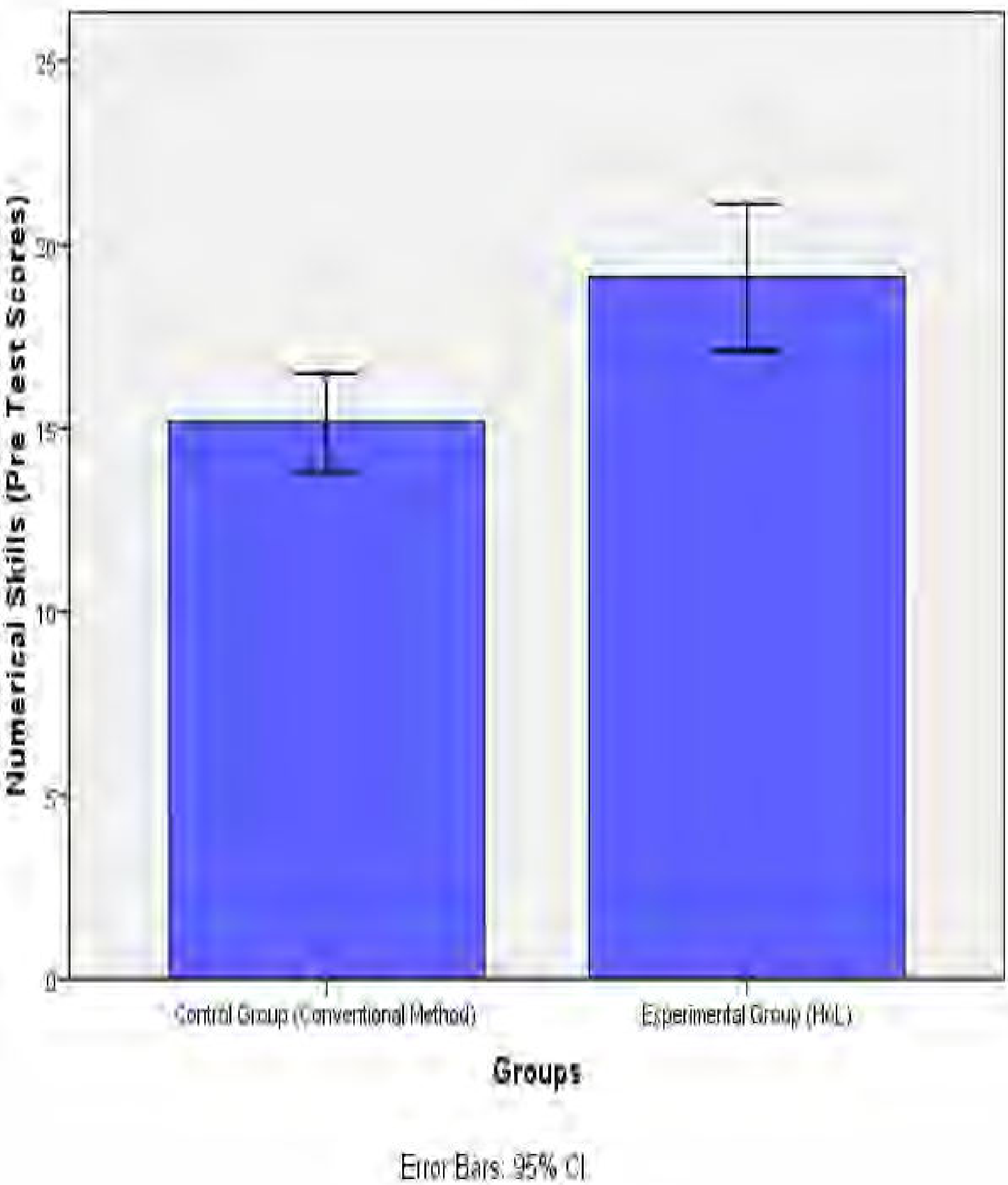

Figure 4.7: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Numerical Skills on Pre-test

Figure 4.7 illustrates the results in table 4.42. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=19.11) and control group (15.17) before treatment. It is also observed that the error bars do not overlap suggesting a significant difference between the mean scores of both groups in improving students' numerical skills with p=0.001. The direction of the mean difference between these two groups presents that students' test score is high of experimental group as compared to control group before treatment.

Table 4.43

One Way ANCOVA and Eta Test for Mean Scores' Difference on Students' Numerical Skills Taught by Hands on Learning and Conventional Method on Post-test

Variable	Group	N	M	SD	df	F-value	p-value	Eta
Numerical Skills	Exp.	36	29.44	3.418	1,70	137.307	0.000	0.662
	Control	36	18.89	4.187				

Table 4.43 reveals the result of One Way ANCOVA for comparing the mean scores of Students' numerical skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test while controlling for the pre-test scores. The results showed that there was a statistical significant difference in the mean scores of experimental group; N=36, M=29.44, SD=3.418, and the mean scores of control group; N=36, M=18.89, SD=4.187; $F(1,70)= 137.03$ and $p=0.000 < 0.05$. Hence, null hypothesis i.e. "$H_0$22: There is no significant difference in the mean scores of students' numerical skills taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=29.44) was more than to the mean scores of control group (M=18.89). Hence, the results show that the instruction based on Hands on Learning is more effective for improving students' numerical skills as compared to instructions based on Conventional Method. Moreover, the Eta value (η=0.662) indicates a moderate to strong association between Hands on Learning and numerical skills which means that Hands on Learning has significant effect on students' numerical skills.

Graphical Representation

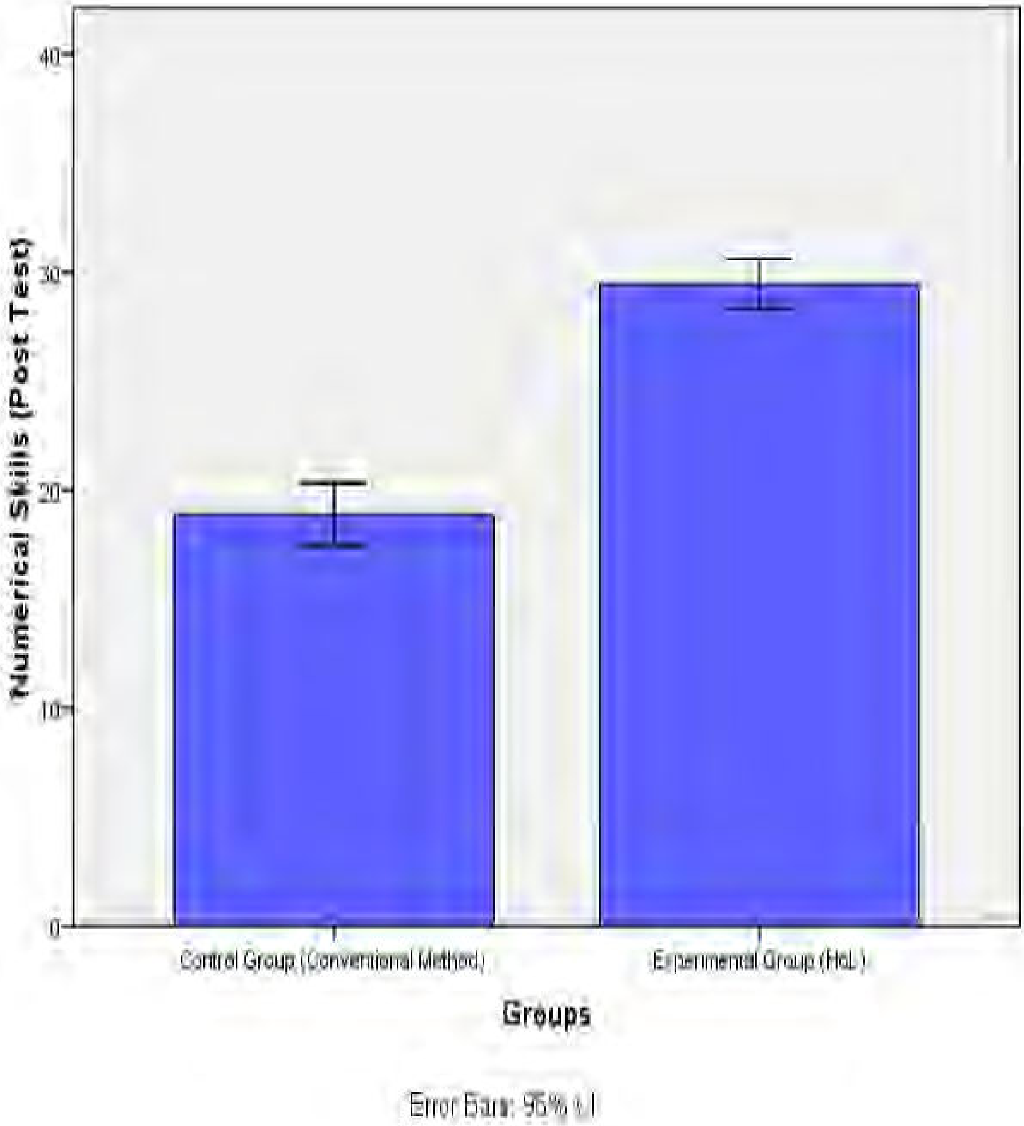

Figure 4.8: Graphical Representation of One Way ANCOVA-test Results for Mean Scores' Difference on Students' Numerical Skills on Post-test

Figure 4.8 reveals the results in table 4.43. The graph in the above figure showed that there is a significant difference in the mean scores of experimental group (M=29.44) and control group (18.89) after treatment. It is also observed that the error bars do not overlap suggesting a significant difference between the mean scores of both groups in improving students' counting skills. The direction of the mean difference between these two groups present that Hands on Learning is more effective in improving students' numerical skills as compared to Conventional Method. Moreover, the Eta value (η=0.662) that Hands on Learning is more effective in improving students' numerical skills.

$H_0$23: There is no significant difference in the mean scores of students' spatial sense taught by Hands on Learning and Conventional method

Statistical Test:

Mean, SD, Independent Sample t-test (Table 4.44)

Mean, SD, One Way ANCOVA, Eta test (Table 4.45)

Table 4.44

Independent Sample t-test for Mean Scores' Difference on Students' Spatial Sense Taught by Hands on Learning and Conventional Method on Pre-test

Variable	Group	N	M	SD	t-value	df	p-value
Spatial Sense	Exp.	36	6.36	1.175	3.189	70	0.002
	Control	36	7.39	1.536			

Table 4.44 shows the result of independent sample t-test for comparing the mean scores of Students' spatial sense taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=6.36, SD=1.175 and the mean scores of control group; N=36, M=7.39, SD=1.536; $t(70) = 3.189$ and $p=0.002 < 0.05$. Hence, null hypothesis "$H_0$23: There is no significant difference in the mean scores of students' spatial sense taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of control group (M=7.39) was more than to the mean scores of experimental group (M=6.36). Hence, the mean scores of both groups on pre-test present that there is a statistically significant difference in the mean scores of students' spatial sense between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

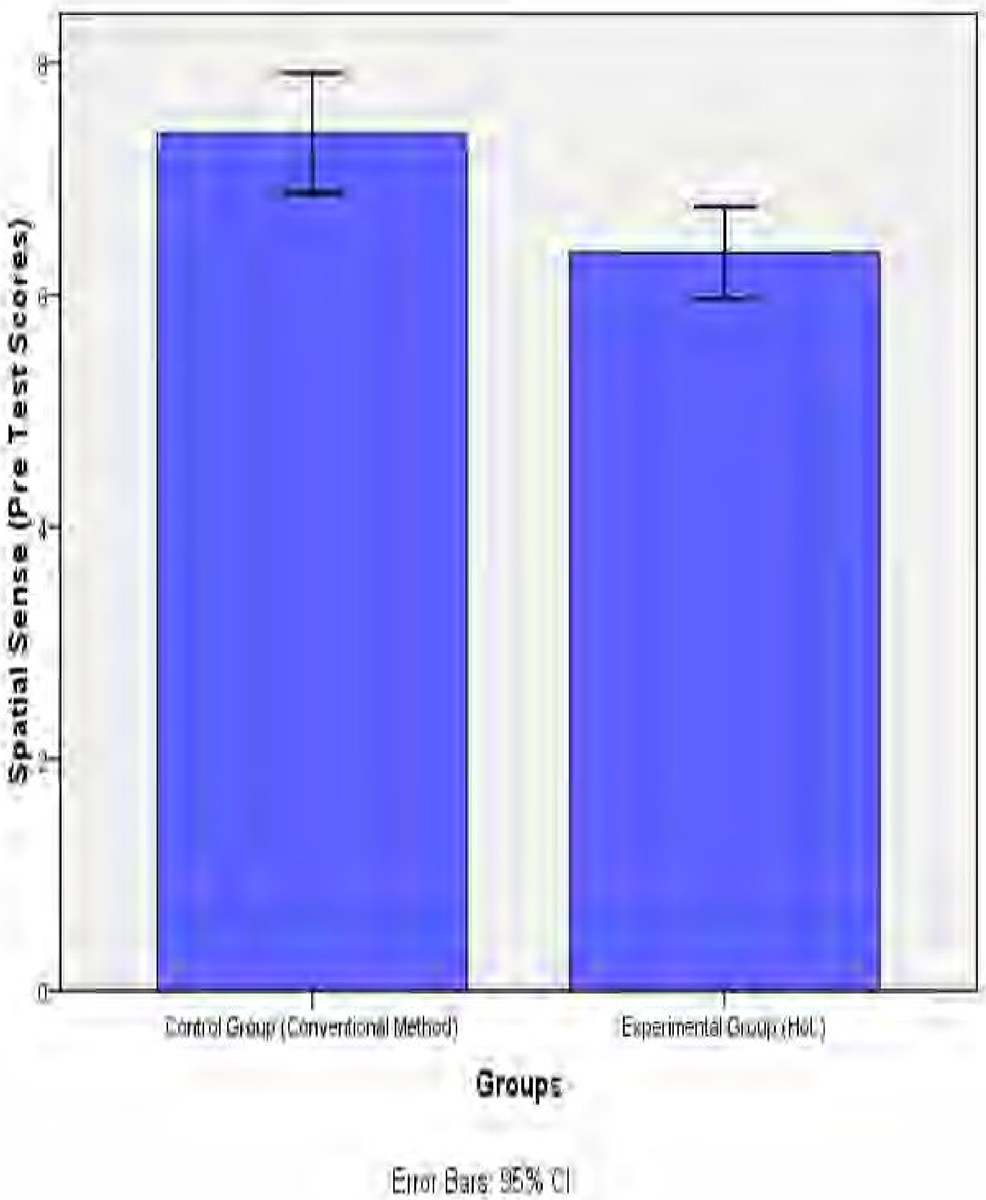

Figure 4.9: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Spatial Sense on Pre-test

Figure 4.9 shows the results in table 4.44. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=6.36) and control group (7.39) before treatment. It is also observed that the error bars do not overlap presenting a significant difference between the mean scores of both groups with p=0.002. The direction of the mean difference between these two groups present that students' test score is high of experimental group as compared to control group before treatment.

Table 4.45

One Way ANCOVA and Eta Test for Mean Scores' Difference on Students' Spatial Sense Taught by Hands on Learning and Conventional Method on Post-test

Variable	Group	N	M	SD	Df	F	P	Eta
Spatial Sense	Exp.	36	9.81	1.305	1, 70	11.113	0.001	0.137
	Control	36	8.72	1.446				

Table 4.45 reveals the result of One Way ANCOVA for comparing the mean scores of Students' spatial sense taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test while controlling for the pre-test scores. The results showed that there was a statistical significant difference in the mean scores of experimental group; N=36, M=9.81, SD=1.305, and the mean scores of control group; N=36, M=8.72, SD=1.446; $F(1,70)= 11.113$ and $p=0.001 < 0.05$. Hence, null hypothesis i.e. "$H_0$23: There is no significant difference in the mean scores of students' spatial sense taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=9.81) was more than to the mean scores of control group (M=8.72). Hence, the results show that the instruction based on Hands on Learning is more effective for improving students' spatial sense as compared to instructions based on Conventional Method. Moreover, the Eta value ($\eta=0.137$) indicates a moderate to strong association between Hands on Learning and spatial sense which means that Hands on Learning has significant effect on students' spatial sense.

Graphical Representation

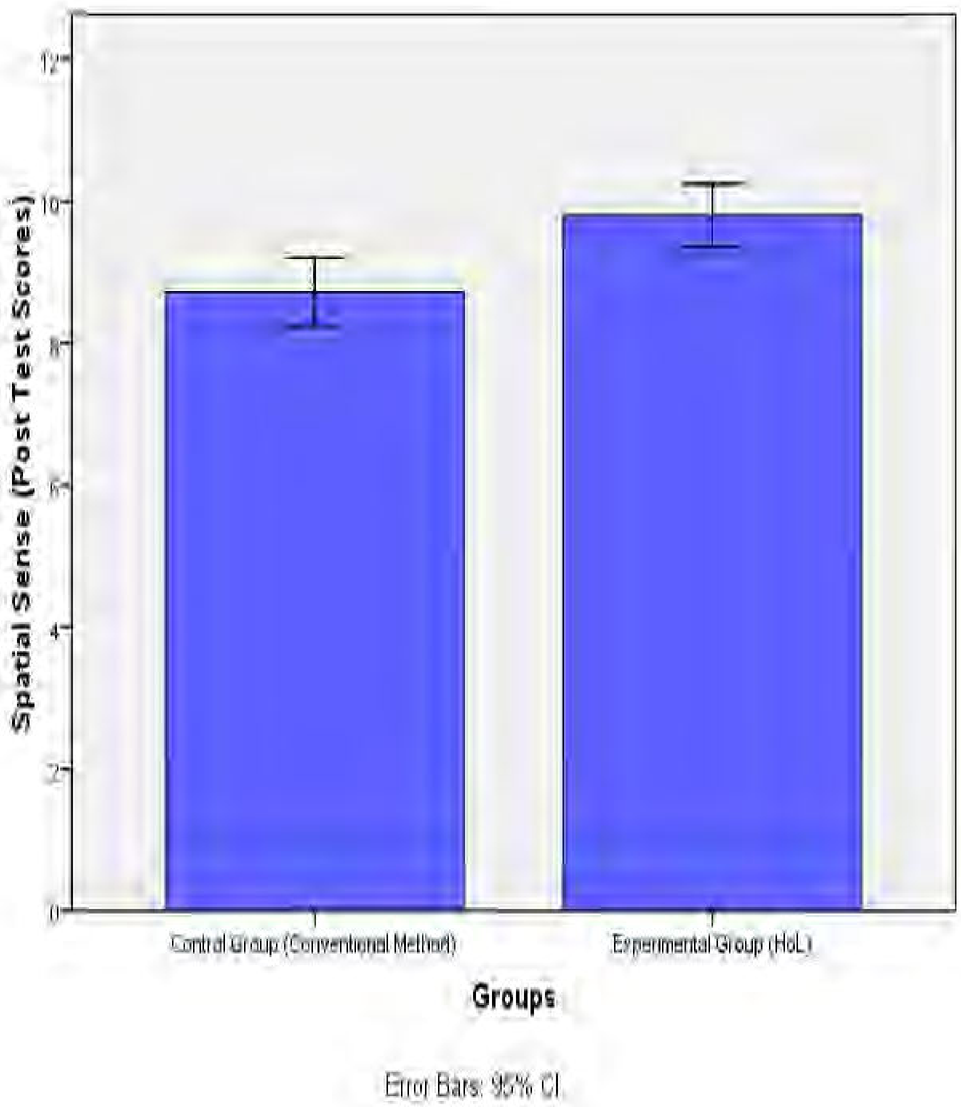

Figure 4.10: Graphical Representation of One Way ANCOVA-test Results for Mean Scores' Difference on Students' Spatial Sense on Post-test

Figure 4.10 reveals the results in table 4.45. The graph in the above figure showed that there is a significant difference in the mean scores of experimental group (M=9.81) and control group (8.72) after treatment. It is also observed that the error bars do not overlap suggesting a significant difference between the mean scores of both groups in improving students' spatial skills. The direction of the mean difference between these two groups present that Hands on Learning is more effective in improving students' spatial skills as compared to Conventional Method. Moreover, the Eta value (η=0.662) indicates that Hands on Learning is more effective in improving students' spatial sense.

$H_0$24: There is no significant difference in the mean scores of students' geometrical awareness taught by Hands on Learning and Conventional method.

Statistical Test:

Mean, SD, Independent Sample t-test (Table 4.46)

Mean, SD, One Way ANCOVA, Eta test (Table 4.47)

Table 4.46

Independent Sample t-test for Mean Scores' Difference on Students' Geometrical Awareness Taught by Hands on Learning and Conventional Method on Pre-test

Variable	Group	N	M	SD	t-value	df	p-value
Geometrical Awareness	Exp.	36	3.78	2.085	2.110	70	0.038
	Control	36	4.69	1.564			

Table 4.46 shows the result of independent sample t-test for comparing the mean scores of Students' geometrical awareness taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=3.78, SD=2.085 and the mean scores of control group; N=36, M=4.69, SD=1.564; t (70) = 2.110 and p=0.038 < 0.05. Hence, null hypothesis "$H_0$24: There is no significant difference in the mean scores of students' geometrical awareness taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of control group (M=4.69) was more than to the mean scores of experimental group (M=3.78). Hence, the mean scores of both groups on pre-test present that there is a statistically significant difference in the mean scores of students' geometrical awareness between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

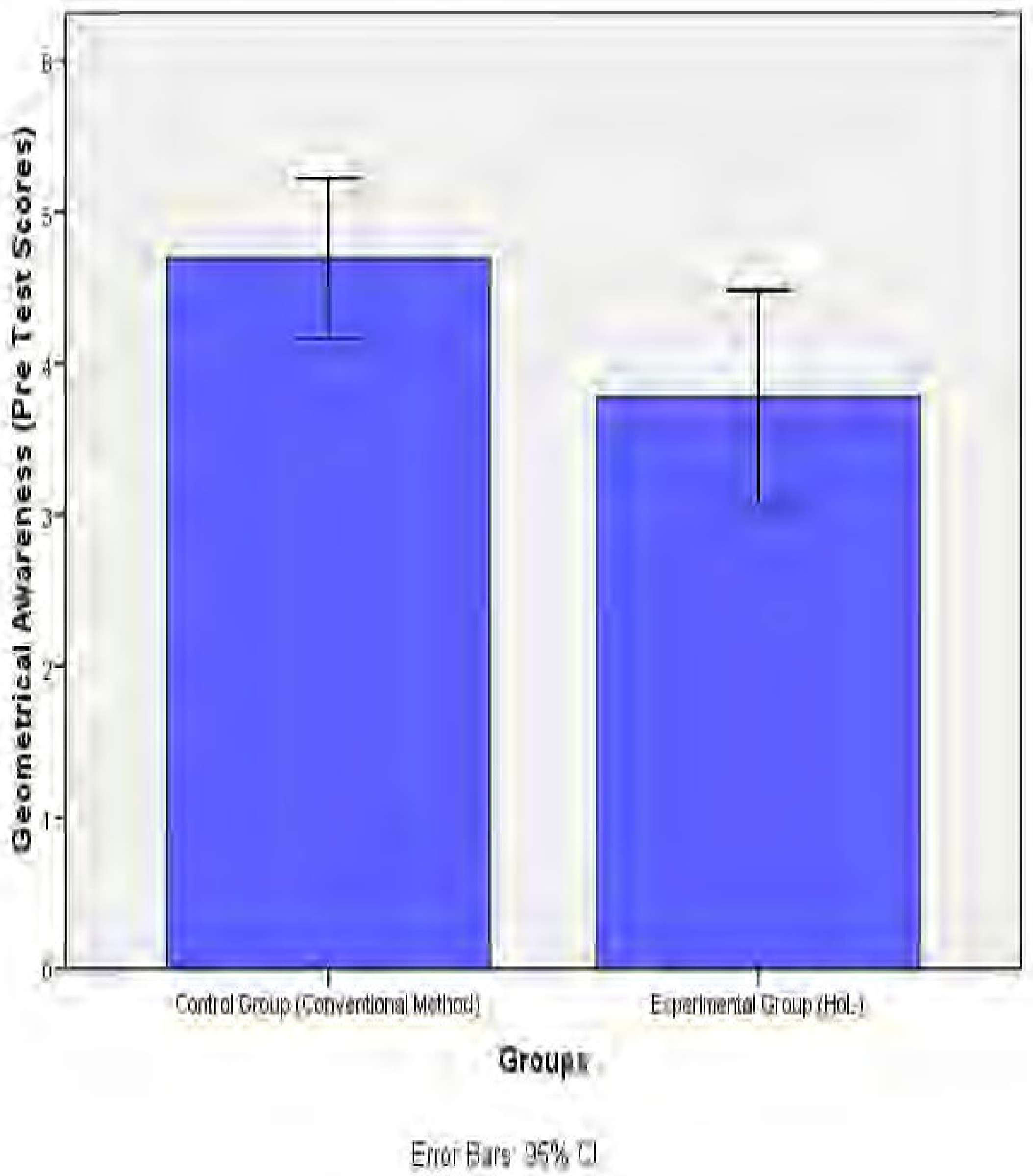

Figure 4.11: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Geometrical Awareness on Pre-test

Figure 4.11 shows the results in table 4.46. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=3.78) and control group (4.69) before treatment. It is also observed that the error bars do not overlap presenting a significant difference between the mean scores of both groups with p=0.038. The direction of the mean difference between these two groups present that students' test score of experimental group is high as compared to control group before treatment.

Table 4.47

One Way ANCOVA and Eta Test for Mean Scores' Difference on Students' Geometrical Awareness Taught by Hands on Learning and Conventional Method on Post-Test

Variable	Group	N	M	SD	df	F	P	Eta
Geometrical Awareness	Exp.	36	8.78	1.514	1,70	45.404	0.000	0.393
	Control	36	6.28	1.632				

Table 4.47 reveals the result of One Way ANCOVA for comparing the mean scores of Students' geometrical awareness taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test while controlling for the pre-test scores. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=8.78, SD=1.514, and the mean scores of control group; N=36, M=6.28, SD=1.632; $F(1,70)= 45.404$ and $p=0.000 < 0.05$. Hence, null hypothesis i.e. "$H_0$24: There is no significant difference in the mean scores of students' geometrical awareness taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=8.78) was more than to the mean scores of control group (M=6.28). Hence, the results show that the instruction based on Hands on Learning is more effective for improving students' geometrical awareness as compared to instructions based on Conventional Method. Moreover, the Eta value (η=0.393) indicates a moderate to strong association between Hands on Learning and geometrical awareness which means that Hands on Learning has significant effect on students' geometrical awareness.

Graphical Representation

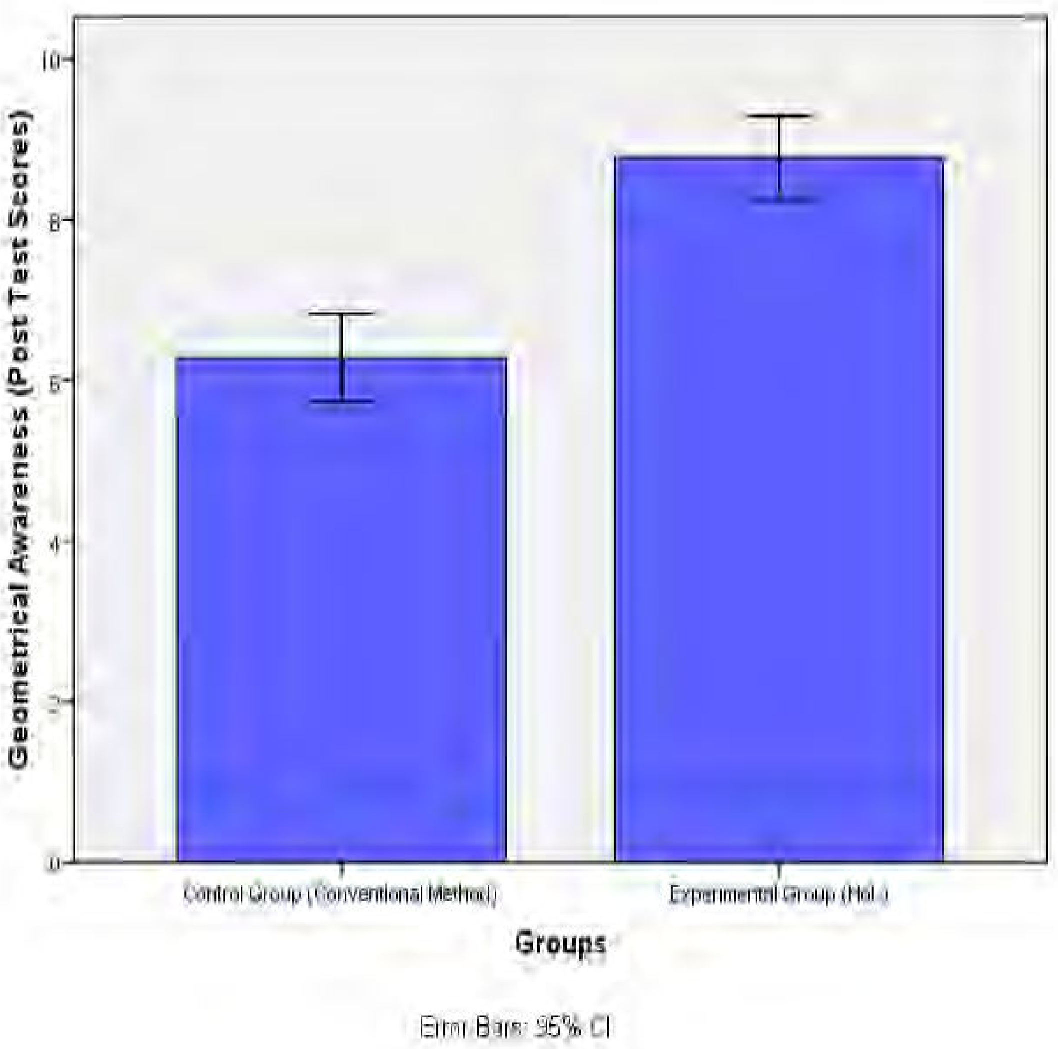

Figure 4.12: Graphical Representation of One Way ANCOVA-test Results for Mean Scores' Difference on Students' Geometrical Awareness on Post-test

Figure 4.12 presents the graphical summary of the results in table 4.47. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=8.78) and control group (6.28) after treatment. It is also observed that the error bars do not overlap suggesting a significant difference between the mean scores of both groups in improving students' geometrical awareness. The direction of the mean difference between these two groups present that Hands on Learning is more effective in improving students' geometrical awareness as compared to Conventional Method. Moreover, the Eta value (η=0.393) indicates that Hands on Learning is more effective in improving students' geometrical awareness.

$H_0$25: There is no significant difference in the mean scores of students' sense of time taught by Hands on Learning and Conventional method.

Statistical Test:

Mean, SD, Independent Sample t-test (Table 4.48)

Mean, SD, One Way ANCOVA, Eta test (Table 4.49)

Table 4.48

Independent Sample t-test for Mean Scores' Difference on Students' Sense of Time Taught by Hands on Learning and Conventional Method on Pre-test

Variable	Group	N	M	SD	t-value	df	p-value
Sense of Time	Exp.	36	4.00	1.639	6.904	70	0.000
	Control	36	6.67	1.639			

Table 4.48 shows the result of independent sample t-test for comparing the mean scores of Students' sense of time taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=4.00, SD=1.639 and the mean scores of control group; N=36, M=6.67, SD=1.639; $t(70) = 6.904$ and $p=0.000 < 0.05$. Hence, null hypothesis "$H_0$25: There is no significant difference in the mean scores of students' sense of time taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of control group (M=6.67) was more than to the mean scores of experimental group (M=4.00). Hence, the mean scores of both groups on pre-test present that there is a statistically significant difference in the mean scores of students' sense of time between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

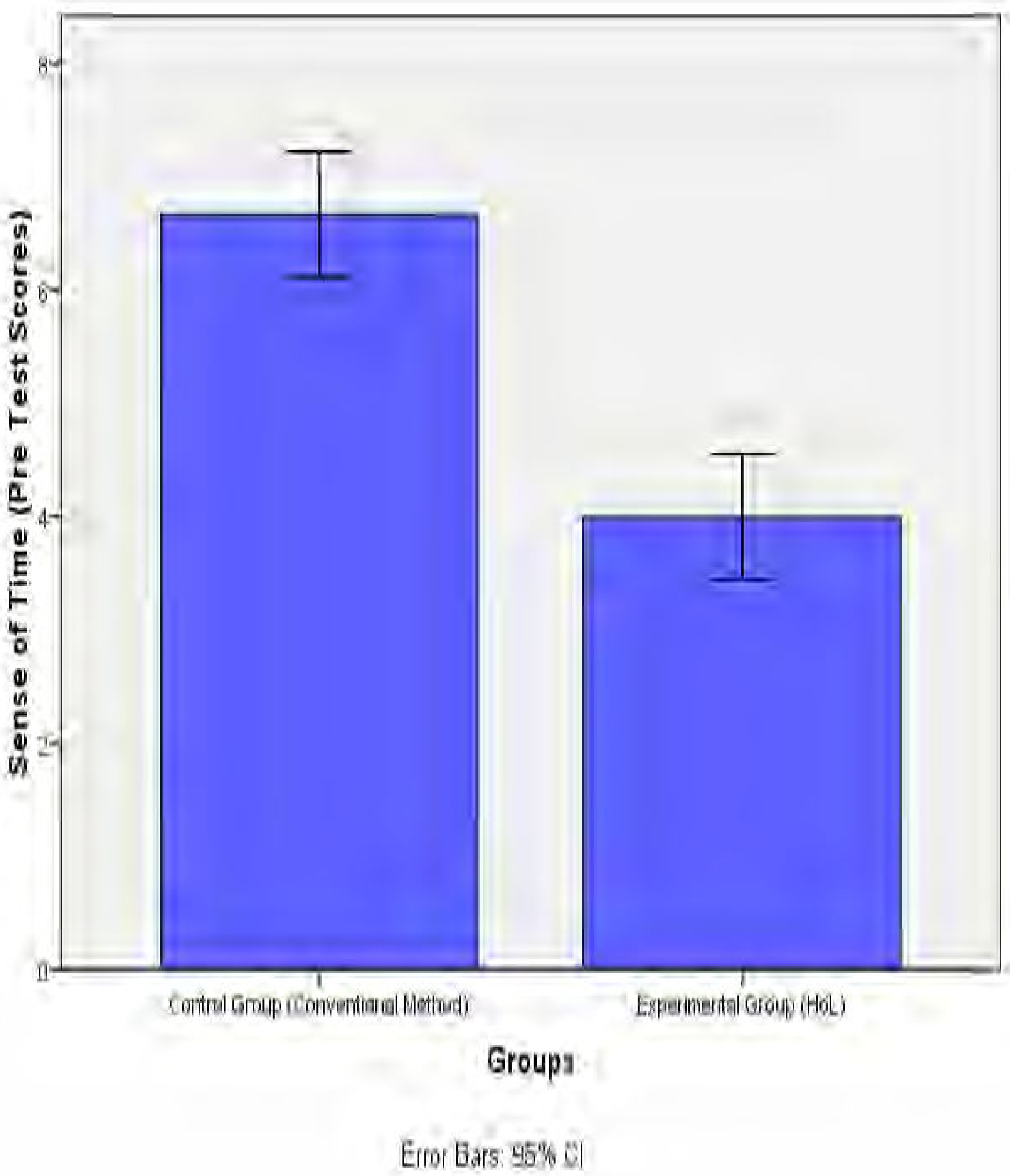

Figure 4.13: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Sense of Time on Pre-test

Figure 4.13 illustrate the pictorial view of the results in table 4.48 The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=4.00) and control group (6.67) before treatment. It is also observed that the error bars do not overlap presenting a significant difference between the mean scores of both groups with p=0.000. The direction of the mean difference between these two groups present that students' test score in sense of time of control group is high as compared to experimental group before treatment.

Table 4.49

One Way ANCOVA and Eta Test for Mean Scores' Difference on Students' Sense of Time Taught by Hands on Learning and Conventional Method on Post-test

Variable	Group	N	M	SD	Df	F-value	p-value	Eta
Sense of Time	Exp.	36	7.31	1.283	70	0.030	0.862	0.000
	Control	36	7.36	1.417				

Table 4.49 shows the result of One Way ANCOVA for comparing the mean scores of Students' sense of time taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test while controlling for the pre-test scores. The results showed that there was no statistical significant difference in the mean scores of experimental group; N=36, M=7.31, SD=1.283, and the mean scores of control group; N=36, M=7.36, SD=1.417; $F(1,70)= 0.030$ and $p=0.862 >0.05$. Hence, null hypothesis i.e. "$H_0$25: There is no significant difference in the mean scores of students' sense of time taught by Hands on Learning and Conventional method" is accepted. Furthermore, the mean test scores of experimental group (M=7.31) was equal to that of the mean scores of control group (M=7.36). Hence, the results show that the instruction based on Hands on Learning and Conventional method has the same effect for improving students' sense of time. Moreover, the Eta value ($\eta=0.000$) indicates no association between Hands on Learning and sense of time which means that Hands on Learning has no significant effect on students' sense of time as compared to control method.

Graphical Representation

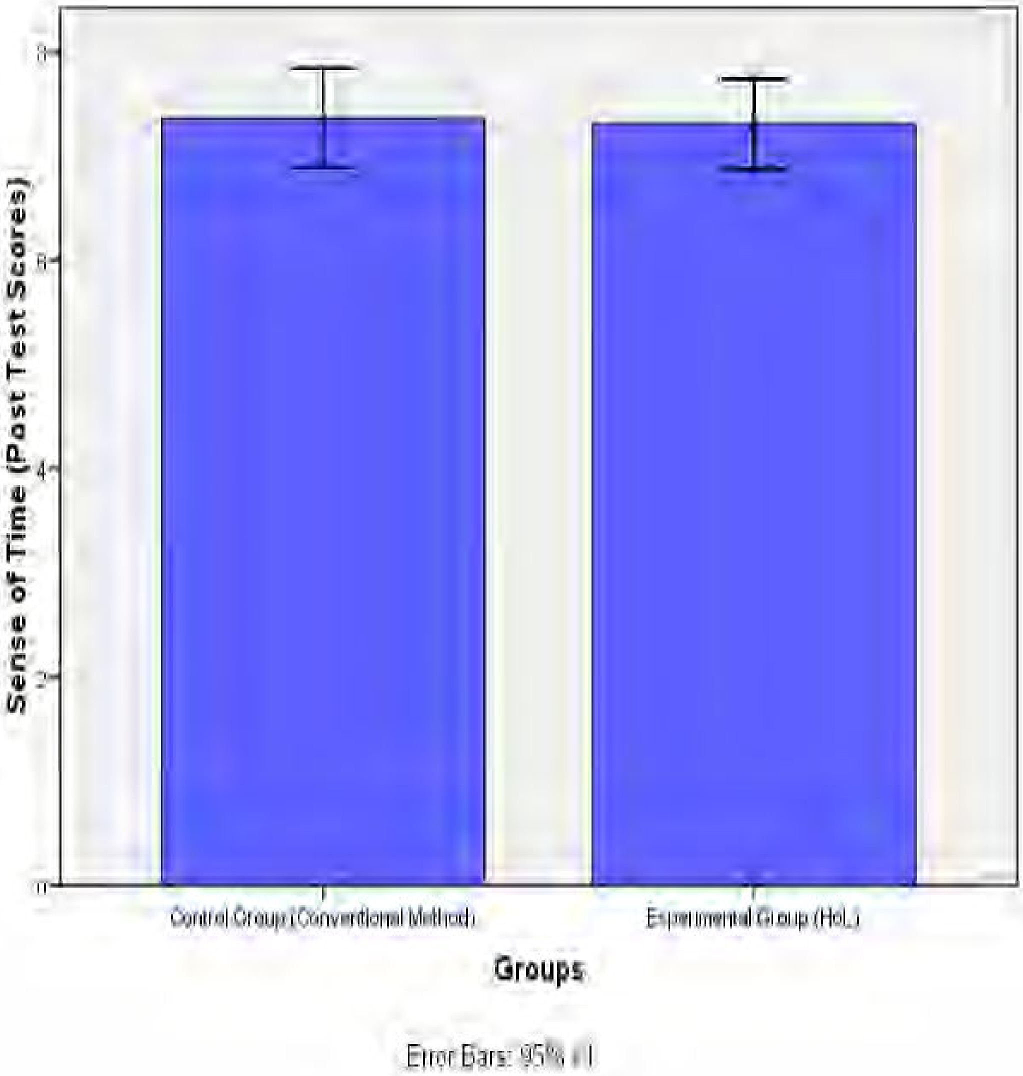

Figure 4.14: Graphical Representation of One Way ANCOVA-test Results for Mean Scores' Difference on Students' Sense of Time on Post-test

Figure 4.14 presents the graphical view of the results in table 4.49. The graph in the above figure showed that there was no significant difference in the mean scores of experimental group (M=7.31) and control group (7.36) after treatment. It is also observed that the error bars overlap indicating no significant difference between the mean scores of both groups in improving students' sense of time. The direction of the mean difference between these two groups present the same effect of Hands on Learning and Conventional Method on students sense of time. Moreover, the Eta value (η=0.000) indicates that Hands on Learning and sense of time has no association in improving sense of time and it is likely due to chance or other extraneous variable.

$H_0$26: There is no significant difference in the mean scores of students' spatial skills taught by Conventional method and Hands on Learning

Statistical Test:

Mean, SD, Independent Sample t-test (Table 4.50)

Mean, SD, One Way ANCOVA, Eta test (Table 4.51)

Table 4.50

Independent Sample t-test for Mean Scores' Difference on Students' Spatial Skills Taught by Hands on Learning and Conventional Method on Pre-test

Variable	Group	N	M	SD	t-value	df	p-value
Spatial Skills	Exp.	36	14.14	3.758	5.127	70	0.000
	Control	36	18.81	3.963			

Table 4.50 shows the result of independent sample t-test for comparing the mean scores of Students' spatial skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=14.14, SD=3.758 and the mean scores of control group; N=36, M=18.81, SD=3.963; t (70) = 5.127 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$26: There is no significant difference in the mean scores of students' spatial skills taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of control group (M=18.81) was more than to the mean scores of experimental group (M=14.14). Hence, the mean scores of both groups on pre-test present that there is a statistically significant difference in the mean scores of students' spatial skills between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

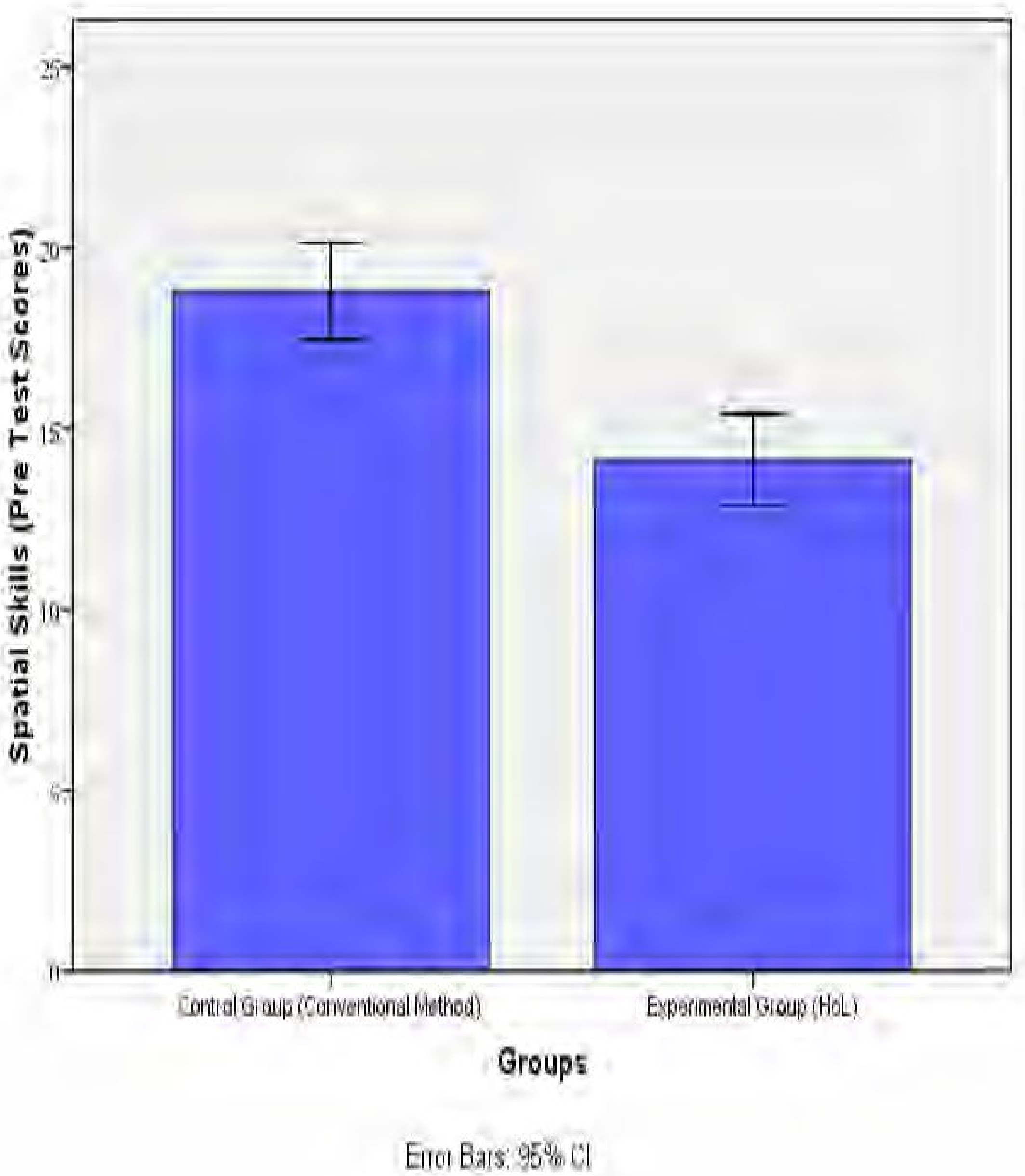

Figure 4.15: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Spatial Skills on Pre-test

Figure 4.15 presents the pictorial view of the results in table 4.50. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=14.14) and control group (18.81) before treatment. It is also observed that the error bars do not overlap presenting a significant difference between the mean scores of both groups with p=0.000. The direction of the mean difference between these two groups present that students' test score in spatial skills of control group is high as compared to experimental group before treatment.

Table 4.51

One Way ANCOVA and Eta Test for Mean Scores' Difference on Students' Spatial Skills Taught by Hands on Learning and Conventional Method on Post-test

Variable	Group	N	M	SD	df	F-value	p-value	Eta
Spatial Skills	Exp.	36	25.89	2.459	1,70	22.470	0.000	0.243
	Control	36	22.36	3.728				

Table 4.51 reveals the result of One Way ANCOVA for comparing the mean scores of Students' spatial skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test while controlling for the pre-test scores. The results showed that there was a statistical significant difference in the mean scores of experimental group; N=36, M=25.89, SD=2.459, and the mean scores of control group; N=36, M=22.36, SD=3.728; $F(1,70)= 22.470$ and $p=0.000 < 0.05$. Hence, null hypothesis i.e. "$H_0$26: There is no significant difference in the mean scores of students' spatial skills taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=25.89) was more than to the mean scores of control group (M=22.36). Hence, the results show that the instruction based on Hands on Learning is more effective for improving students' spatial skills as compared to instructions based on Conventional Method. Moreover, the Eta value (η=0.243) indicates a moderate to strong association between Hands on Learning and spatial skills which means that Hands on Learning has significant effect on students' spatial skills.

Graphical Representation

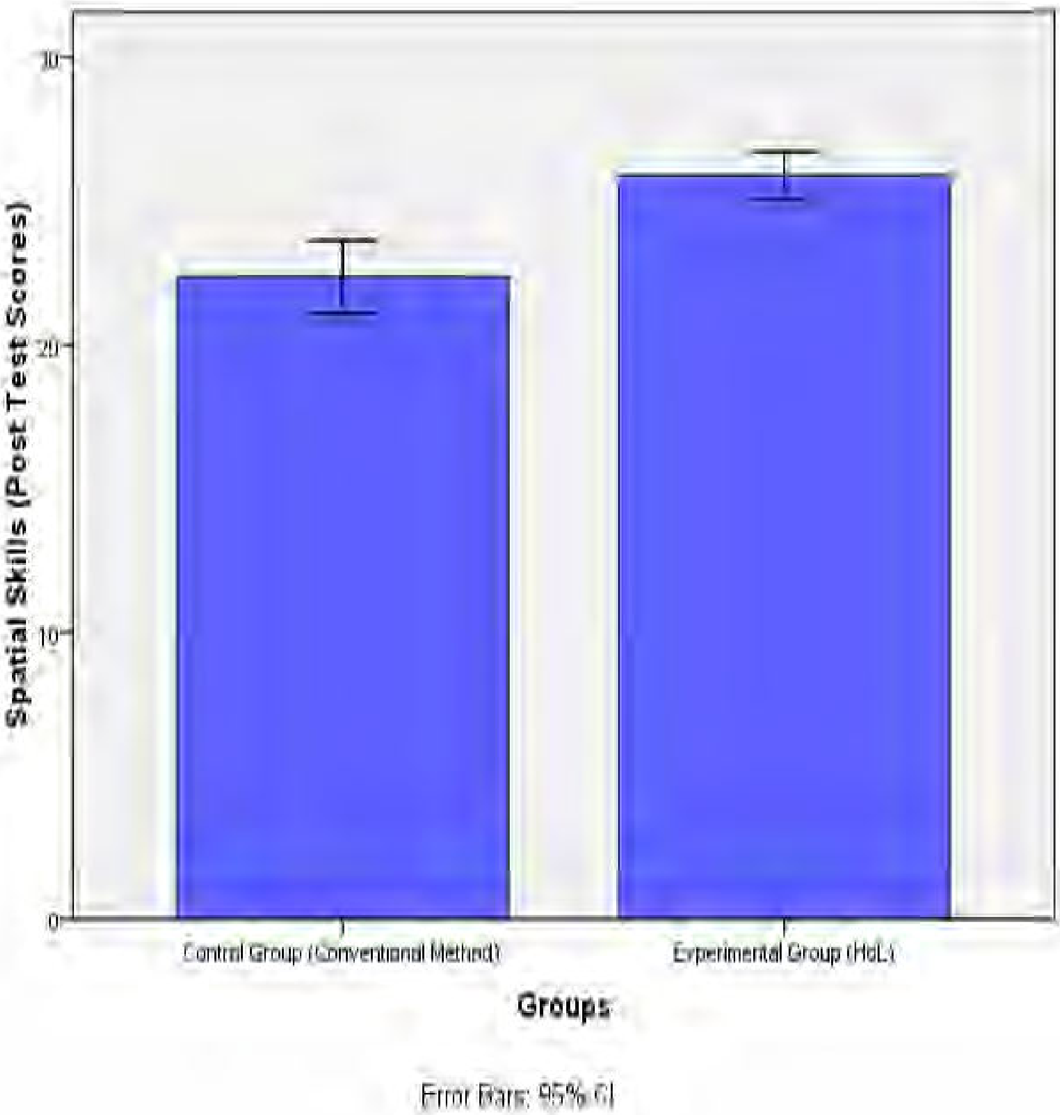

Figure 4.16: Graphical Representation of One Way ANCOVA-test Results for Mean Scores' Difference on Students' Spatial Skills on Post-test

Figure 4.16 presents the graphical view of the results in table 4.51. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=25.89) and control group (22.36) after treatment. It is also observed that the error bars overlap indicating a significant difference between the mean scores of both groups in improving students' spatial skills. The direction of the mean difference between these two groups present that the Hands on Learning is more effective in improving students' spatial skills as compared to Conventional Method. Moreover, the Eta value (η=0.243) indicates that Hands on Learning is more effective in improving students' spatial skills.

$H_0$27: There is no significant difference in the mean scores of students' mathematical thinking taught by Conventional method and Hands on Learning

Statistical Test:

Mean, SD, Independent Sample t-test (Table 4.52 & 4.53)

Table 4.52

Independent Sample t-test for Mean Scores' Difference on Students' Mathematical Thinking Taught by Hands on Learning and Conventional Method on Pre-test

Variable	Group	N	M	SD	t-value	Df	p-value
Mathematical Thinking	Exp.	36	12.53	3.247	1.012	70	0.315
	Control	36	11.69	3.725			

Table 4.52 shows that there was no statistically significant difference in the mean scores of experimental group; N=36, M=12.53, SD=3.247, and the mean scores of control group; N=36, M=11.69, SD=3.725; $t(70) = 1.012$ and $p=0.315 > 0.05$ on Students' mathematical thinking. Hence, null hypothesis "$H_0$27: There is no significant difference in the mean scores of students' mathematical thinking taught by Hands on Learning and Conventional method" is accepted. Furthermore, the mean test scores of experimental group (M=12.53) was almost similar to the mean scores of control group (M=11.69). Hence, the mean scores of both groups in pre-test present that there is no statistically significant difference in the mean scores of students' mathematical thinking between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

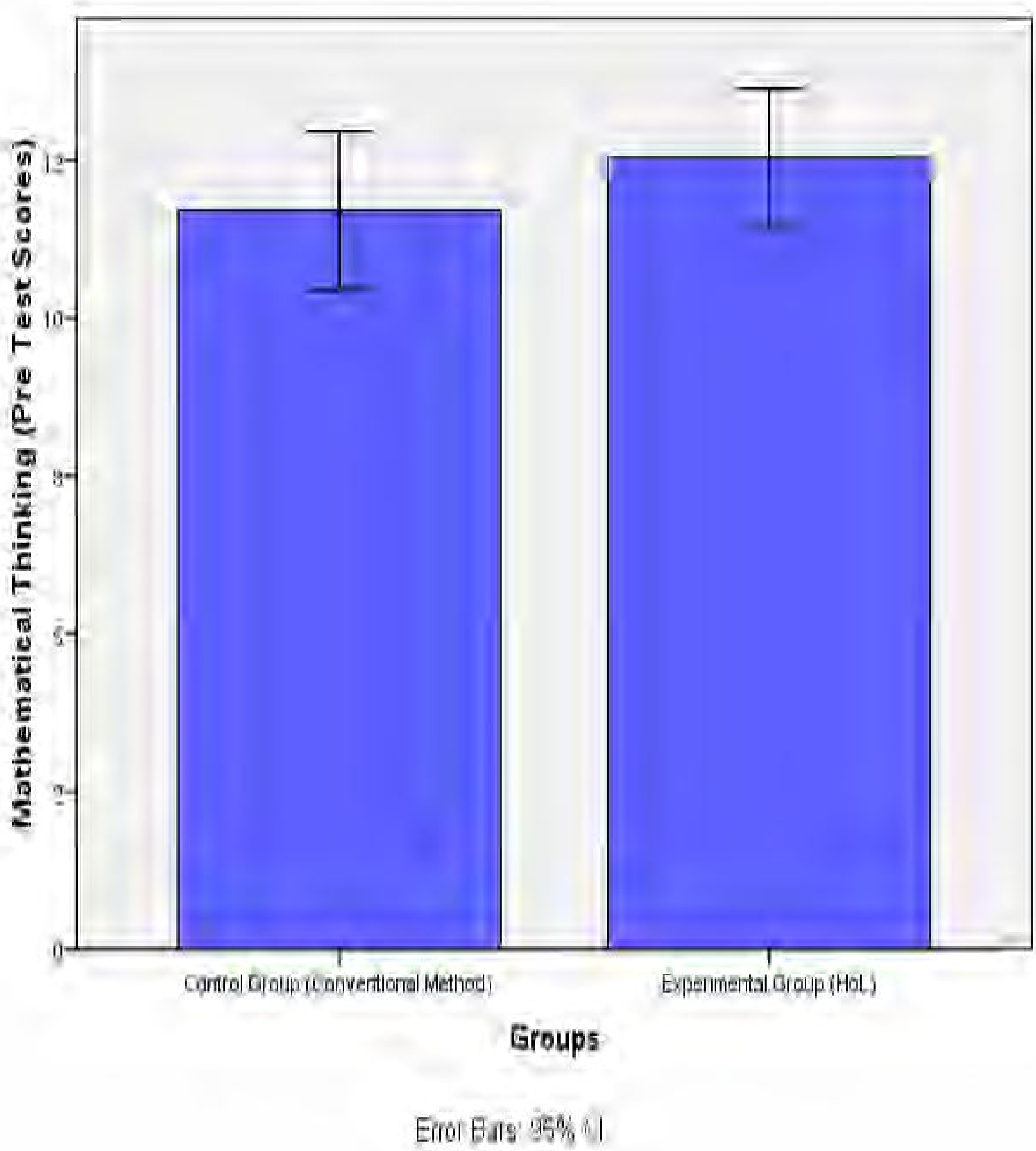

Figure 4.17: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Mathematical Thinking on Pre-test

Figure 4.17 illustrates the graphical summary of the results in table 4.52. The graph in the above figure showed that there was no significant difference in the mean scores of experimental group (M=12.53) and control group (11.69) before treatment. It is also observed that the error bars overlap presenting no significant difference between the mean scores of both groups with p=0.315>0.05. The direction of the mean difference between these two groups presents that the students' test score in mathematical thinking are almost same of both groups before treatment.

Table 4.53

Independent Sample t-test for Mean Scores' Difference on Students' Mathematical Thinking Taught by Hands on Learning and Conventional Method on Post-Test

Variable	Group	N	M	SD	t-value	Df	p-value
Mathematical Thinking	Exp.	36	21.58	2.655	7.688	70	0.000
	Control	36	15.53	3.910			

Table 4.53 shows the result of independent sample t-test for comparing the mean scores of Students' mathematical thinking taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=21.58, SD=2.655 and the mean scores of control group; N=36, M=15.53, SD=3.910; t (70) = 7.688 and p=0.000 < 0.05. Hence, null hypothesis i.e."$H_0$27: There is no significant difference in the mean scores of students' mathematical thinking taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=21.58) was more than to the mean scores of control group (M=15.53). Hence, the mean scores of both groups on post-test present that there is a statistically significant difference in the mean scores of students' mathematical thinking between Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test.

Graphical Representation

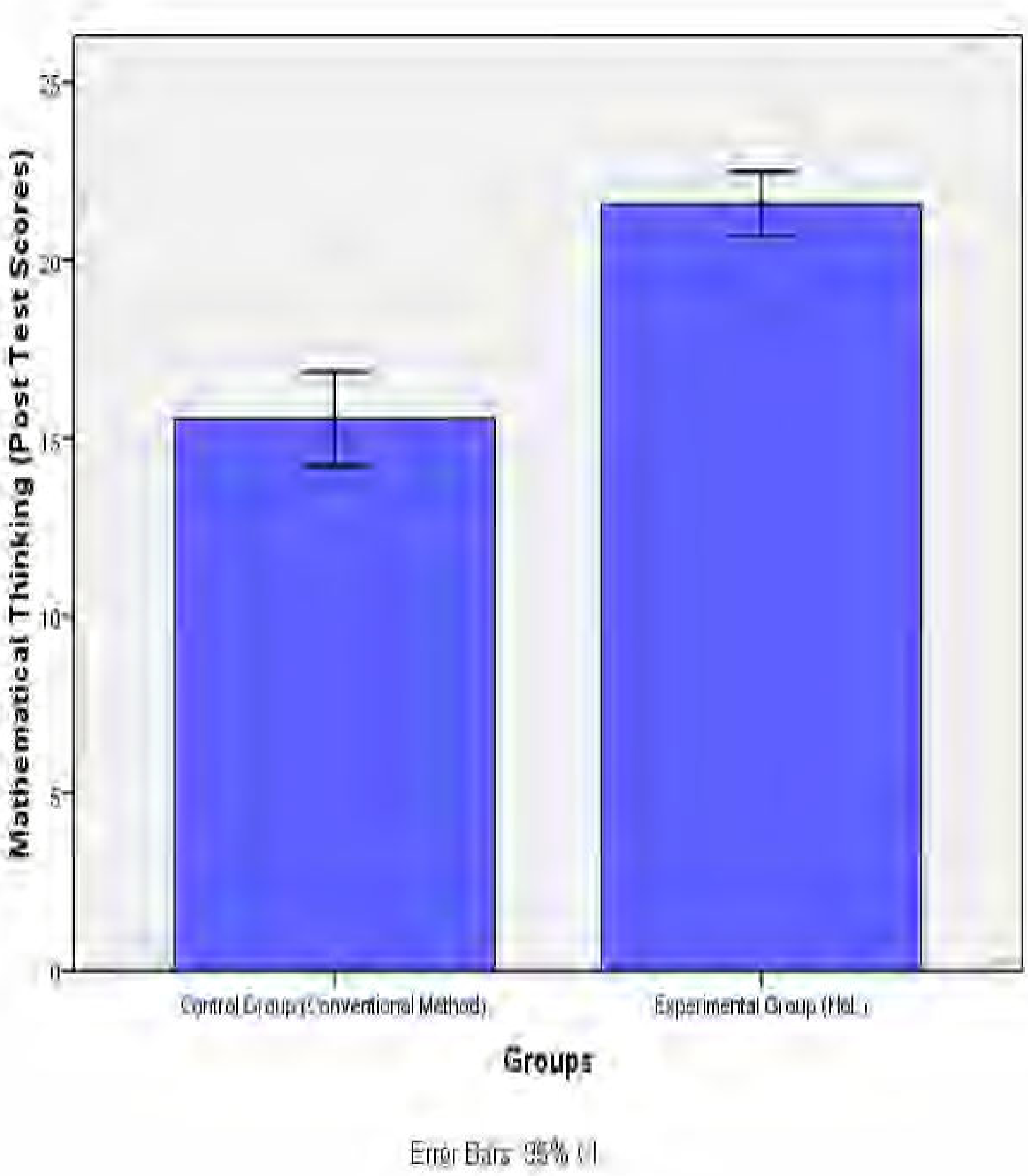

Figure 4.18: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Mathematical Thinking on Post-test

Figure 4.18 presents the pictorial view of the results in table 4.53. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=21.58) and control group (15.53) after treatment. It is also observed that the error bars do not overlap indicating a significant difference between the mean scores of both groups in improving students' mathematical thinking. The direction of the mean difference between these two groups present that Hands on Learning is more effective in improving students' mathematical thinking as compared to Conventional Method.

$H_0$28: There is no significant effect of Hands on Learning on students' scientific skills.

Statistical Test: Mean, SD, Paired Sample t-test

Table 4.54

Paired Sample t-test for effect of Hands on Learning on Students' Scientific Skills

Variable	N	Pre Test		Post Test		t-value	df	p-value
		M	SD	M	SD			
Scientific Skills	**36**	**45.78**	**9.610**	**76.94**	**6.516**	**16.074**	**35**	**0.000**

Table 4.54 presents the result of paired sample t-test regarding instructions based on Hands on Learning in scientific skills. The results showed that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=76.94, SD=6.516, and pre test; N=36, M=45.78, SD=9.610. t (35) = 16.074 and p=0.000 < 0.05. Hence, null hypothesis "$H_0$28: There is no significant effect of Hands on Learning on students' scientific skills" is rejected. Furthermore, the mean value of post-test (M=76.94) was greater than that of pre-test (M=45.78). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of Hands on Learning on students' scientific skills.

Graphical Representation

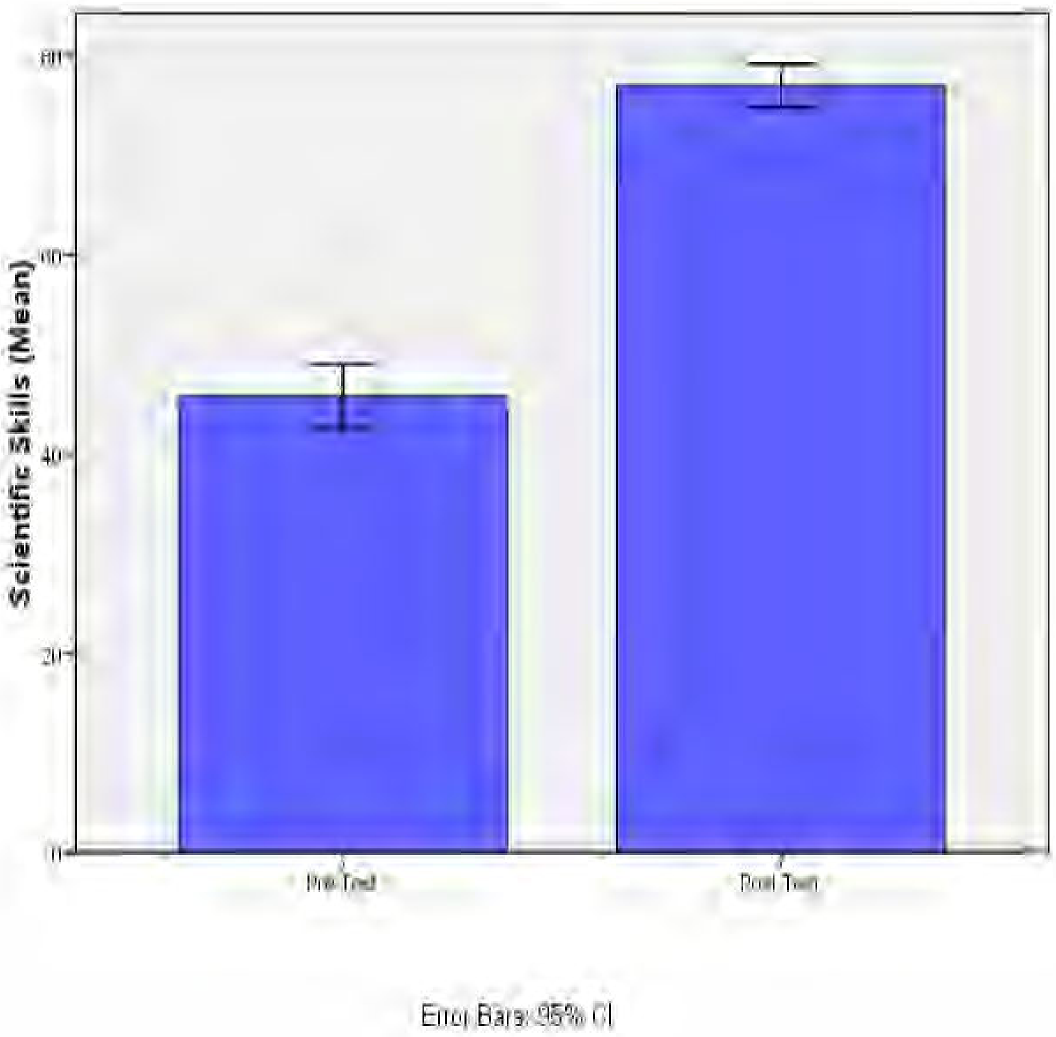

Figure 4.19: Graphical Representation of Paired Sample t-test Results for Mean Scores' Difference on Students' Scientific Skills through Hands on Learning on Pre-test and Post-test

Figure 4.19 provides the graphical summary of the results in table 4.54. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (Hands on Learning) on pre test (M=45.78) and post test (76.94). It is also observed that the error bars are not overlapping presenting a significant difference between the mean scores of both groups with p=0.000. The direction of the mean difference between pre-test and post-test present that the Students are performing better when intervention was given through Hands on Learning. Overall, the results show that treatment was effective regarding instructions based on Hands on Learning for improving students' scientific skills.

H_029: There is no significant effect of Conventional Method on students' scientific skills.

Statistical Test: Mean, SD, Paired Sample t-test

Table 4.55

Paired Sample t-test for effect of Conventional Method on Students' Scientific Skills

Variable	N	Pre Test		Post Test		t-value	df	p-value
		M	SD	M	SD			
Scientific Skills	**36**	**44.64**	**9.728**	**56.83**	**9.866**	**14.352**	**35**	**0.000**

Table 4.55 presents the result of paired sample t-test regarding conventional method in scientific skills. The results showed that there was a statistically significant difference in the mean scores of students in post-test; N=36, M=56.83, SD=9.866, and pre-test; N=36, M=44.64, SD=9.728. t (35) = 14.352 and $p=0.000 < 0.05$. Hence, null hypothesis "H_029: There is no significant effect of conventional method on students' scientific skills" is rejected. Furthermore, the mean value of post-test (M=56.83) was greater than that of pre-test (M=44.64). Hence, the students scored more in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' scientific skills.

Graphical Representation

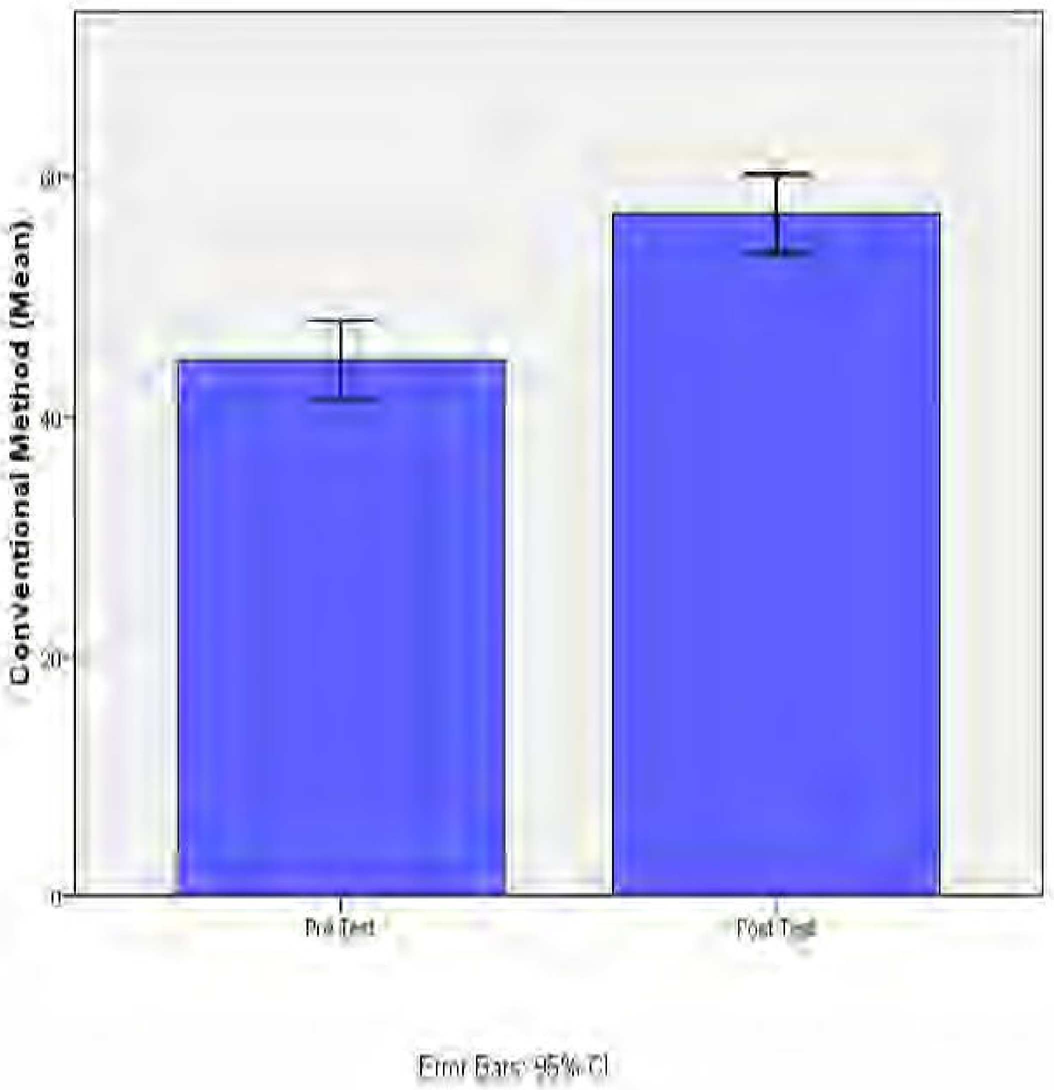

Figure 4.20: Graphical Representation of Paired Sample t-test Results for Mean Scores' Difference on Students' Scientific Skills through Conventional Method on Pre-test and Post-test

Figure 4.20 provides the graphical summary of the results in table 4.55. The graph in the above figure showed that there was a significant difference in the mean scores of Control group (Conventional Method) on pre test (M=44.64) and post test (56.83). It is also observed that the error bars are not overlapping presenting a significant difference between the mean scores of both groups with p=0.000. The direction of the mean difference between pre-test and post-test presents that the Students are performing better when intervention was given through Conventional Method. Overall, the results show that treatment was effective through Conventional Method for improving students' scientific skills.

$H_0$30: There is no significant difference in students' scientific skills taught by Hands on Learning and Conventional method.

Statistical Test: Mean, SD, Independent Sample t-test (Table 4.56 & Table 4.57)

Table 4.56

Independent Sample t-test for Mean Scores' Difference on Students' Scientific Skills Taught by Hands on Learning and Conventional Method on Pre-test

Variable	Group	N	M	SD	t-value	df	p-value
Scientific Skills	Exp.	36	45.78	9.610	0.500	70	0.619
	Control	36	44.64	9.728			

Table 4.56 shows the result of independent sample t-test for comparing the mean scores of Students' scientific skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test. The results showed that there was no statistically significant difference in the mean scores of experimental group; N=36, M=45.78, SD=9.610, and the mean scores of control group; N=36, M=44.64, SD=9.728; $t(70) = 0.500$ and $p=0.619 > 0.05$ on Students' scientific skills. Hence, null hypothesis "$H_0$30: There is no significant difference in the mean scores of students' scientific skills taught by Hands on Learning and Conventional method" is accepted. Furthermore, the mean test scores of experimental group (M=45.78) was almost similar to the mean scores of control group (M=44.64). Hence, the mean scores of both groups in pre-test present that there is no statistically significant difference in the mean scores of students' scientific skills between Hands on Learning (Experimental group) and Conventional Method (Control group) on pre-test.

Graphical Representation

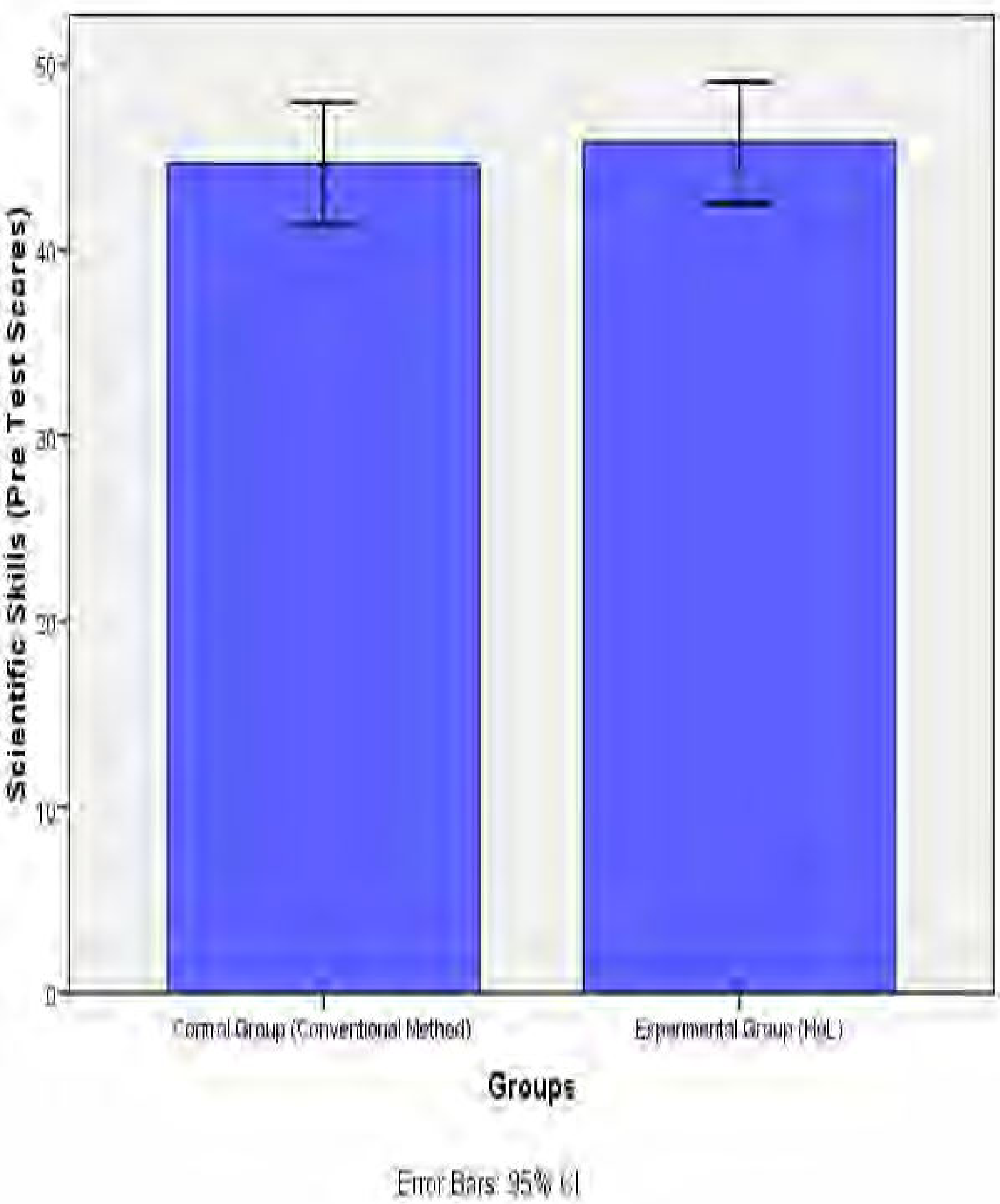

Figure 4.21: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Scientific Skills on Pre-test

Figure 4.21 illustrates the graphical summary of the results in table 4.60. The graph in the above figure showed that there was no significant difference in the mean scores of experimental group (M=45.78) and control group (44.64) before treatment. It is also observed that the error bars overlap presenting no significant difference between the mean scores of both groups with p=0.619. The direction of the mean difference between these two groups present that the students' test score in scientific skills are almost same of both groups before treatment.

Table 4.57

Independent Sample t-test for Mean Scores' Difference on Students' Scientific Skills Taught by Hands on Learning and Conventional Method on Post-test

Variable	Group	N	M	SD	t-value	df	p-value
Scientific Skills	Exp.	36	76.94	6.516	10.206	70	0.000
	Control	36	56.83	9.866			

Table 4.57 shows the result of independent sample t-test for comparing the overall mean scores of Students' scientific skills taught by Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test. The results showed that there was a statistically significant difference in the mean scores of experimental group; N=36, M=76.94, SD=6.516 and the mean scores of control group; N=36, M=56.83, SD=9.866; $t(70) = 10.206$ and $p=0.000 < 0.05$. Hence, null hypothesis i.e."$H_0$30: There is no significant difference in the mean scores of scientific skills taught by Hands on Learning and Conventional method" is rejected. Furthermore, the mean test scores of experimental group (M=76.94) was more than to the mean scores of control group (M=56.83). Hence, the mean scores of both groups on post-test present that there is a statistically significant difference in the mean scores of students' scientific skills between Hands on Learning (Experimental group) and Conventional Method (Control group) on post-test and students performed better after treatment.

Graphical Representation

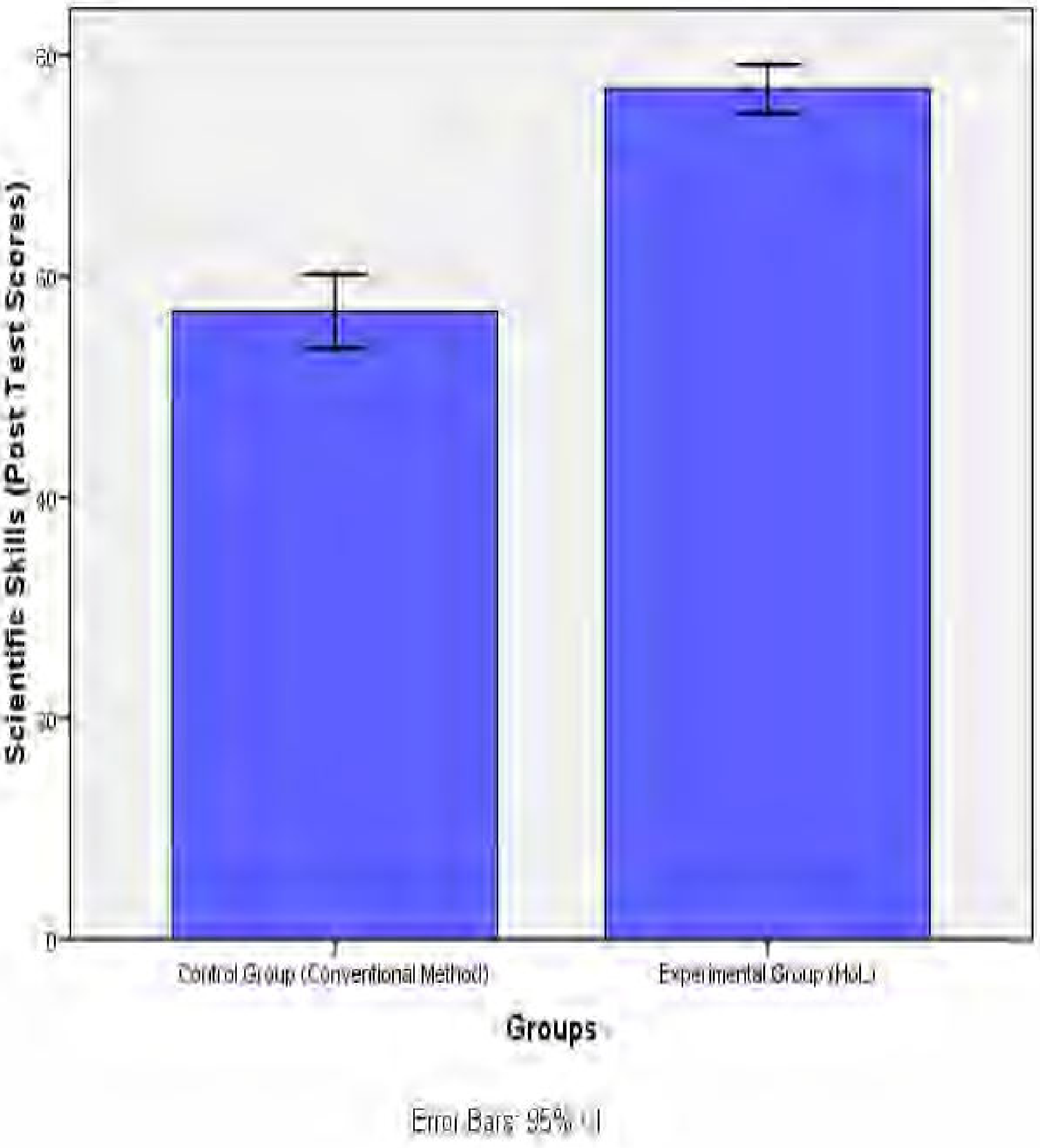

Figure 4.22: Graphical Representation of Independent t-test Results for Mean Scores' Difference on Students' Scientific Skills on Post-test

Figure 4.22 provides the graphical summary of the results in table 4.57. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=76.94) and control group (56.83) after treatment. It is also observed that the error bars do not overlap indicating a significant difference between the mean scores of both groups in improving students' scientific skills. The direction of the mean difference between these two groups present that instructions based on Hands on Learning are more effective in improving students' scientific skills as compared to Conventional Method.

4.9 Summary of Chapter 4

This chapter presents the results of the data collection and analysis process. The data were collected from 72 first graders who participated in the study, with 36 students in the experimental group receiving instruction through Hands on Learning and 36 students in the control group receiving instruction through conventional method. The Mathematics Achievement Test (MAT) was administered as a pretest and posttest to measure scientific skills. The data were analyzed by using descriptive, inferential statistics and through graphical representation. In this chapter, the results were presented in alignment with seven objectives and thirty hypotheses of the study. This chapter consisted of 57 tables and 22 figures. Descriptive statistics (Mean and SD) revealed that the experimental group showed significant improvement in scientific skills, with a mean posttest score; M= 76.94 compared to a mean pretest score; M=45.78. In contrast, the control group showed minimal improvement, with a mean posttest score; M= 56.83 compared to a mean pretest score; M=44.64. Inferential statistics, including paired sample t-test, independent sample t-test and ANCOVA, were used to compare the mean scores of the experimental and control groups. The results showed that the experimental group performed significantly better than the control group on the posttest, with a p-value of 0.000 <0.005. The Eta test results also revealed that the Hands-on learning had a significant effect on scientific skills on post-test scores. The graphical representation also showed positive effect of Hands on Learning on the development of scientific skills in first graders. Overall, the results of this study provide strong evidence for the effectiveness of Hands-on Learning activities in improving scientific skills in first graders.

CHAPTER 5
SUMMARY, FINDINGS, DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Mathematics is known as queen of all subjects and its effect is in the whole life of students. So, if it is taken at early stages, its effect will be long life. The only way to promote mathematics learning and developing scientific skills in Mathematics among students at early stages is to engage them in different activities by using activity-based pedagogies. Hands on Learning (HoL) is considered the best activity-based pedagogy. It guides the students to gain knowledge by experience and learning by doing. Keeping in view the outcomes of Hands on Learning, it was found imperative to conduct a study for analyzing the effect of Hands on Learning on the development of scientific skills in first graders. The objectives of the current study were; 1). to measure the effect of Hands on Learning on the development of scientific skills in terms of numerical skills, 2). to examine the effect of Hands on Learning on the development of scientific skills in terms of spatial skills, 3).to evaluate the effect of Hands on Learning on the development of scientific skills in terms of mathematical thinking, 4). to measure the effect of conventional method on the development of scientific skills in terms of numerical skills, 5). to examine the effect of conventional method on the development of scientific skills in terms of spatial skills, 6). to evaluate the effect of conventional method on the development of scientific skills in terms of mathematical thinking, and 7). to compare the effect of Hands on Learning (experimental group) with conventional method (control group) on the development of scientific skills. The study was experimental in nature. True Experimental Research Design: the pretest-posttest equivalent group was used. In the present study, the target population of the study was first grader students of district Kotli who were studying Mathematics. Government Boys High School Hatli Kotli was selected randomly as a sample. From this school, 72 Mathematics Students of first graders were chosen which were divided into two groups such as Group- A (Experimental Group) and Group-B (Control Group). These both groups were formed through randomization and each group consisting of 36 students. Experimental group was taught by Hands on Learning and Control group was taught by Conventional Method and the duration of the study was eight weeks. Pre-test and post-test were used as research instruments. Pre-test and post-test were of 100 marks consisting of 20 MCQs items, 10 completion items, 5 True / False items, 5 matching columns items, 18 short answers items and 6 open-ended items. Research instruments were validated by educational experts of International Islamic University Islamabad, Women University of Bagh AJ&K, International Ibadat University Islamabad, University of Kotli, Principal GCET (Male) Kotli, Subject Specialist of Mathematics and Head Examiner of Mathematics BISE AJ&K. Pilot testing was executed on fifteen Mathematics students of Grade-1 in Government Boys Higher secondary School Andrla Nar Kotli AJ&K. Cronbach's Alpha was used to test the reliability of pre-test and post-test and its value was 0.83. Thirty two (32) lessons were planned for this study from the text book of Mathematics Grade-1 in consultation with the educational experts for experimental group. Data were collected in the form of pretest before treatment and posttest after treatment from both groups and results were collected. Data were analyzed by using descriptive statistics (Mean & SD), inferential statistics (Paired sample t-test, Independent Sample t-test, One Way ANCOVA and Eta-test) and graphical representation through SPSS Version 25.

5.2 Findings

The findings of the study were;

5.2.1 Findings Related to Measure the Effect of Hands on Learning on the Development of Scientific Skills in terms of Numerical Skills

The analysis of the data revealed the positive effect of Hands on Learning on the development of scientific skills in terms of numerical skills including number sense, counting skills and basic arithmetic skills in first graders. The findings are as under:

1. It was found that the mean achievement scores of students increased from M=6.83 (SD=1.935) to M= 986 (1.018) in number sense, M=8.69 (SD=2.352) to M=9.97 (SD=1.483) in counting skills and M= 3.61 (3.101) to M= 9.64 (1.839) in basic arithmetic skills with the mean differences of 3.03, 1.28 & 6.03 respectively which shows that the performance of students was better in all variables of numerical skills (number sense, counting skills and basic arithmetic skills) taught by Hands on Learning from pre-test to post-test (Table 4.1).
2. Descriptive statistics explored that the mean achievement scores of students increased from M=19.11 (SD=5.888) to M=29.44 (3.418) with the difference

of 10.33 in numerical skills which shows that the students were performing better in numerical skills taught by Hands on Learning (Table 4.2).

3. It was revealed that the mean achievement scores of students were better in number sense instructed by Hands on Learning on posttest . The scores of posttest were; N=36, M=9.86, SD=1.935, and pre-test were; N=36, M=6.83, SD=1.018; t (35) = 8.220 and p=0.000 < 0.05 (Table 4.3).
4. It was illustrated that there was a significant difference between the achievement scores of pre-test and post-test in students' counting skills taught by Hands on Learning from pre-test to post-test. The scores of post-test were; N=36, M=9.97, SD=1.483, and pre-test were; N=36, M=8.69, SD=2.352; t (35) = 2.839 and p=0.007 < 0.05 (Table 4.4).
5. It was found that there was a significant difference between the achievement scores of students' basic arithmetic skills taught by Hands on Learning from pre-test to post-test. The scores of post-test were; N=36, M=9.64, SD=1.839, and pre-test were; N=36, M=3.6, SD=3.101; t (35) = 9.736 and p=0.007 < 0.05 (Table 4.5).
6. The results of the study presented that there was a significant difference in the mean achievement scores of students' numerical skills taught by Hands on Learning from pre-test to post-test. The scores of post-test were; N=36, M=29.44, SD=3.418, and pre-test were; N=36, M=19.11, SD=5.888. t (35) = 8.779 and p=0.000 < 0.05 (Table 4.6).

5.2.2 Findings Related to Measure the Effect of Hands on Learning on the Development of Scientific Skills in terms of Spatial Skills

The analysis of the data revealed the positive effect of Hands on Learning on the development of scientific skills in terms of spatial skills including spatial sense, geometrical awareness and sense of time in first graders. The findings are as under:

7. It was found from the descriptive statistics that the mean achievement scores of students increased from M= 6.36 (SD=1.175) to M= 9.81 (SD=1.305) in spatial sense, M= 3.78 (SD=2.085) to M= 8.78 (SD=1.514) in geometrical awareness and M= 4.00 (SD=1.639) to M= 7.31 (SD=1.283) in sense of time skills with the mean differences of 3.45, 5.00 & 3.31 respectively which shows that the performance of students is better in all variables of spatial skills taught by Hands on Learning from pre-test to post-test (Table 4.7).

8. Descriptive statistics explored that the mean achievement scores of students increased from M= 14.22 (SD=3.986) to M= 25.89 (SD= 2.459) with the difference of 11.67 in spatial skills which shows that the performance of students is better in spatial skills through Hands on Learning from pre-test to post-test (Table 4.8).
9. It was revealed that there was a significant difference between the achievement scores of students' spatial sense taught by Hands on Learning from pre-test to post-test. The scores of post-test were; M=9.81, SD=1.305, and pre-test were; N=36, M=6.36, SD=1.175. t (35) = 12.686 and p=0.000 < 0.05 (Table 4.9).
10. It was illustrated that there was a significant difference between the achievement scores of pre-test and post-test in students' geometrical awareness on Hands on Learning from pre-test to post-test. The scores of post-test were; N=36, M=8.78, SD=1.514, and pre-test were; N=36, M=3.78, SD=2.085. t (35) = 11.225 and p=0.000 < 0.05 (Table 4.10).
11. It was found that there was a significant difference between the achievement scores of students' sense of time skills taught by Hands on Learning from pre-test to post-test. The scores of post-test were; N=36, M=7.31, SD=1.283, and pre-test were; N=36, M=4.00, SD=1.639. t (35) = 9.062 and p=0.000 < 0.05 (Table 4.11).
12. The results of the study presented that there was a significant difference in the mean achievement scores of students' spatial skills taught by Hands on Learning from pre-test to post-test. The scores of post-test were; N=36, M=25.89, SD=2.459, and pre-test were; N=36, M=14.14, SD=2.459. t (35) = 15.557 and p=0.000 < 0.05 (Table 4.12).

5.2.3 Findings Related to Measure the Effect of Hands on Learning on the Development of Scientific Skills in terms of Mathematical Thinking

The analysis of the data revealed the positive effect of Hands on Learning on the development of scientific skills in terms of mathematical thinking in first graders. The findings are as under:

13. Descriptive statistics explored that the mean achievement scores of students increased from M= 12.53 (SD=3.246) to M= 21.58 (SD=2.655) with the difference of 9.05 in mathematical reasoning and thinking skills which shows that the performance of students is better in mathematical reasoning

and thinking skills taught by Hands on Learning from pre-test to post-test (Table 4.13).

14. It was revealed that there was a significant difference between the achievement scores of students' mathematical reasoning and thinking skills regarding HoL from pre-test to post-test. The scores of post-test were; N=36, M=21.58, SD=2.655, and pre-test; N=36, M=12.53, SD=3.247, t (35) = 14.180 and p=0.000 < 0.05 (Table 4.14).

5.2.4 Findings Related to Measure the Effect of Conventional Method on the Development of Scientific Skills in terms of Numerical Skills

The analysis of the data revealed the positive effect of Conventional Method on the development of scientific skills in terms of numerical skills including number sense, counting skills and basic arithmetic skills in first graders. The findings are as under:

15. It was found from the descriptive statistics that the mean achievement scores of students increased from M= 6.14 (SD=1.869) to M= 7.89 (SD=1.769) in number sense, M= 7.22 (SD=1.397) to M= 6.14 (SD= 2.140) in counting skills and M= 2.92 (SD=1.713) on pre-test and M= 4.00 (SD= 1.957) in basic arithmetic skills with the mean differences of 1.75, 1.08 & 1.08 respectively which shows that the performance of students is better in all variables of numerical skills (number sense, counting skills and basic arithmetic skills) through Conventional Method from pre-test to post-test (Table 4.15).

16. Descriptive statistics explored that the mean achievement scores of students increased from M= 15.17 (SD=3.197) to M= 18.99 (SD= 4.187) with the difference of 3.82 in numerical skills which shows that the students performed better in numerical skills taught by Conventional Method from pre-test to post-test (Table 4.16).

17. It was revealed that there was a significant difference between the achievement scores of students' number sense regarding instructions based on Conventional Method from pre-test to post-test. The scores of post-test were; N=36, M=7.89, SD=1.769, and pre-test were; N=36, M=6.14, SD=1.869, t (35) = 10.247 and p=0.000 < 0.05 (Table 4.17).

18. It was illustrated that there was a significant difference between the achievement scores of pre-test and post-test in students' counting skills

taught by Conventional Method from pre-test to post-test. The scores of post-test were; N=36, M=7.22, SD=2.140, and pre-test were; N=36, M=6.14, SD=1.397. t (35) = 3.993 and p=0.000 < 0.05 (Table 4.18).

19. It was found that there was a significant difference between the achievement scores of students' basic arithmetic skills taught by Conventional Method from pre-test to post-test. The scores of post-test were; N=36, M=4.00, SD=1.957, and pre test; N=36, M=2.92, SD=1.713. t (35) = 4.638 and p=0.000 < 0.05 (Table 4.19).

20. The results of the study presented that there was a significant difference in the mean achievement scores of students' numerical skills taught by Conventional Method from pre-test to post-test. The scores of post-test were; N=36, M=18.89, SD=4.187, and pre-test were; N=36, M=15.17, SD=3.917. t (35) = 9.761 and p=0.000 < 0.05 (Table 4.20).

5.2.5 Findings Related to Examine the Effect of Conventional Method on the Development of Scientific Skills in terms of Spatial Skills

The analysis of the data revealed the positive effect of Conventional Method on the development of scientific skills in terms of spatial skills including spatial sense, geometrical awareness and sense of time in first graders. The findings are as under:

21. It was found from the descriptive statistics that the mean achievement scores of students increased from , M=7.39 (SD=1.536) to M=8.72 (SD=1.446) in spatial sense and M=4.69 (SD=1.564) to M=6.28 (SD=1.632) in geometrical awareness with the mean differences of 1.33 & 1.59 respectively which indicates that the performance of students are better in variables of spatial skills (spatial sense and geometrical awareness) but a smaller and moderate improvement in sense of time and achievement scores increased M= 6.67 (SD=1.639) to M=7.36 (SD=1.417) in sense of time with the difference of 0.69 through Conventional Method from pre-test to post-test (Table 4.21).

22. Descriptive statistics explored that the mean achievement scores of students increased from M= 17.78 (SD=4.466) to M= 21.03 (SD=3.410) with the difference of 3.55 in spatial skills which shows that the performance of students is better in spatial skills through Conventional Method from pre-test to post-test (Table 4.22).

23. It was revealed that there was a significant difference between the achievement scores of students' spatial sense taught by Conventional Method from pre-test to post-test. The scores of post-test were; N=36, M=8.72, SD=1.446, and pre-test were; N=36, M=7.39, SD=1.536, t (35) = 9.661 and p=0.000 < 0.05 (Table 4.23).

24. It was illustrated that there was a significant difference between the achievement scores of pre-test and post-test in students' geometrical awareness regarding Conventional Method from pre-test to post-test. The scores of post-test were; N=36, M=6.28, SD=1.632 and pre- test were; N=36, M=4.69, SD=1.564. t (35) = 10.867 and p=0.000 < 0.05 (Table 4.24).

25. It was found that there was a significant difference between the achievement scores of students' sense of time skills regarding Conventional Method from pre-test to post-test. The scores of post-test were; N=36, M=7.36, SD=1.417, and pre test; N=36, M=6.67, SD=1.639, t (35) = 4.129 and p=0.000 < 0.05 (Table 4.25).

26. The results of the study presented that there was a significant difference in the mean achievement scores of students' spatial skills regarding Conventional Method from pre-test to post-test. The scores of post-test were; N=36, M=22.36, SD=3.963, and pre-test were; N=36, M=18.81, SD=3.728, t (35) = 13.095 and p=0.000 < 0.05 (Table 4.26).

5.2.6 Findings Related to Evaluate the Effect of Conventional Method on the Development of Scientific Skills in terms of Mathematical Thinking

The analysis of the data revealed the positive effect of Conventional Method on the development of scientific skills in terms of mathematical thinking in first graders. The findings are as under:

27. Descriptive statistics explored that the mean achievement scores of students increased from M= 11.69 (SD=3.725) to M=15.53 (SD=3.910) with the difference of 3.84 in mathematical reasoning and thinking skills which shows that the performance of students is better in mathematical thinking taught by Conventional Method from pre-test to post-test (Table 4.27).

28. It was revealed that there was a significant difference between the achievement scores of students' mathematical reasoning and thinking skills regarding Conventional Method from pre-test to post-test. The scores of post-

test were; N=36, M=15.53, SD=3.910, and pre-test were; N=36, M=11.69, SD=3.725, t (35) = 13.960 and p=0.000 < 0.05 (Table 4.28).

5.2.7 Findings Related to Compare Hands on Learning (Experimental Group) with Conventional Method (Control Group) on the Development of Scientific Skills on the Basis of Descriptive Analysis

A comparative analysis through descriptive statistics between Hands on Learning and Conventional Method revealed distinct differences in the scientific skills in Mathematics of first graders. The results of pre-test and post-test showed that students who were taught by Hands on Learning demonstrated significantly greater improvement in scientific skills compared to those who were taught by conventional method. The findings are as under:

29. Descriptive statistics regarding comparison of experimental group and control group showed that the net effect on the outcome variables of numerical skills such as number sense, counting skills and basic arithmetic skills of the instructions based on Hands on Learning was 3.45 and the net effect on the outcome variables of the instructions based on Conventional Method was1.30 which was very low. The difference of averages between experimental group (Hands on Learning) and control group (Conventional Method) 3.45 and 1.30 showed that experimental group performed better with Hands on Learning as compared to control group that was taught by Conventional Method. The results inferred that Hands on Learning was better than Conventional Method (Table 4.29).

30. Descriptive statistics explored that the difference in mean achievement scores of experimental group in outcome variable numerical skills was 10.33 and control group was 3.72 from pre-test to post-test. The difference in achievement scores indicated that experimental group performed better than Conventional Method regarding numerical skills (Table 4.30).

31. Descriptive statistics regarding comparison of experimental group and control group showed that the net effect on the outcome variables i.e. number sense, counting skills and basic arithmetic skills of the instructions based on Hands on Learning was 3.92 and the net effect on the outcome variables of the instructions based on Conventional Method was1.20 which was very low. The difference of averages between experimental group (Hands on Learning) and control group (Conventional Method) 3.92 and 1.20 showed that experimental group performed better with Hands on Learning as compared to control group that was taught by Conventional Method. The results inferred that Hands on Learning was better than Conventional Method (Table 4.31).

32. Descriptive statistics explored that the difference in mean achievement scores of experimental group in outcome variable spatial skills was 11.75 and control group was 3.55 from pre-test to post-test. The difference in achievement scores indicated that experimental group performed better than Conventional Method regarding numerical skills (Table 4.32).

33. Descriptive statistics regarding comparison of experimental group and control group showed that the net effect on the outcome variables of mathematical thinking and reasoning skills of the instructions based on Hands on Learning was 9.05 and the net effect on the outcome variables of the instructions based on Conventional Method was 3.84 which was very low. The difference of averages between experimental group (Hands on Learning) and control group (Conventional Method) 9.05 and 3.84 showed that Hands on Learning was better than Conventional Method (Table 4.33).

34. It was found from the descriptive statistics that the mean achievement scores in all variables of scientific skills of experimental group (Hands on Learning) increased from 19.11 to 29.44 (difference =10.33) in numerical skills test, 14.14 to 25.89 (difference =11.75) in spatial skills test and 12.53 to 21.58 (difference = 9.05) in mathematical reasoning and thinking skills from pre-test to post-test. The difference in all variables of scientific skills (10.33, 11.75 & 9.05) showed that experimental group performed better with Hands on Learning. Hence, it was inferred from the result that Hands on Learning is better in developing scientific skills of students (Table 4.34).

35. Descriptive statistics explored that the mean achievement scores of students increased from M= 76.94 (SD=6.516) to M= 45.78 (SD=9.610) with the difference of 31.16 in scientific skills. The results show that experimental group performed better with Hands on Learning. (Table 4.35).

36. It was found from the descriptive statistics that the mean achievement scores in all variables of scientific skills of control group (Conventional Method) increased from 15.17 to 18.89 (difference=3.72) in numerical skills test, 18.81

to 22.36 (difference=3.55) in spatial skills test and 11.69 to 15.53 (difference =3.84) in mathematical reasoning and thinking skills from pre-test to post-test. The difference in all variables of scientific skills (3.72, 3.55 & 3.70) showed that control group performed better with Conventional Method (Table 4.36).

37. Descriptive statistics explored that the mean achievement scores of students increased from M= 44.64 (SD=9.728) to M= 56.83 (SD=9.866) with the difference of 12.19 in scientific skills. The results show that control group performed better with Conventional Method (Table 4.37).

38. Descriptive statistics regarding comparison of experimental group and control group showed that the net effect on the outcome variables of scientific skills such as numerical skills, spatial skills and mathematical reasoning and thinking skills of the instructions based on Hands on Learning was 10.38 and the net effect on the outcome variables of the instructions based on Conventional Method was 3.70 which was very low. The difference of averages between experimental group (Hands on Learning) and control group (Conventional Method) 10.38 and 3.70 showed that experimental group performed better with Hands on Learning as compared to control group that was taught by Conventional Method. The results inferred that Hands on Learning was better in developing all variables of scientific skills than Conventional Method (Table 4.38).

39. Descriptive statistics explored that the difference in mean achievement scores of experimental group in outcome variable scientific skills was 31.16 and control group was 12.19 from pre-test to post-test. The difference in achievement scores (31.16–12.19=18.97) indicated that experimental group performed better in developing scientific skills of students than Conventional Method (Table-4.39).

5.2.8 Findings related to Compare Hands on Learning (Experimental Group) with Conventional Method (Control Group) on the Development of Scientific Skills on the Basis of Inferential Analysis

A comparative analysis through inferential statistics between instruction based on Hands on Learning and instruction based on Conventional Method revealed distinct differences in the scientific skills in Mathematics of first graders. The results of pre-test and post-test showed that students who were taught by Hands on Learning demonstrated significantly greater improvement in scientific skills compared to those who were taught by conventional method. The findings related to compare the achievement scores in scientific skills of HoL with Conventional Method are as under:

40. It was revealed that there was no significant difference between the achievement scores of experimental group and control group in number sense. The scores of experimental group were; N=36, M=6.14, SD=1.869, and the scores of control group were; N=36, M=6.83, SD=1.935, $t(70)=1.549$ and $p=0.126 > 0.05$. (Table-4.40).

41. It was illustrated that there was a significant difference between the achievement scores of experimental group and control group in students' number sense after treatment. The scores of experimental group were; N=36, M=9.86, SD=1.018, and the scores of control group were; N=36, M=7.89, SD=1.769. $t(70) = 5.797$ and $p=0.000 < 0.05$ (Table-4.41).

42. It was found that there was a significant difference between the achievement scores of experimental group and control group in students' counting skills before treatment. The scores of experimental group were; N=36, M=8.69, SD=2.325 and the scores of control group were; N=36, M=6.14, SD=1.397; $t(70) = 5.605$ and $p=0.000 < 0.05$ (Table-4.42).

43. The results of the study presented that there was a significant difference between the achievement scores of experimental group and control group in students' counting skills after treatment. The scores of experimental group were; N=36, M=9.97, SD=1.483, and the scores of control group; N=36, M=7.22, SD=2.140; $F(1,70)= 40.143$ and $p=0.000 < 0.05$. It also indicated a moderate to strong association between Hands on Learning and counting skills with Eta value ($\eta=0.365$) (Table-4.43).

44. It was revealed that there was no significant difference between the achievement scores of experimental group and control group in basic arithmetic skills before treatment. The scores of experimental group were; N=36, M=3.61, SD=3.101, and the scores of control group were; N=36, M=2.92, SD=1.713; $t(70) = 1.176$ and $p=0.245 > 0.05$ (Table-4.44).

45. It was illustrated that there was a significant difference between the achievement scores of experimental group and control group in students' basic arithmetic skills after treatment. The scores of experimental group were; N=36, M=9.64, SD=1.839 and the scores of control group; N=36, M=4.00, SD=1.957; t (70) = 12.601 and p=0.000 < 0.05 (Table-4.45).

46. It was found that there was a significant difference between the achievement scores of experimental group and control group in students' numerical skills before treatment. The scores of experimental group were; N=36, M=19.11, SD=5.888 and the scores of control group were; N=36, M=15.17, SD=3.917; t (70) = 3.346 and p=0.001< 0.05 (Table-4.46).

47. The results of the study presented that there was a significant difference between the achievement scores of experimental group and control group in students' numerical skills after treatment. The scores of experimental group were; N=36, M=29.44, SD=3.418, and the scores of control group; N=36, M=18.89, SD=4.187; F(1,70)= 137.03 and p=0.000 < 0.05 (Table-4.47).

48. It was revealed that there was a significant difference between the achievement scores of experimental group and control group in spatial sense before treatment. The scores of experimental group were; N=36, M=6.36, SD=1.175 and the scores of control group; N=36, M=7.39, SD=1.536; t (70) = 3.189 and p=0.002 < 0.05(Table 4.48).

49. It was illustrated that there was a significant difference between the achievement scores of experimental group and control group in students' spatial sense after treatment. The scores of experimental group were; N=36, M=9.81, SD=1.305, and the scores of control group; N=36, M=8.72, SD=1.446; F(1,70)= 11.113, p=0.001 < 0.05 & η=0.137 (Table-4.49).

50. It was found that there was a significant difference between the achievement scores of experimental group and control group in students' geometrical awareness before treatment. The scores of experimental group were; N=36, M=3.78, SD=2.085 and the scores of control group; N=36, M=4.69, SD=1.564; t (70) = 2.110 and p=0.038 < 0.05 (Table 4.50).

51. The results of the study presented that there was a significant difference between the achievement scores of experimental group and control group in students' geometrical awareness after treatment. The scores of experimental group were; N=36, M=8.78, SD=1.514, and the mean scores of control group; N=36, M=6.28, SD=1.632; $F(1,70)= 45.404$, $p=0.000 < 0.05$ and $\eta=0.393$ (Table 4.51).

52. It was revealed that there was a significant difference between the achievement scores of experimental group and control group in sense of time before treatment. The scores of experimental group were; N=36, M=4.00, SD=1.639 and the mean scores of control group; N=36, M=6.67, SD=1.639; $t(70) = 6.904$ and $p=0.000 < 0.05$ (Table-4.52).

53. It was illustrated that there was no significant difference between the achievement scores of experimental group and control group in students' sense of time after treatment. The scores of experimental group were; N=36, M=7.31, SD=1.283, and the mean scores of control group; N=36, M=7.36, SD=1.417; $F(1,70)= 0.030$ and $p=0.862 > 0.05$ (Table 4.53).

54. It was found that there was a significant difference between the achievement scores of experimental group and control group in students' spatial skills before treatment. The scores of experimental group were; N=36, M=14.14, SD=3.758 and the scores of control group; N=36, M=18.81, SD=3.963; $t(70) = 5.127$ and $p=0.000 < 0.05$ (Table-4.54).

55. The results of the study presented that there was a significant difference between the achievement scores of experimental group and control group in students' spatial skills after treatment. The scores of experimental group were; N=36, M=25.89, SD=2.459, and the scores of control group; N=36, M=22.36, SD=3.728; $F(1,70)= 22.470$, $p=0.000 < 0.05$ & $\eta=0.243$ (Table-4.55).

56. It was revealed that there was no significant difference between the achievement scores of experimental group and control group in mathematical reasoning and thinking skills before treatment. The scores of experimental group were; N=36, M=12.53, SD=3.247, and the scores of control group; N=36, M=11.69, SD=3.725; $t(70) = 1.012$ and $p=0.315 > 0.05$ (Table-4.56).

57. The results of the study presented that there was a significant difference between the achievement scores of experimental group and control group in students' mathematical reasoning and thinking skills after treatment. The scores of experimental group were; N=36, M=21.58, SD=2.655 and the scores of control group were; N=36, M=15.53, SD=3.910; t (70) = 7.688 and p=0.000 < 0.05 (Table-4.57).

58. It was illustrated that there was a significant difference between the achievement scores of pre-test and post-test in students' scientific skills regarding instructions based on Hands on Learning from pre-test to post-test. The scores of post-test were; N=36, M=76.94, SD=6.516, and pre-test were; N=36, M=45.78, SD=9.610; t (35) = 16.074 and p=0.000 < 0.05. The results of the study inferred that Hands on Learning is more effective in developing scientific skills of students (Table-4.58).

59. It was revealed that there was a significant difference between the achievement scores of pre-test and post-test in students' scientific skills on Conventional Method from pre-test to post-test. The scores of post-test were; N=36, M=56.83, SD=9.866, and pre-test were; N=36, M=44.64, SD=9.728. t (35)=14.352 and p=0.000 < 0.05. (Table-4.59).

60. It was found that there was no significant difference between the achievement scores of experimental group and control group in scientific skills before treatment. The scores of experimental group were; N=36, M=45.78, SD=9.610, and the mean scores of control group; N=36, M=44.64, SD=9.728; t (70) = 0.500 and p=0.619 > 0.05 (Table-4.60).

61. The results of the study presented that there was a significant difference between the achievement scores of experimental group and control group in students' scientific skills after treatment. The scores of experimental group were;N=36, M=76.94, SD=6.516 and the scores of control group; N=36, M=56.83, SD=9.866; t (70) = 10.206 and p=0.000 < 0.05. The results of the study inferred that Hands on Learning is more effective than Conventional Method in developing scientific skills of students (Table-4.61).

5.2.9 Findings related to Compare Hands on Learning (Experimental Group) with Conventional Method (Control Group) on the Development of Scientific Skills on the Basis of Graphical Representation

A comparative analysis through graphical representation between instruction based on Hands on Learning and instruction based on Conventional Method revealed distinct differences in the scientific skills in Mathematics of first graders. The results of pre-test and post-test showed that students who were taught by Hands on Learning demonstrated significantly greater improvement in scientific skills compared to those who were taught by conventional method. The findings related to compare the achievement scores in scientific skills of HoL with Conventional Method are as under:

62. The graphical representation showed that the test scores of experimental group (M=6.83) and control group (M=6.14) in number sense were almost same with $p=0.126>0.05$. It indicated that the performance of both groups was similar before treatment (Figure-1).

63. The graphical representation showed that the test scores of experimental group (M=9.86) more than control group (M=7.89) in number sense with $p=0.000<0.05$ after treatment. It indicated that experimental group performed better in number sense as compared to control group (Figure-2).

64. The graph presented that the test scores of experimental group (M=8.69) were more than control group (M=6.14) group in students' counting skills with $p=0.000<0.05$ before treatment. It indicated that experimental group was better than control group in counting skills before treatment (Figure-3).

65. The graph showed that that the test scores of experimental group (M=9.97) were more than control group (M=7.22) group in students' counting skills with $p=0.000<0.05$ and $\eta=0.365$ after treatment. It indicated that experimental group performed better in counting skills as compared to control group (Figure-4).

66. The graphical representation showed that the test scores of experimental group (M=3.61) and control group (M=2.92) in basic arithmetic skills were almost same with $p=0.245>0.05$. It indicated that the performance of both groups was similar before treatment (Figure-5).

67. The graph showed that that the test scores of experimental group (M=9.64) were more than control group (M=4.00) group in students' basic arithmetic skills with $p=0.000< 0.05$. It indicated that experimental group performed better in basic arithmetic skills as compared to control group (Figure-6).

68. The graphical representation showed that the test scores of experimental group (M=19.11were more than control group (M=15.17) in basic arithmetic skills with $p=0.001< 0.05$ before treatment. It indicated that the performance of experimental group was better than control group in numerical skills before treatment (Figure-7).

69. The graph showed that that the test scores of experimental group (M=29.44) were more than control group (M=18.89) group in students' basic arithmetic skills with $p=0.000 < 0.05$ and ($\eta=0.662$) after treatment. It indicated that experimental group performed better in numerical skills as compared to control group (Figure-8).

70. The graphical representation showed that the test scores of control group (M=6.36) were more than experimental group (M=7.39) in spatial sense with $p=0.002< 0.05$ before treatment. It indicated that the performance of control group was better than experimental group in spatial sense before treatment (Figure-9).

71. The graph showed that that the test scores of experimental group (M=9.81) were more than control group (M=8.72) group in students' spatial sense with $p=0.001 < 0.05$ and $\eta=0.137$ after treatment. It indicated that experimental group performed better in numerical skills than control group (Figure-10).

72. The graphical representation showed that the test scores of control group (M=4.69) were more than experimental group (M=3.69) in geometrical awareness with $p=0.038<0.05$ before treatment. It indicated that the performance of control group was better than experimental group in geometrical awareness before treatment (Figure-11).

73. The graph showed that that the test scores of experimental group (M=8.78) were more than control group (M=6.28) group in students' geometrical awareness with $p=0.000 < 0.05$ and $\eta=0.393$ after treatment. It indicated that experimental group performed better in geometrical awareness as compared to control group (Figure-12).

74. The graphical representation showed that the test scores of control group (M=4.00) were more than experimental group (M=6.904) in sense of time skills with $p=0.000<0.05$ before treatment. It indicated that the performance of control group was better than experimental group in geometrical awareness before treatment (Figure-13).

75. The graphical representation showed that the test scores of experimental group (M=7.31) and control group (M=7.36) in sense of time were almost same with $p=0.245>0.05$ & ($\eta=0.000$). It indicated that the performance of both groups was similar after treatment and there is no association of Hands on Learning and conventional method with sense of time. It is likely due to chance or others extraneous variable (Figure-14).

76. The graphical representation showed that the test scores of control group ($M=14.14$) were more than experimental group ($M=18.81$) in spatial skills with $p=0.000<0.05$ before treatment. It indicated that the performance of control group was better than experimental group in geometrical awareness before treatment (Figure-15).

77. The graph showed that that the test scores of experimental group ($M=25.89$) were more than control group ($M=22.36$) group in students' spatial skills with $p=0.000 < 0.05$ and $\eta=0.243$ after treatment. It indicated that experimental group performed better in spatial skills as compared to control group (Figure-16).

78. The graphical representation showed that the test scores of experimental group ($M=12.53$) and control group ($M=11.69$) in mathematical reasoning and thinking skills were almost same with $p=0.315>0.05$. It indicated that the performance of both groups was similar before treatment (Figure-17).

79. The graph showed that that the test scores of experimental group ($M=25.89$) were more than control group ($M=22.36$) group in students' mathematical reasoning and thinking skills with $p=0.000 < 0.05$ after treatment. It indicated that experimental group performed better in mathematical reasoning and thinking skills as compared to control group (Figure-18).

80. The graph showed that that the scores of post-test ($M=76.94$) were more than the scores of pre-test ($M=45.78$) in students' scientific skills with $p=0.000<0.05$. It indicated that experimental group performed better in developing scientific skills of students from pre-test to post-test. Hence, the graph indicated that instructions based on Hands on Learning are more effective in developing scientific skills of students (Figure-19).

81. The graph showed that that the scores of post-test ($M=56.83$) were more than the scores of pre-test ($M=44.64$) in students' scientific skills which indicated that instructions based on Conventional Method are effective in developing scientific skills of students (Figure-20).

82. The graphical representation showed that the test scores of experimental group (M=45.78) and control group (M=44.64) in scientific skills were almost same with p=0.619>0.05 before treatment. It indicated that the performance of both groups was similar before treatment (Figure-21).

83. The graph showed that that the test scores of experimental group (M=76.94) were more than control group (M=56.83) group in students' scientific skills with p=0.000<0.05 after treatment. It indicated that experimental group performed better in scientific skills as compared to control group. Hence, the graph indicated that instruction based on HoL was more effective than Conventional Method in developing scientific skills (Figure-22).

5.3 Discussion

Quality education always demands an alignment of curriculum with teaching, learning activities and assessment system. It is also helpful for developing mathematical skills (Hussain & Mahmood, 2020). Developing scientific skills in Mathematics always demands acquiring knowledge and skills (Suneetha & Rao, 2010). Single National Curriculum (2020) of Pakistan is developed according to the international standards and modern trends. Single National Curriculum (2020) of Mathematics grade 1-5 of Pakistan is helpful for enhancing mathematical literacy, induce logical thinking, reasoning and solve real life situations among students (Government of Pakistan, 2020; Zaman et al., 2021; Dilshad et al., 2023). During the review of literature, it was found that there is no alignment in curriculum and teaching. Despite of the improvement in curriculum of Mathematics, the performance of the students show another story. There is a gap between curricula goals and what is actually happening in mathematics classroom of Pakistan. There are numbers of studies which highlighted that the students' achievement in Mathematics was very poor. According to the result of TIMSS in 2019, Pakistan ranked second to last in mathematics among 58 countries. Only 27% of Pakistani Children met the low international benchmark, 8% of Pakistani children met the intermediate benchmark and 1% met the high benchmark in mathematics (Halai, 2021). A study conducted by Azeem (2021) on 5th grade students' achievement in mathematics told us the performance of students in written papers of math was less than 45% and overall (both written and multiple choice) in mathematics was 57%. Another study conducted by the Agha khan University's Institute for Educational Development (IED) Pakistan in 2022 reported that more than 90 percent of the primary and lower secondary students across Pakistan were weak or lack basic understanding of Mathematics. (The Aga khan University, 2022). There are number of studies that depicted the reasons of students' low performance in Mathematics. The main reasons of students' low performance in mathematics are: teachers' rigid teaching style teaching methods (conventional method, question-answer method, teacher-centered method) (Micheal, 2015; Amin and Mariani, 2017; Mbatha, 2018 & Makondo and Makando, 2020). The above studies showed that there was low achievement in Mathematics and their main focus was on inappropriate teaching method. For the effective achievement of the objectives of Single National Curriculum of Pakistan (2020) of Pakistan, activity based pedagogy was required and they could not be attained through conventional method (Halai, 2021).

According to Adu and Oyinloye (2020),Ogunkola (2020) and Sinaga (2022) Hands on Learning plays a crucial role for enhancing mathematical literacy, induce logical thinking, reasoning and solve real life situations among students and it is also very helpful to promote Mathematics' achievement. The present study "Effect of Hands on Learning on the Development of Scientific Skills in First Graders" was conducted for developing scientific skills of students in Mathematics in the term of numerical skills, spatial skills and mathematical reasoning and thinking skills. For this purpose, true experimental research design was used. The study was based on seven research objectives and 30 research hypotheses. Data were collected before and after treatment on the basis of research objectives and research hypotheses. Eighty three findings were explored.

The finding of the present study from descriptive statistics revealed that the performance and the achievement scores of students improved after the intervention through Hands on Learning in numerical skills. Furthermore, inferential statistics on the basis of paired sample t-test presented a significant difference in the mean scores of students' numerical skills instructed through Hands on Learning. The scores of post-test were; N=36, M=29.44, SD=3.418, and pre-test were; N=36, M=19.11, SD=5.888. $t(35) = 8.779$ and $p=0.000 < 0.05$. Hence, the findings of the study stated that the performance of students improved in numerical skills (number sense, counting skills and basic arithmetic skills) through instructions based on Hands on Learning. The findings of the study is in line with the findings of some earlier studies on the positive effect of Hands on Learning on students' numerical skills. The study conducted by Friso-van den Bos et al., (2018) support the finding of present study. The finding of the study exposed that Hands-on learning was helpful in developing counting skills and basic arithmetic operations, such as counting with physical items or utilizing fingers, have been linked to considerable improvements in arithmetic skills. It was also found that kindergartners who received counting-based training performed better in addition and symbolic number problems than those in typical learning environments. These strategies not only help you comprehend numerical sequences, but they also make it easier to go on to more sophisticated operations. A study conducted by Starkey and Klein (2020) provides credibility for the present study. This study showed that the students who participated in hands on activities performed better and their numerical skills improved. Another study conducted by Afolabi (2020) also supports the finding of the present study. The results of the study indicated that students who participated in hands on mathematics activities, their performance increased in numerical skills and a significant improvement was seen in numerical skills of students as compared to traditional method. The results of the study conducted by Yılmaz-Yenioğlu and Sonmez-Kartal (2023) also support the finding of the present study. According to them children counting tactics with hands-on exercises showed considerable gains in their comprehension of number sequences, cardinality, and basic arithmetic operations. Tasks like forward and backward counting with manipulatives not only improved numerical abilities but also helped bridge the gap between tangible and abstract mathematical reasoning. These all findings of different research studies indicated that there was an alignment in the finding of present study with all these studies. So, these all studies support the results of present study in term of numerical skills.

The finding of the present study from descriptive statistics showed that the performance and the achievement scores of students also improved after the intervention through Hands on Learning in spatial skills. Furthermore, inferential statistics on the basis of paired sample t-test presented the achievement scores of students' spatial skills (spatial sense, geometrical awareness) regarding instructions based on Hands on Learning from pre-test to post-test. The scores of post-test were; N=36, M=25.89, SD=2.459, and pre-test were; N=36, M=14.14, SD=2.459. $t(35) = 15.557$ and $p=0.000 < 0.05$. Hence, the result of the study stated that the performance of students improved in spatial skills (number sense, counting skills and basic arithmetic skills) through instructions based on Hands on Learning from pre-test to post-test. These results were also supported by the results of the study done by Gilligan (2020). According to him, spatial skills, which is developed via hands-on activities like constructing blocks and puzzles, corresponds substantially with numerical tasks such as locating numbers on a number line and doing computations with missing values. He supported that Hands on activities were very helpful in developing spatial skills of students. A study conducted by Rubel and Nicol (2020) also align with the finding of the present study. The study is consistent with the wider literature on the significance of experience and hands-on learning in developing spatial and numerical abilities. Activities such as mapping, modelling, and investigating geometric relationships with tangible instruments help students learn fundamental spatial reasoning skills while also engaging them in meaningful, contextually relevant ways. Another study conducted by Shi et al., (2023) explored that Hands-on learning activities encourage active learning and engagement, allowing students to visualize and manipulate geometric forms. For example, utilizing physical items to investigate topics such as congruence, symmetry, and tessellations helps students get a better grasp of geometric relationships. These findings highlight the relevance of incorporating sensory experiences while learning geometric ideas. These all findings of different research studies indicated that there was an alignment in the finding of present study with all these studies. So, these all studies support the results of current study in term of spatial skills.

The verdicts of the current study from descriptive statistics directed that the performance and the achievement scores of students improved after the intervention through Hands on Learning in mathematical reasoning and thinking skills. Furthermore, inferential statistics on the basis of paired sample t-test presented that the achievement scores of students' mathematical reasoning and thinking skills regarding instructions based on Hands on Learning. The scores of post-test were; $N=36$, $M=21.58$, $SD=2.655$, and pre-test were; $N=36$, $M=12.53$, $SD=3.247$, $t\ (35) = 14.180$ and $p=0.000 < 0.05$. Hence, the result of the study stated that the performance of students improved in mathematical reasoning and thinking skills through instructions based on Hands on Learning from pre-test to post-test. These results were also supported by the results of the study done by Thuneberg et al., (2018) which revealed that Hands on Learning developed mathematical reasoning and scientific thinking among students. The study indicated that introducing hands-on modules into mathematics can result in a more engaging and successful learning environment. This strategy combines creativity and systematic inquiry to enhance varied cognitive talents and create greater comprehension. Hands-on exercises encourage creative problem-solving by allowing students to investigate different answers and devise novel ways to mathematical issues. Autonomy in hands-on inquiry-based learning promotes self-directed exploration and critical thinking. Students who solved problems independently showed improved memory and knowledge of mathematical topics. Hands-on activities greatly improved visual thinking, which is an important component of spatial and mathematical abilities. Another study conducted by Dahlan and Wibisono (2021) supported the finding of present study which investigated that hands-on learning activities, such as using physical manipulatives or conducting experiments, help pupils understand mathematical ideas. Interacting with actual items helps learners form a stronger link to abstract ideas, resulting in improved mental clarity. Hands-on learning also improves mathematical understanding. Students who participate in hands-on activities exhibit improved problem-solving abilities, logical reasoning, and the capacity to create mathematical arguments. The tactile and visual character of these activities improves cognitive processes required for reasoning. Another study conducted by Fraihat et al., (2022) highlighted the effect of Hands on Learning on students mathematical reasoning and thinking skills. In this study, it was found that the contextual learning environment through Hands on Learning considerably enhanced students' mathematical reasoning skills. Students who participated in activities involving investigation, reasoning, and justification had a greater comprehension of logical structures and linkages. So, these all studies support the results of present study in term of mathematical reasoning and thinking of students.

The current study explored that the performance of students in outcome variable scientific skills was improved through instructions based on Hands on Learning as compared to the instructions based on Conventional Method. Furthermore, inferential statistics on the basis of paired sample t-test presented that the achievement scores of students' scientific skills regarding instructions based on Hands on Learning and instructions based on Conventional Method. The scores of experimental group were; N=36, M=76.94, SD=6.516 and the scores of control group were; N=36, M=56.83, SD=9.866; $t(70) = 10.206$ and $p=0.000 < 0.05$. The results of the study inferred that Hands on Learning is more effective than Conventional Method in developing scientific skills (numerical skills, spatial skills and mathematical reasoning and thinking skills) of students. These findings were also supported by the results of the study done by Singh et al., (2020) which investigated the impact of hands-on activities and conventional method on the development of scientific skills in mathematics among secondary school pupils. The findings highlight how introducing hands-on, experiential learning methodologies into mathematics training may greatly improve students' numerical reasoning, spatial awareness, and mathematical problem-solving skills. The study also revealed that including hands-on activities into mathematics courses might help students develop not just computational competency but also higher-order abilities like reasoning and critical thinking. Teachers are urged to employ manipulatives, real-world problem-solving settings, and collaborative projects to successfully develop these abilities. They indicated that hands o learning activities are more effective in developing scientific skills of students as compared to conventional method. Another study conducted by Smussen et al., (2020) also showed an alignment with the finding of the present study which explored the importance of hands-on activities in developing mathematical thinking and reasoning. The findings show that learning by doing method in mathematics education improve students' capacity to think critically and reason about mathematical topics. This study indicated that the students who participated in hands-on learning activities showed significant improvements in their scientific skills in mathematics compared to students who received conventional instruction. So, these studies support the results of present study in term of scientific skills.

Hence, the findings of the current study provided evidences which favoured Hands on Learning as compared to conventional method for developing scientific skills of first graders. Hands on Learning is more effective in developing all variables of scientific skills in Mathematics such as numerical skills, spatial skills and mathematical reasoning and thinking skills. It was found that instructions based on Hands on Learning was more effective in developing students' number sense, counting skills, basic arithmetic skills, spatial sense, geometrical awareness, sense of time and mathematical thinking. It was also explored that to some extent, conventional method also played its role for developing scientific skills in term of sense of time but overall instructions based on Hands on Learning were more effective in all respects. Overall, Hands on Learning showed significant development in scientific skills of students in Mathematics as compared to Conventional Method.

5.4 Conclusions

Following conclusions were drawn:

1. In this study, it was concluded on the basis of descriptive analysis that the performance of the students improved taught by Hands on Learning in all variables of numerical skills including number sense, counting skills and basic arithmetic skills. The performance of students indicated that Hands on Learning is more effective method in developing all variables of numerical skills. Furthermore, it was also concluded on the basis of paired sample t-test results that there was a significant difference on students' number sense, counting skills and basic arithmetic skills taught by Hands on Learning. The results suggested that the students taught by Hands on Learning showed significant improvement in all variables of numerical skills. Overall, it was suggested that Hands on Learning is more effective and appropriate method in developing students' scientific skills in terms of numerical skills at grade-1 (Findings 1-6).
2. In this study, it was concluded on the basis of descriptive analysis that the performance of the students improved through Hands on Learning in all variables of spatial skills in Mathematics including spatial sense, geometrical awareness and sense of time skills. The performance of students indicated that Hands on Learning is more effective method in developing all variables of spatial skills. Furthermore, it was also concluded on the basis of paired sample t-test results that there was a significant difference on students' spatial sense, geometrical awareness and sense of time skills through Hands on Learning. The results of the study indicated that the students taught by Hands on Learning showed significant improvement in their all variables of spatial skills in Mathematics including spatial sense, geometrical awareness and sense of time skills. Overall, Overall, it was suggested that Hands on Learning is more effective and appropriate method in developing students' scientific skills in terms of spatial skills at grade-1 (Findings 7-12).
3. In this study, it was concluded on the basis of descriptive analysis that the performance of the students improved through Hands on Learning in mathematical thinking. The performance of students indicated that Hands on Learning is more effective method in developing mathematical thinking.

Furthermore, it was also determined on the basis of paired sample t-test results that there was a significant difference on students' mathematical thinking taught by Hands on Learning. The study directed that the students taught by Hands on Learning showed significant improvement in mathematical thinking. Overall, Overall, it was suggested that Hands on Learning is more effective and appropriate method in developing students' scientific skills in terms of mathematical thinking at grade-1 (Findings 13-14).

4. It was concluded that the performance of the students improved through Conventional Method in all variables of numerical skills including number sense, counting skills and basic arithmetic skills which indicated that Conventional Method is effective method in developing all variables of numerical skills. Furthermore, it was also concluded on the basis of paired sample t-test results that there was a statistically significant difference on students' number sense, counting skills and basic arithmetic skills through Conventional Method. It was also indicated that the students taught by Conventional Method showed an improvement in all variables of numerical skills in Mathematics including number sense, counting skills and basic arithmetic skills. Overall, Overall, it was suggested that Conventional Method is effective method of instructions in developing students' scientific skills in terms of numerical skills at grade-1 (findings 15-20).
5. It was concluded that the performance of the students improved through Conventional Method in all variables of spatial skills in Mathematics including spatial sense, geometrical awareness and sense of time skills which indicated that Conventional Method is effective method in developing all variables of spatial skills. Furthermore, it was also concluded on the basis of paired sample t-test results that there was a statistically significant difference on students' spatial sense, geometrical awareness and sense of time skills taught by Conventional Method from pre-test to post-test. The results of the study indicated that the students taught by Conventional Method showed an improvement in all variables of spatial skills. Overall, Overall, it was suggested that Conventional Method is effective method in developing students' scientific skills in terms of spatial skills at grade-1 (Findings 21-26).

6. It was concluded on the basis of descriptive analysis that the performance of the students increased through Conventional Method in mathematical thinking. The performance of students indicated that Conventional Method is an effective method of instructions in developing students' mathematical thinking. Furthermore, it was also determined on the basis of paired sample t-test results that there was a significant difference on students' mathematical thinking through Conventional Method. It was indicated that the students taught by Conventional Method showed an improvement in mathematical thinking. Overall, Overall, it was suggested that Conventional Method is an effective method in developing students' scientific skills in terms of mathematical thinking at grade-1 (Findings 27-28).
7. In the study, it was concluded on the basis of descriptive analyses that hands-on learning is a more effective method of instruction than conventional method in promoting students' scientific skills in mathematics. The results of the study show that students who participated in hands-on learning activities demonstrated significant improvements in their numerical skills, spatial skills, and mathematical thinking. In contrast, students who received instructions through conventional method showed significant declines in these skills. Hence, Hands on Learning is an effective and appropriate method of instructions than Conventional Method in developing scientific skills of students in terms of numerical skills, spatial skills and mathematical thinking (Findings 29-39).
8. It was also concluded from the results on the basis of independent sample t-test, One Way ANCOVA and Eta test results that there was a significant difference on students' scientific skills taught by Hands on Learning as compared to Conventional Method from pre-test to post-test. The results of the study indicated that the students taught by Hands on Learning showed significant improvement in all variables of scientific skills in Mathematics including numerical skills, spatial skills, and mathematical thinking as compared to Conventional Method which means that Hands on Learning is more effective method of instructions than Conventional Method in developing students' scientific skills in Mathematics (Findings 40-61).

9. It was also concluded from the graphical comparison of the study that Hands on Learning was more effective than conventional method in developing students' scientific skills in Mathematics. The graph showed a significant difference in the performance of students who received instruction through Hands on Learning and those who received instruction through Conventional Method (Findings 62-83).
10. The study investigated the effect of Hands on Learning on the development of scientific skills in Mathematics in first graders. The findings of the study based on descriptive statistics, inferential statistics and graphical representation indicated that Hands on Learning was more effective method than conventional Method in developing scientific skills in terms of numerical skills, spatial skills and mathematical thinking in first graders (Findings 29-83).

5.5 Recommendations

Keeping in view the findings and conclusions of the study, following recommendations are made:

1. Hands on Learning is more effective method than Conventional Method in developing students' scientific skills in terms of numerical skills. So, it is suggested that teacher may use Hands on Learning for Mathematics' classroom. Teacher may use hands on activities including number lines, counting blocks, number bingo, fraction pizza, shopping, cooking, addition war, base ten blocks, math war and story problem for developing students' scientific skills in terms of numerical skills (number sense, counting skills and basic arithmetic skills) in first graders.
2. Hands on Learning has proved its strength more than Conventional Method in developing students' scientific skills in terms of spatial skills. So, it is recommended that this method may be used for developing the spatial skills of students in Mathematics classroom. Teacher may use hands on activities including shape sorting, pattern blocks, tangram puzzles, mirror activity, spatial memory game, puzzle solving and obstacle course for developing students' scientific skills in terms of spatial skills including spatial sense, geometrical awareness and sense of time skills.
3. Hands on Learning helps in developing mathematical thinking of students at the very early stage. Therefore, it is recommended that teacher may use this method in Mathematics' classroom at grade-1 by using hands on activities such as math bingo, math war, pattern block, number patterns, shape patterns, story problem and mathematical presentation.
4. The focus of Hands on Learning is on learning by doing which aligns with the demand for scientific skills that also emphasizes learning by doing. So, it is suggested that Hands on Learning may be implemented in mathematics classroom to develop scientific skills in Mathematics at the very early stages. This method may help students to develop their deeper understanding of mathematical concepts and scientific skills in Mathematics including numerical skills, spatial skills and mathematical reasoning and thinking skills.

5. It is recommended that policy makers may develop policies to support Hands on Learning activities in mathematics education by providing funds for material and resources.
6. It is also recommended that curriculum developer may develop mathematics curricula that incorporate Hands on Learning activities and promote scientific skills in Mathematics.
7. To deliver training of Hands on Learning to the teachers of mathematics, it is proposed that trainers can be equipped for communicating training. For this purpose, Hands on Learning may be included in training programs.
8. Keeping in view the significance of Hands on Learning, it is suggested that all mathematics teachers may be given at least one chance of refresher courses and in-service training input on Hands on Learning activities in every one year.
9. Hands on Learning is an operative method of instructing mathematics. So, it is recommended that HoL may be encompassed in pre-service training, induction training and in-service training programs.
10. Further researches may be conducted for the validation and improvement of this study. To check the effectiveness of this method in the subject of Mathematics, other researches may be conducted on different levels such as ECCE and Elementary level.

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Appendix-i

Subject Achievement Test (Pre-test)

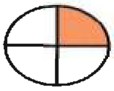
Mathematics Grade 1

Name:	
Total Marks: 100	**Obtained Marks:**

<u>Section A (Objectives) 40 Marks</u>

Q.1(a). Tick the correct answer each of the following (20*1=20) marks

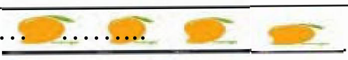
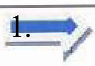
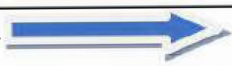
Note: No award will be given on over-writing and cutting.

Sr. No.	Statements	A	B	C	D
1.	How many roses are shown in figure? 	2	4	3	5
2.	What fraction is shaded? 	1/4	2/4	3/4	4/4
3.	Which one is ordinal number in figure?	6	6^{th}	six	Sixth
4.	In the series, 4,8,12,…… ….. what should be the next number?	14	16	18	20
5.	Three in numeral form is written as…….	1	2	3	4
6.	Two and four make…………	Three	Five	six	Seven
7.	Who is the tallest? 	the dog	the rat	the duck	the snake
8.	The snake  is ……than  .	Shorter	Longer	taller	Shortest

9.	**Which is the heaviest ball from the following.** **a.**  **b.**  **c.**  **d.** 	a	B	c	D
10.	Which No. of apple is heaviest from others?	1 	2 	3 	4 
11.	Which No. of fruit is lightest in weight?				
12.	Which is a triangle?				
13.	How many sides a Square has?	2	1	3	4
14.	In number "28", what is the place value of 8?	Ones	Tens	Hundreds	Thousands
15.	What number am I, if 3 less make me 20?	17	23	25	27
16.	Ali had 13 toffees. He gave 10 toffees to Shoib. How many toffees are left with Ali?	2	3	4	23
17.	What are the numbers that make 10 when they added?	2+4	3+6	5+5	8+1
18.	Complete the pattern by choosing the correct option. 				
19.	I am a shape with no sides and corners.				
20.	Which will come next in the pattern? 				

Q.1: b). Fill in the blanks with correct option. **(10*1=10) marks**

Note: No award will be given on over-writing and cutting.

1.	There are……… mangoes.
2.	… .... comes after 6.
3.	Clock has .... Shape.
4.	There are……… minutes in an hour.
5.	A minute has………seconds.
6.	Blue rectangle  is ………… than green rectangle  .
7.	The number…….. arrow is the smallest. 1.  2.  3. 
8.	4 ☐ 3 = 7.
9.	9 ☐ 4 = 5
10.	The four equal sides of a shape is called…………………..

Q.1: c). Write "T" for true and "F" for false statement **(5*1=05) marks**

Note: No award will be given on over-writing and cutting.

1.	There are six stars. 	
2.	In the given data 8 occurs lowest time. 8,8,8, 4, 4,8,3,2.	
3.	There are 60 minutes in an hour.	
4.	Is the pattern completed? 	
5.	Is the sum of 12, 6 & 4 is 20?	

Q.1: d). Matching column A with correct option in column B. (5*1=05) marks

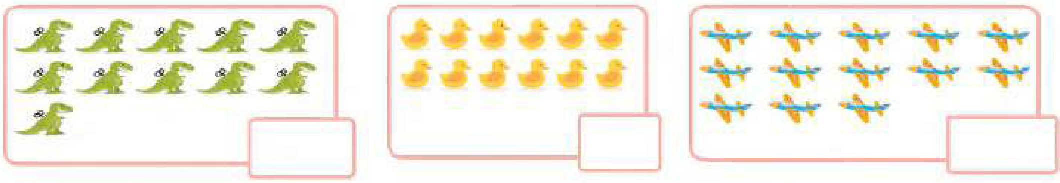
Note: No award will be given on over-writing and cutting.

Sr. No.	Column A	Column B
1.	1, 2, 3, 4, 5. Is in order.	60
2.	A minute has…… seconds.	Rectangle
3.	7+ 3 – 6=	Smallest
4.		4
5.	The kid is …… than the boy.	Ascending
		Square
		16

<u>SECTION B (Short Questions) 36 Marks</u>

Q.2: Attempt all questions **(18*2= 36) marks**

i. Count the objects of each box and write down the numbers in specific boxes.



ii. Write down 5 in ordinal numbers (in words and figures)

Number	Ordinal Number in word	Ordinal Number in figure
5		

iii. Tick (√) the words form of 13 and 10.

Nine	**Ten**
Thirteen	**Six**

iv. Write the following numbers in numeral form.

a. **Five = ………………..** b. **Thirty-one = ………………………**

c. **Eighty-four = …………** d. **One Hundred=……………………….**

v. Add

Tens	Ones		Tens	Ones		Tens	Ones
9	0	+	0	5	=		

vi. Nadia has 35 mangoes and Labia has 14 mangoes. How many mangoes they have altogether?

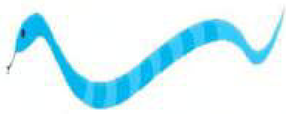
		Tens	Ones	
Nadia has	=			Mangoes
Labia has	=			Mangoes
Total Mangoes	=			

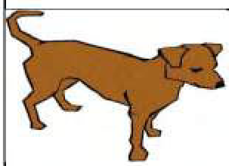
vii. There are 12 birds in a tree. 5 birds flew down from the tree. How many birds left on the tree?

		Tens	Ones	
Sitting on a tree	=			Birds
Flew down from tree	=			Birds
Left on tree	=			Birds

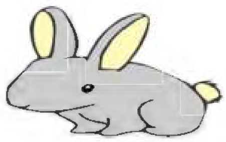
viii. Look at the pictures in the boxes. Answer the question by ticking (√) the correct picture.

Which is longer?

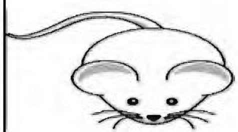


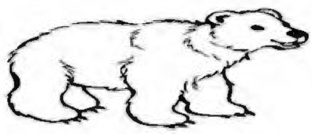


Which has shorter ears?

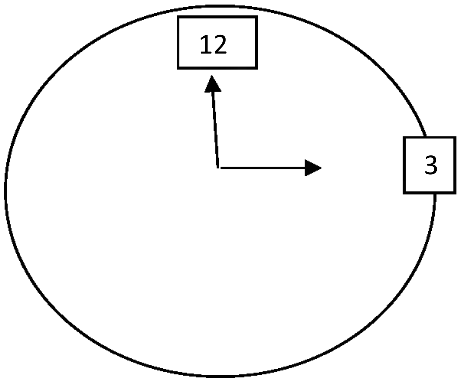


Which has a longer tail?

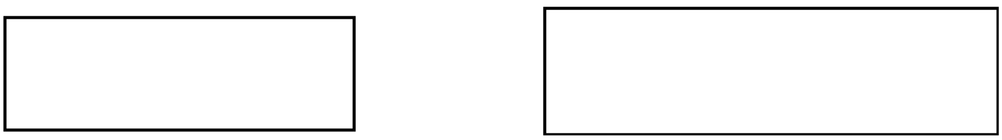




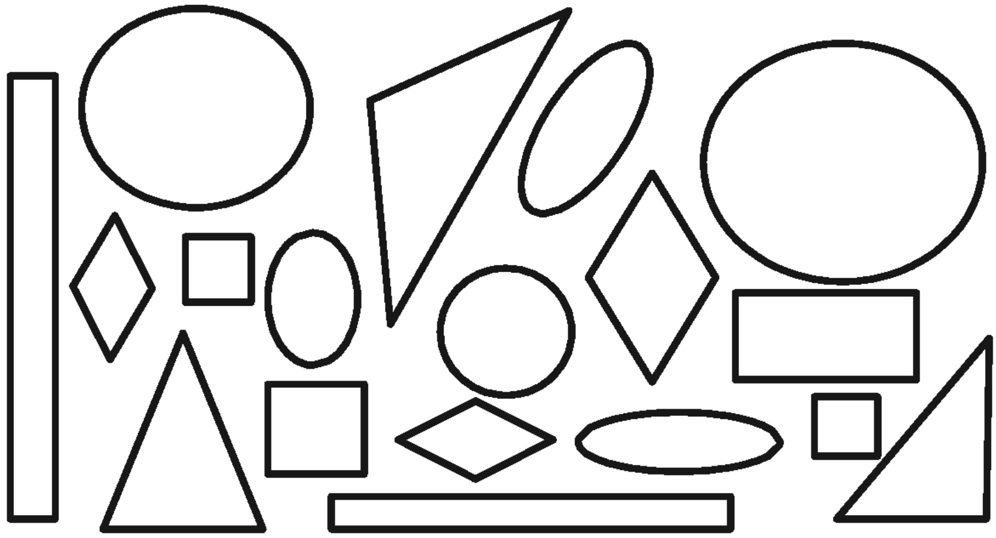
ix. What is the time on the watch
………………… O' Clock



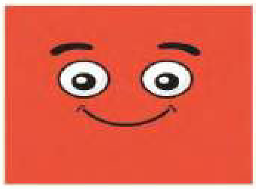
x. **Tick (√) the longest rectangle and fill the color in the smallest rectangle.**



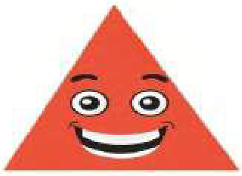
xi. Find 2 rectangles and color them.



xii. **Write the names of the shapes (Squar / Triangle).**

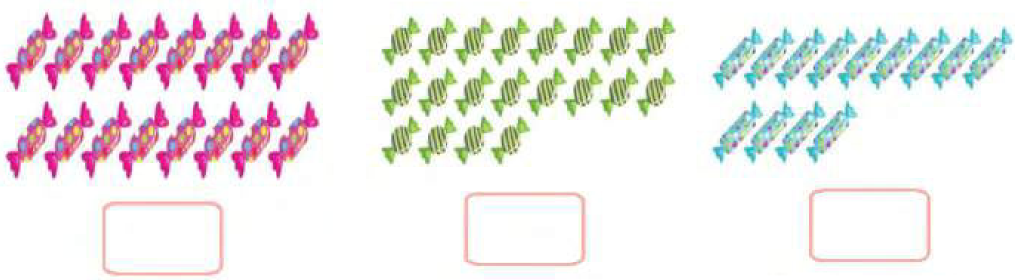


S ……………………………….



T……….…………………..

xiii. Before counting, circle the group you think has the most items. Then count.



Did you circle the correct group? Yes/ No

Now cross out the group with the least items.

xiv. Follow the example and describe the number pattern by counting up and down.

Count up____by 2_____'s from 2_____to 16.

2	4	6	8	10	12	14	16
5	10	15	20	25	30	35	40

Count_by____'s from________________to ______.

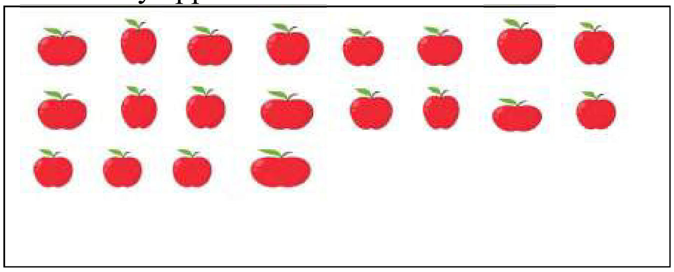
Count__by____'s from...................to_____.

44	40	36	32	28	24	20	16
100	90	80	70	60	50	40	30

Count__by____'s from ______to_____.

xv. How many apples are there?..............................

Cross out 4 apples. How many apples are left? ....



Cross out 4 more apples. How many apples are left? ....

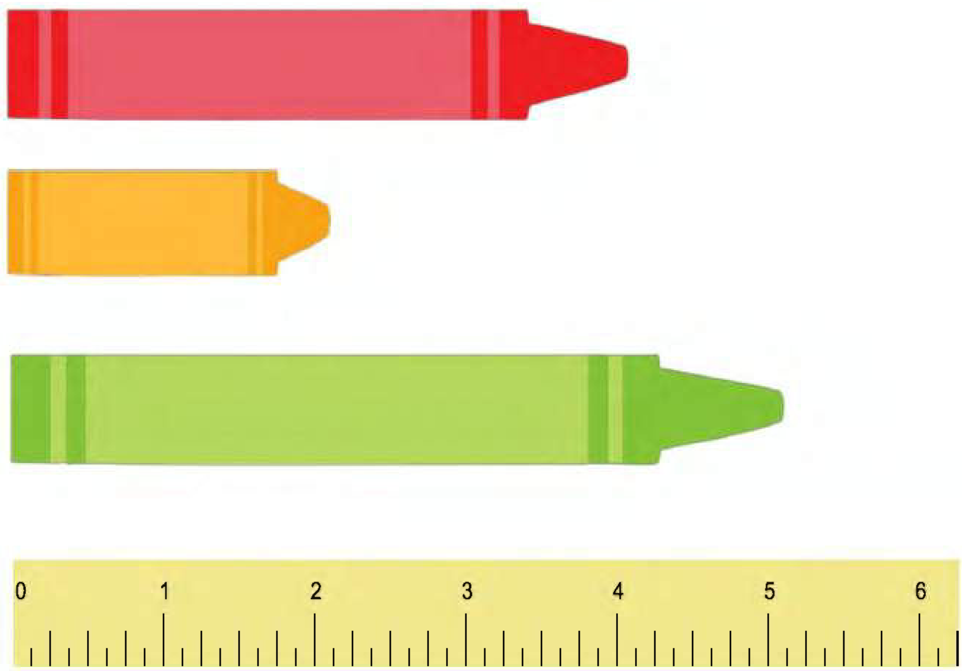
Cross out 4 more apples. How many apples are left? ....

Cross out 4 more apples. How many apples are left?..................................

Cross out 4 more apples. How many apples are left? ....

xvi. **Draw a Circle and fill it with colors in four equal parts.**

xvii. Using the ruler, measure the following marker and circle the longest marker.

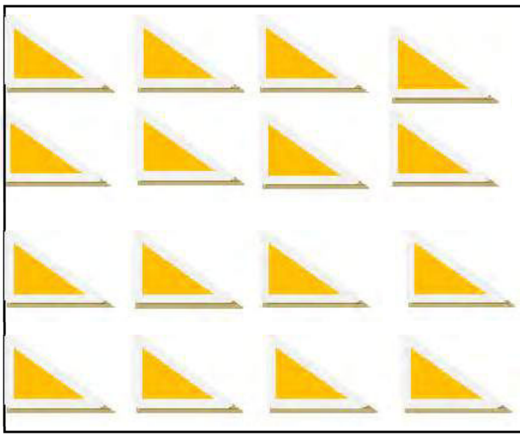


xviii. Draw a rectangle and fill it with green color.

<u>**Section C (Long Questions) 24 Marks**</u>

Q. 3: Attempt all questions. **(4*6=24) Marks**

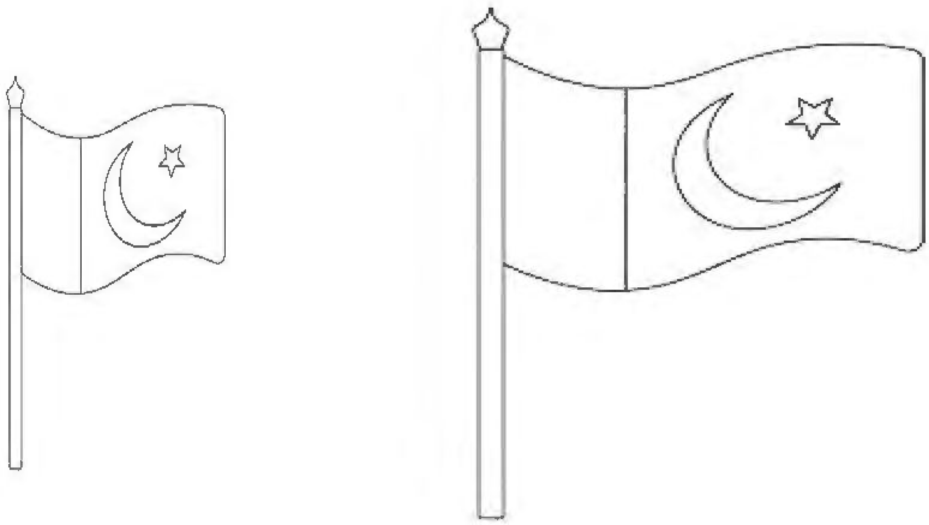
A. Count and write the total numbers of triangles in Tens and Ones.

	Tens	Ones
		

B. Zahid has 24 pencils. He gave 12 to them to his friends. How many pencils are left with Zahid?

	T	O	
Zahid has			Pencils
He gave			Pencils
Zahid left			Pencils

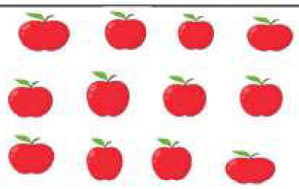
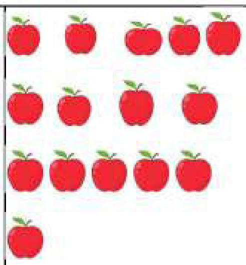
C. Color the highest flag with green and lowest flag with red.



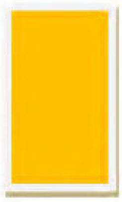
D. Make a Clock and show 9 0' clock time on it.

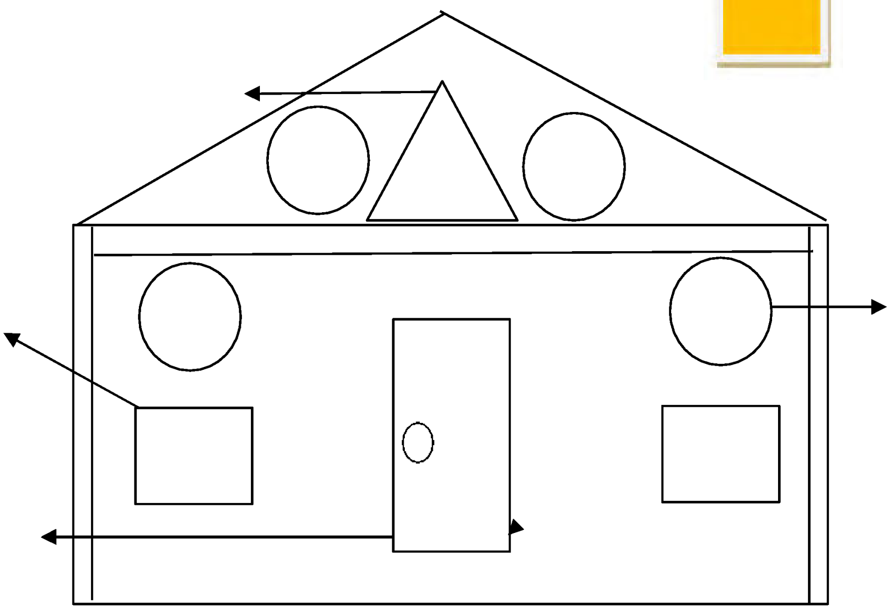
Clock

E. Solve

 ……………………. Apples	And +	 ……....Apples	Make =	 …………..Apples

F. Color the shape according to the key provided and label the figure

Red  , Blue  , Green  and Orange 



Appendix-ii

Subject Achievement Test (Post-test)

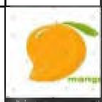
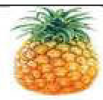
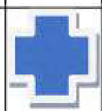
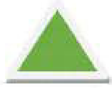
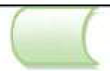
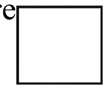
Mathematics Grade 1

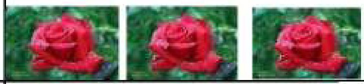
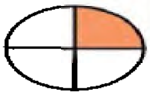
Name:	
Total Marks: 100	**Obtained Marks:**

<u>Section A (Objectives)   40 Marks</u>

Q.1(a). Tick the correct answer each of the following   (20*1=20) marks

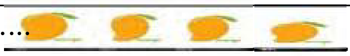
Note: No award will be given on over-writing and cutting.

Sr. No.	Statements	A	B	C	D
1.	Who is the tallest? 	the dog	the rat	the duck	the snake
2.	The snake  Is …….than rat  .	shortest	longer	Shorter	Taller
3.	Which is the heaviest ball from the following. a.  b.  c.  d. 	a	B	C	D
4.	Which No. of apple is heaviest from others?	1 	2 	3 	4 
5.	Which No. of fruit is lightest in weight.				
6.	Which is a triangle?				
7.	How many sides a Square  has?	2	1	3	4

8.	How many roses are shown in figure? 	2	4	3	5
9.	 What fraction is shaded?	1/4	2/4	3/4	4/4
10.	Which one is ordinal number in figure?	6	6^{th}	six	Sixth
11.	In the series, 4,8,12,…… ….. what should be the next number?	14	16	18	20
12.	Three in numeral form is written as…….	1	2	3	4
13.	Two and four make…………	Three	Five	six	Seven
14.	Complete the pattern by choosing the correct option.  ………………..				
15.	I am a shape with no sides and corners.				
16.	Which will come next in the pattern?  …………..				
17.	What are the numbers that make 10 when they added?	2+4	3+6	5+5	8+1
18.	In number "28", what is the place value of 8?	Ones	Tens	Hundreds	Thousands
19.	What number am I, if 3 less make me 20?	17	23	25	27
20.	Ali had 13 toffees. He gave 10 toffees to Shoib. How many toffees are left with Ali?	2	3	4	23

Q.1: b). Fill in the blanks with correct option **(10*1=10) marks**

Note: No award will be given on over-writing and cutting.

1.	4 + 3 = …………………………..
2.	9 ☐ 4 = 5
3.	The four equal sides of a shape is called…………………..
4.	There are……… minutes in an hour.
5.	A minute has……….seconds.
6.	Blue rectangle  is ………… than green rectangle 
7.	The number…….. arrow is the smallest. 1. 2. 3. 
8.	There are……..  mangoes.
9.	……………………..comes after 6.
10.	Clock has……………………………Shape.

Q.1: c). Write "T" for true and "F" for false statement **(5*1=05) marks**

1.	There are 60 minutes in an hour.	
2.	Is the pattern completed? 	
3.	There are six stars. 	
4.	In the given data 8 occurs lowest time. 8,8,8, 4, 4,8,3,2.	
5.	Is the sum of 12, 6 & 4 is 20?	

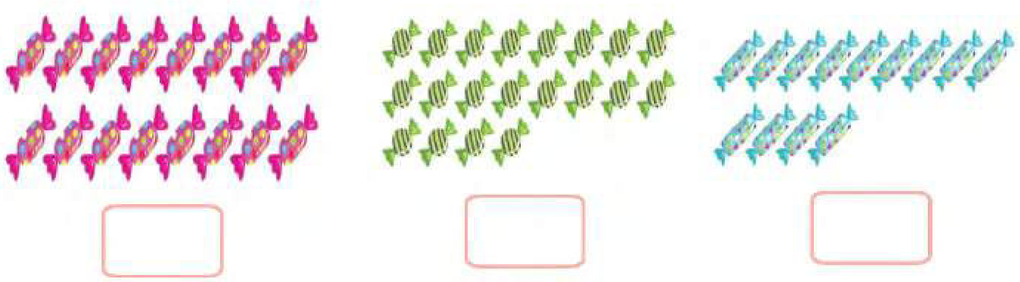
Q.1: d). Matching column A with correct option in column B. (5*1=05) marks

Sr. No.	Column A	Column B
1.		60
2.	The kid is …… than the boy.	Rectangle
3.	1, 2, 3, 4, 5. Is in order.	Smallest
4.	A minute has…… seconds.	Square
5.	7+ 3 – 6=	Ascending
		16
		4

SECTION B (Short Questions) 36 Marks

Q.2: Attempt all questions **(18*2= 36) marks**

i. Before counting, circle the group you think has the most items. Then count.



Did you circle the correct group? Yes/ No

Now cross out the group with the least items.

ii. Follow the example and describe the number pattern by counting up and down.

2	4	6	8	10	12	14	16

Count up___by 2___'s from 2___to 16.

5	10	15	20	25	30	35	40

Count_________by________'s from_________to________.

44	40	36	32	28	24	20	16

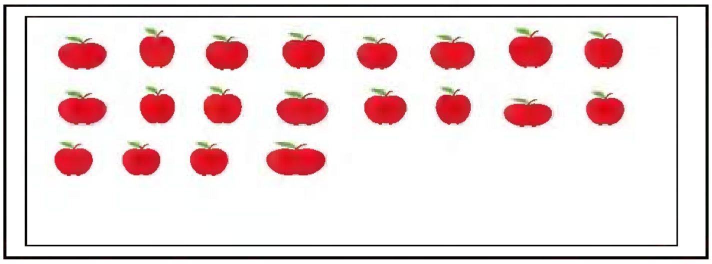
Count_________by________'s from_________to________.

100	90	80	70	60	50	40	30

Count_________by________'s from_________to________.

iii. **Draw a Circle and fill it with colors in four equal parts.**

iv. How many apples are there?..............................



Cross out 4 apples. How many apples are left? …………………………..………

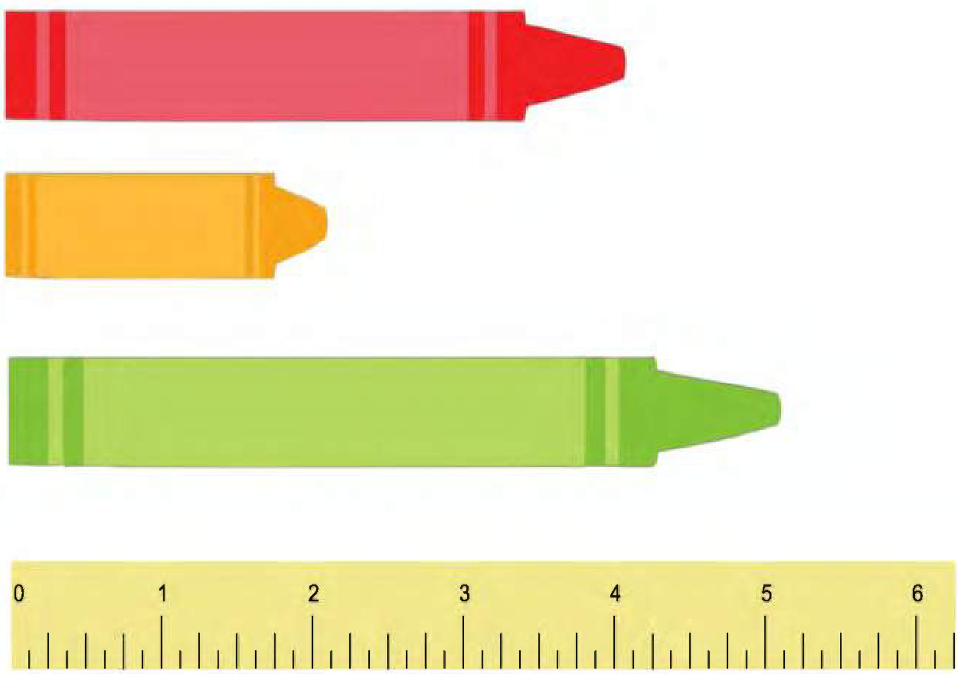
Cross out 4 more apples. How many apples are left? …………………… ………

Cross out 4 more apples. How many apples are left? ……………………..………

Cross out 4 more apples. How many apples are left?................................ ....

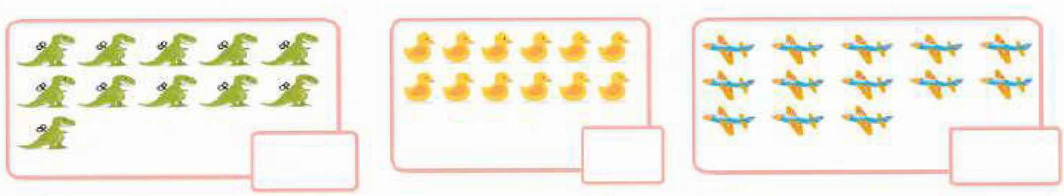
Cross out 4 more apples. How many apples are left? ……………………… ……

v. Using the ruler, measure the following marker and circle the longest marker.



vi. **Draw a rectangle and fill it with green color.**

vii. **Count the objects of each box and write down the numbers in specific boxes.**



viii. **write down 5 in ordinal numbers (in words and figures)**

Number	Ordinal Number in word	Ordinal Number in figure
5		

ix. **Tick (√) the words form of 13 and 10.**

Nine	**Ten**
Thirteen	**Six**

x. **Write the following numbers in numeral form.**

a. **Five = ………………** b. **Thirty-one = ……………………**

c. **Eighty-four = ……………** d. **One Hundred=……………….**

xi. **Add**

Tens	**Ones**		**Tens**	**Ones**		**Tens**	**Ones**
9	0	+	0	5	=		

xii. Nadia has 35 mangoes and Labia has 14 mangoes. How many mangoes they have altogether?

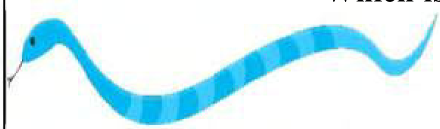
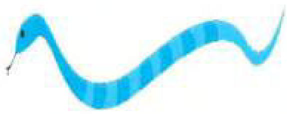
		Tens	**Ones**	
Nadia has	=			Mangoes
Labia has	=			Mangoes
Total Mangoes	=			

xiii. There are 12 birds in a tree. 5 birds flew down from the tree. How many birds left on the tree?

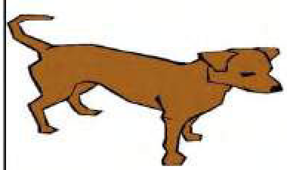
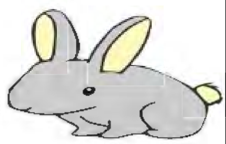
		Tens	**Ones**	
Sitting on a tree	=			Birds
Flew down from tree	=			Birds
Left on tree	=			Birds

xiv. Look at the pictures in the boxes. Answer the question by ticking (√) the correct picture.

Which is longer?

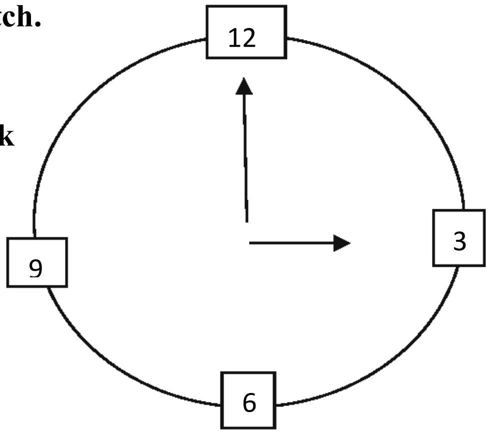
Which has shorter ears?

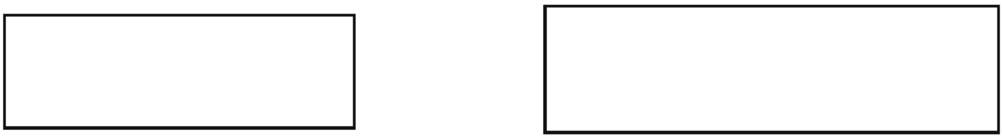
Which has a longer tail?


xv. What is the time on the watch.

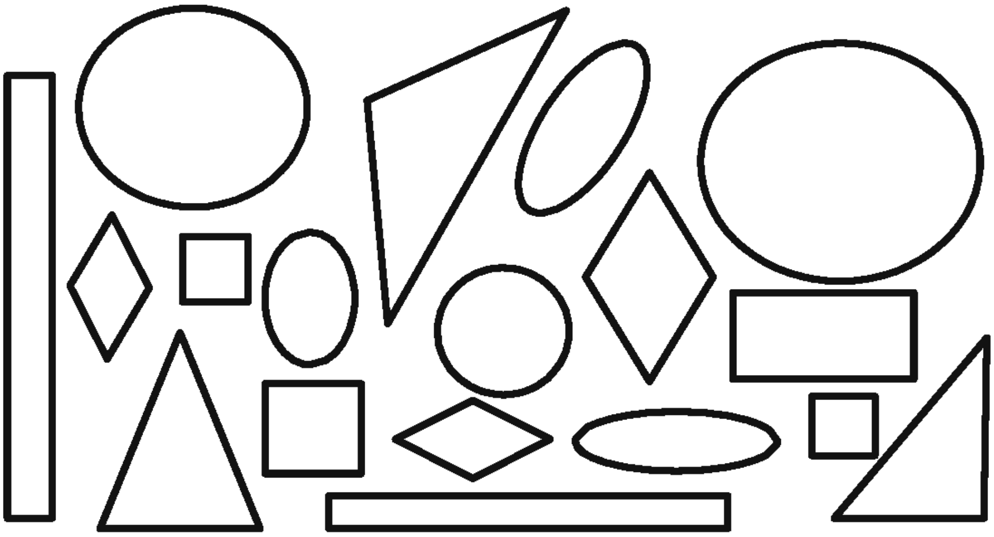
………………… O' Clock



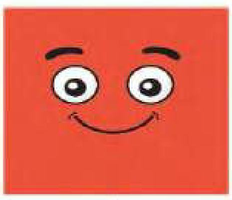
xvi. Tick (√) the longest rectangle and fill the color in the smallest rectangle.



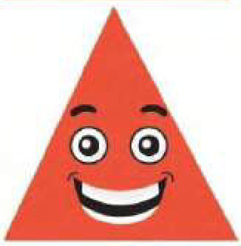
xvii. Find 2 rectangles and color them.



xviii. Write the names of the shapes (Squar / Triangle).



S ………………………………

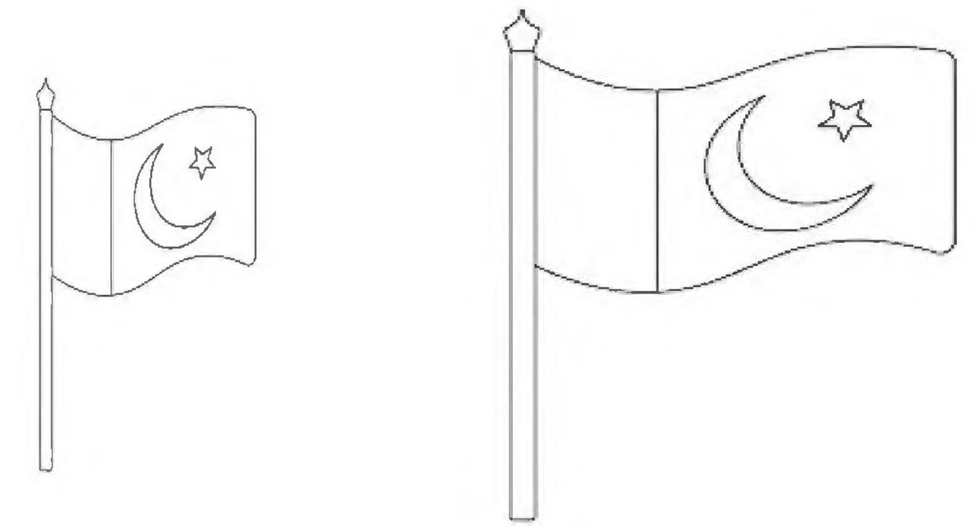


T………..…………………..

Section C (Long Questions) 24 Marks

Q. 3: Attempt all questions. **(4*6=24) Marks**

A. Color the highest flag with green and lowest flag with red.



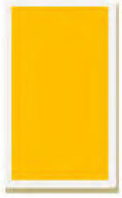
B. Make a Clock and show 9 0' clock time on it.

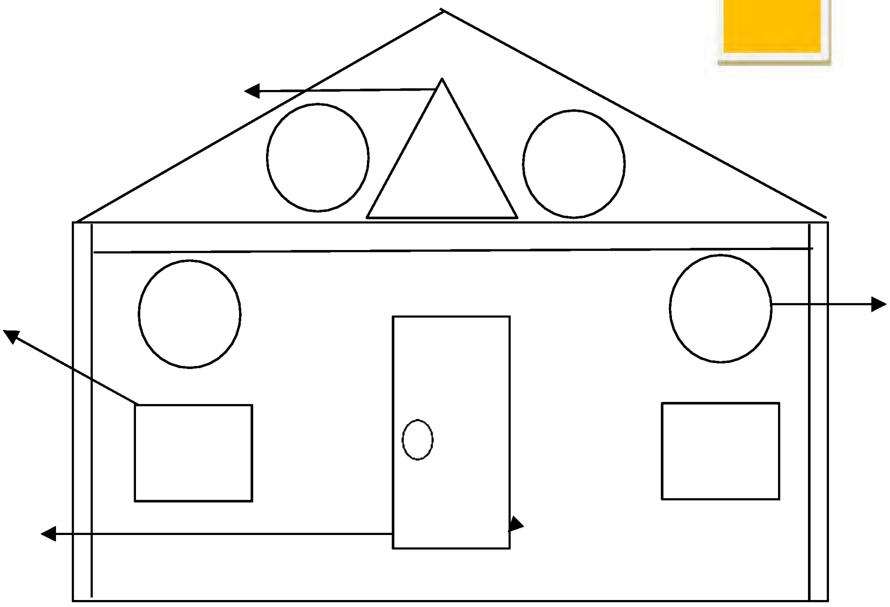
Clock

C. Zahid has 24 pencils. He gave 12 to them to his friends. How many pencils are left with Zahid?

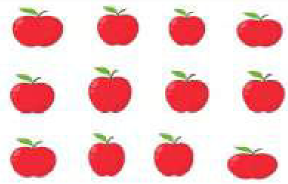
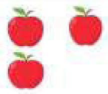
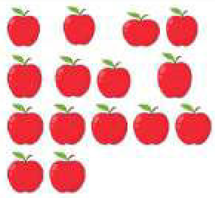
	T	O	
Zahid has			Pencils
He gave			Pencils
Zahid left			Pencils

D. Color the shape according to the key provided and label the figure

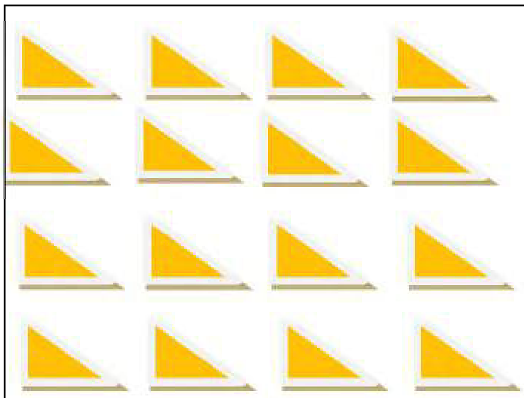
Red , Blue , Green  and Orange 



E. Solve

	And		Make	
… .... Apples	+	...Apples	=	..........Apples

F. Count and write the total numbers of triangles in Tens and Ones

	Tens	Ones
		

THE END

Appendix-iii

Statistical Data (Test Scores) of Experimental Group

Sr. No.	Name of Participants	Pre-test Scores				Post-test Scores			
		NS	SS	MT	T	NS	SS	MT	T
1.	Muhammad Bilal	17	12	08	**37**	31	26	24	**81**
2.	Shahban Aslam	17	10	07	**34**	33	26	19	**78**
3.	Sammer Ali	18	15	13	**46**	29	26	19	**77**
4.	Hasan Ali	22	11	08	**41**	30	19	22	**71**
5.	Zayan Iftikhar	17	15	16	**48**	19	25	19	**63**
6.	Ali Mustafa	15	09	08	**33**	26	21	14	**61**
7.	Muhammad Shahbaz	13	10	11	**34**	30	28	23	**81**
8.	Azan Javid	29	14	17	**64**	33	27	21	**81**
9.	Shayan	22	12	11	**45**	27	28	24	**79**
10.	Abaid	27	14	16	**60**	32	27	20	**79**
11.	Umair	29	13	16	**58**	33	27	24	**84**
12.	Aqib	24	14	14	**52**	25	27	21	**73**
13.	Husnain Ayub	19	10	10	**39**	31	29	24	**84**
14.	Ahmad	23	14	15	**52**	31	26	23	**80**
15.	Arbab Shamraiz	17	13	11	**41**	33	26	22	**80**
16.	Anas Kabir	21	14	17	**52**	26	23	21	**70**
17.	Akash Imran	23	16	17	**56**	26	29	20	**75**
18.	Muhammad Saim	24	13	13	**47**	29	26	22	**77**
19.	Arman Ali	12	08	07	**27**	31	22	19	**72**
20.	Arman Waseem	21	13	08	**42**	27	27	22	**76**
21.	Uswa Haroon	23	26	17	**63**	33	25	25	**83**

22.	Hadia Noor	17	24	17	**58**	33	24	26	**83**
23.	Samia Kosar	20	14	10	**44**	31	25	22	**78**
24.	Alisha Abid	26	14	13	**53**	28	27	21	**76**
25.	Seher Saghir	21	21	18	**60**	20	25	19	**64**
26.	Aneeqa Yasin	15	16	11	**42**	26	23	16	**65**
27.	Zarash Tahir	15	19	11	**45**	29	25	22	**72**
28.	Memoona Kazim	14	21	14	**49**	30	24	18	**72**
29.	Anayia Kabir	12	12	10	**34**	30	28	24	**82**
30.	Hania Parvaiz	06	17	13	**36**	33	28	25	**86**
31.	Hareem	09	12	09	**30**	31	26	20	**77**
32.	Amina	19	18	12	**49**	30	29	21	**80**
33.	Shahzima	26	13	12	**51**	31	29	23	**93**
34.	Ghumama Afraz	07	11	14	**36**	33	30	26	**89**
35.	Raif Imran	28	12	14	**54**	29	27	23	**79**
36.	Rehber Aslam	20	12	13	**45**	31	22	23	**76**

Appendix-iv

Statistical Data (Test Scores) of Control Group

Sr. No.	Name of Participants	Pre-test Scores				Post-test Scores			
		NS	SS	MT	T	NS	SS	MT	T
1.	Umair Shoukat	20	22	14	**56**	26	24	18	**68**
2.	Abdul Wahab	15	21	11	**47**	16	22	14	**52**
3.	Haider Ali	10	19	09	**38**	15	22	12	**49**
4.	Zaryab	08	09	02	**19**	17	14	07	**38**
5.	Subhan	10	19	11	**40**	17	20	14	**51**
6.	Awais Ali	07	10	06	**23**	14	16	11	**41**
7.	Muhammad Riaz	17	17	11	**45**	18	19	18	**55**
8.	Yasir Ali	17	20	12	**49**	21	25	17	**63**
9.	Muhammad Manan	09	20	07	**36**	10	21	11	**42**
10.	Ayan Khalid	14	18	09	**41**	17	19	14	**50**
11.	Ghoar Shoukat	14	15	10	**39**	17	21	13	**51**
12.	Amad-ul-Islam	14	17	09	**40**	15	19	17	**51**
13.	Mursaleen Khan	16	17	09	**42**	18	21	10	**49**
14.	Farman Ali	14	20	11	**45**	19	19	15	**53**
15.	Muhammad Ameen	10	15	05	**30**	14	17	09	**37**
16.	Abdul Raheem	12	19	12	**43**	19	19	15	**53**
17.	Shamsheer Bashir	14	18	10	**42**	18	21	12	**51**
18.	Arooj Fatima	15	14	13	**42**	18	18	18	**54**
19.	Sonaina Zulfiqar	16	21	18	**55**	23	22	25	**70**
20.	Anayia Munir	25	20	18	**63**	33	22	21	**76**

21.	Salar Naeem	15	14	14	**43**	17	20	20	**57**
22.	Falak	13	15	11	**39**	16	17	15	**48**
23.	Seyam	15	18	11	**44**	17	18	15	**50**
24.	Farya	18	21	14	**53**	24	21	20	**65**
25.	Muqdis	16	15	12	**43**	17	19	16	**52**
26.	Saba Saroosh	18	24	12	**54**	23	25	16	**64**
27.	Zobia	18	19	15	**52**	18	20	18	**56**
28.	Hajab Fatima	17	22	17	**56**	19	27	18	**54**
29.	Habiba	18	22	10	**50**	21	24	14	**59**
30.	Iqra Kanwal	15	22	12	**49**	18	23	14	**55**
31.	Huma Bibi	20	24	17	**61**	25	25	20	**70**
32.	Almas Shoukat	20	24	17	**61**	21	27	20	**68**
33.	Alyia Sadaqat	19	25	18	**62**	21	27	20	**68**
34.	Faiza Kousar	17	22	12	**51**	21	24	15	**60**
35.	Farzana Kousar	20	25	14	**59**	23	25	18	**66**
36.	Yashfa	10	12	08	**30**	14	14	09	**37**

Appendix-v

Statistical Data (Numerical Skills) of Experimental Group

Sr. No.	Participants	Pre-test Scores Numerical Skills				Post-test Scores Numerical Skills (33)			
		Num. Senses (11)	Count. Skills (11)	Basic Arth. Skills (11)	Total (33)	Num. Senses (11)	Count. Skills (11)	Basic Arth. Skills (11)	Total (33)
1.	Muhammad Bilal	07	10	00	**17**	09	11	11	**31**
2.	Shahban Aslam	06	10	01	**17**	11	11	11	**33**
3.	Sammer Ali	06	10	02	**18**	09	09	11	**29**
4.	Hasan Ali	05	11	06	**22**	10	09	11	**30**
5.	Zayan Iftikhar	08	05	04	**17**	09	06	04	**19**
6.	Ali Mustafa	08	07	00	**15**	10	07	09	**26**
7.	Muh. Shahbaz	07	05	01	**13**	08	11	11	**30**
8.	Azan Javid	09	11	09	**29**	11	11	11	**33**
9.	Shayan	08	06	08	**22**	09	07	11	**27**
10.	Abaid	07	11	09	**27**	10	11	11	**32**
11.	Umair	09	11	09	**29**	11	11	11	**33**
12.	Aqib	08	11	05	**24**	10	10	05	**25**
13.	Husnain Ayub	06	10	03	**19**	11	11	10	**31**
14.	Ahmad	07	11	05	**23**	11	10	10	**31**
15.	Arbab Shamraiz	07	10	00	**17**	11	11	11	**33**
16.	Anas Kabir	06	08	07	**21**	07	11	08	**26**
17.	Akash Imran	08	10	05	**23**	10	08	08	**26**

18.	Muhammad Saim	07	11	03	**24**	10	10	09	**29**
19.	Arman Ali	03	08	01	**12**	09	11	11	**31**
20.	Arman Waseem	09	09	03	**21**	09	11	07	**27**
21.	Uswa Haroon	07	09	07	**23**	11	11	11	**33**
22.	Hadia Noor	07	08	02	**17**	11	11	11	**33**
23.	Samia Kosar	06	09	05	**20**	10	10	11	**311**
24.	Alisha Abid	08	11	07	**26**	09	09	10	**28**
25.	Seher Saghir	06	10	05	**21**	08	06	06	**20**
26.	Aneeqa Yasin	08	07	00	**15**	09	09	08	**26**
27.	Zarash Tahir	09	05	01	**15**	10	11	08	**29**
28.	Memoona Kazim	08	05	01	**14**	10	10	10	**30**
29.	Anayia Kabir	07	04	01	**12**	09	11	10	**30**
30.	Hania Parvaiz	01	05	00	**06**	11	11	11	**33**
31.	Hareem	01	07	01	**09**	10	11	10	**31**
32.	Amina	07	11	01	**19**	10	10	10	**30**
33.	Shahzima	08	11	07	**26**	11	11	09	**31**
34.	Ghumama Afraz	05	05	01	**07**	11	11	11	**33**
35.	Raif Imran	09	10	09	**28**	10	10	09	**29**
36.	Rehber Aslam	08	11	01	**20**	10	10	11	**31**

Appendix-vi

Statistical Data (Numerical Skills) of Control Group

Sr. No.	Participants	Pre-test Scores Numerical Skills				Post-test Scores Numerical Skills (33)			
		Num. Senses (11)	Count. Skills (11)	Basic Arth. Skills (11)	Total (33)	Num. Senses (11)	Count. Skills (11)	Basic Arth. Skills (11)	Total (33)
1.	Umair Shoukat	08	07	05	**20**	10	11	05	**26**
2.	Abdul Wahab	05	07	03	**15**	07	06	03	**16**
3.	Haider Ali	05	04	01	**10**	06	06	03	**15**
4.	Zaryab	05	03	00	**08**	06	06	05	**17**
5.	Subhan	03	04	03	**10**	07	07	05	**17**
6.	Awais Ali	04	03	00	**07**	07	04	03	**14**
7.	Muhammad Riaz	07	05	05	**17**	08	05	05	**18**
8.	Yasir Ali	07	07	04	**17**	07	11	03	**21**
9.	Muhammad Manan	02	04	03	**09**	03	04	03	**10**
10.	Ayan Khalid	03	07	04	**14**	05	07	05	**17**
11.	Ghoar Shoukat	04	07	03	**14**	07	07	03	**17**
12.	Amad-ul-Islam	06	06	02	**14**	06	06	03	**15**
13.	Mursaleen Khan	06	06	04	**16**	07	06	05	**18**
14.	Farman Ali	04	07	03	**14**	07	07	05	**19**
15.	Muhammad Ameen	04	05	01	**10**	06	05	03	**14**
16.	Abdul Raheem	05	06	01	**12**	08	06	05	**19**
17.	Shamsheer Bashir	05	06	03	**14**	07	06	05	**18**
18.	Arooj Fatima	05	07	03	**15**	08	07	03	**18**

19.	Sonaina Zulfiqar	08	07	01	**16**	10	11	02	**23**
20.	Anayia Munir	09	09	07	**25**	11	11	11	**33**
21.	Salar Naeem	07	07	01	**15**	09	07	01	**17**
22.	Falak	07	06	00	**13**	07	09	00	**16**
23.	Seyam	07	07	01	**15**	09	07	01	**17**
24.	Farya	08	07	03	**18**	10	11	03	**24**
25.	Muqdis	07	04	05	**16**	08	04	05	**17**
26.	Saba Saroosh	08	07	03	**18**	09	11	03	**23**
27.	Zobia	08	07	03	**18**	08	07	03	**18**
28.	Hajab Fatima	08	06	03	**17**	09	07	03	**19**
29.	Habiba	08	07	03	**18**	09	07	05	**21**
30.	Iqra Kanwal	07	07	01	**15**	08	07	03	**18**
31.	Huma Bibi	08	07	05	**20**	11	07	07	**25**
32.	Almas Shoukat	08	07	05	**20**	11	11	05	**21**
33.	Alyia Sadaqat	07	07	05	**19**	09	07	05	**21**
34.	Faiza Kousar	07	07	03	**17**	09	07	05	**21**
35.	Farzana Kousar	08	07	05	**20**	09	07	07	**23**
36.	Yashfa	03	04	03	**10**	06	05	03	**14**

Appendix-vii

Statistical Data (Spatial Skills) of Experimental Group

Sr. No.	Participants	Pre-test Scores				Post-test Scores			
		Spatial Skills				Spatial Skills			
		Sp. Senses (12)	Geo. Aw. (11)	Sense Of Time (11)	Total (34)	Sp. Senses (12)	Geo. Aw. (11)	Sense Of Time (11)	Total (34)
1.	Muhammad Bilal	06	02	04	**12**	10	08	08	**26**
2.	Shahban Aslam	06	01	03	**10**	10	09	07	**26**
3.	Sammer Ali	07	03	05	**15**	11	07	08	**26**
4.	Hasan Ali	06	02	03	**11**	06	06	07	**19**
5.	Zayan Iftikhar	06	04	05	**15**	08	09	08	**25**
6.	Ali Mustafa	06	02	01	**09**	08	09	04	**21**
7.	Muh. Shahbaz	04	03	03	**10**	11	09	08	**28**
8.	Azan Javid	06	04	04	**14**	10	10	07	**27**
9.	Shayan	06	02	04	**12**	10	10	08	**28**
10.	Abaid	07	04	03	**14**	10	09	08	**27**
11.	Umair	05	05	03	**13**	10	10	07	**27**
12.	Aqib	07	04	03	**14**	09	11	07	**27**
13.	Husnain Ayub	06	03	01	**10**	10	11	08	**29**
14.	Ahmad	06	04	04	**14**	10	07	09	**26**
15.	Arbab Shamraiz	06	02	05	**13**	10	09	07	**26**
16.	Anas Kabir	06	03	05	**14**	09	06	08	**23**
17.	Akash Imran	07	04	05	**16**	10	11	08	**29**
18.	Muhammad Saim	05	03	05	**13**	12	10	04	**26**
19.	Arman Ali	06	01	01	**08**	09	05	08	**22**

20.	Arman Waseem	06	03	04	**13**	10	10	07	**27**
21.	Uswa Haroon	09	07	07	**26**	11	09	05	**25**
22.	Hadia Noor	07	11	06	**24**	11	08	05	**24**
23.	Samia Kosar	07	03	04	**14**	10	09	06	**25**
24.	Alisha Abid	06	04	04	**14**	11	08	08	**277**
25.	Seher Saghir	07	09	05	**21**	11	08	06	**25**
26.	Aneeqa Yasin	04	06	06	**16**	09	06	08	**23**
27.	Zarash Tahir	07	06	06	**19**	10	08	07	**25**
28.	Memoona Kazim	09	04	08	**21**	09	08	07	**24**
29.	Anayia Kabir	07	04	01	**12**	11	09	08	**28**
30.	Hania Parvaiz	08	05	04	**17**	11	09	08	**28**
31.	Hareem	05	04	03	**12**	07	10	09	**26**
32.	Amina	09	05	04	**18**	11	09	09	**29**
33.	Shahzima	06	02	05	**13**	09	11	09	**29**
34.	Ghumama Afraz	05	03	03	**11**	12	10	08	**30**
35.	Raif Imran	06	01	05	**12**	09	10	08	**27**
36.	Rehber Aslam	07	03	02	**12**	08	08	06	**22**

Appendix-viii

Statistical Data (Spatial Skills) of Control Group

Sr. No.	Participants	Pre-test Scores Spatial Skills				Post-test Scores Spatial Skills			
		Sp. Senses (12)	Geo. Aw. (11)	Sense Of Time (11)	Total (34)	Sp. Senses (12)	Geo. Aw. (11)	Sense Of Time (11)	Total (34)
1.	Umair Shoukat	08	06	08	**22**	09	07	08	**24**
2.	Abdul Wahab	08	05	08	**21**	08	06	08	**22**
3.	Haider Ali	07	06	06	**19**	09	07	06	**22**
4.	Zaryab	07	01	01	**09**	08	02	04	**14**
5.	Subhan	07	05	07	**19**	08	07	05	**20**
6.	Awais Ali	05	03	02	**10**	07	05	04	**16**
7.	Muhammad Riaz	07	03	07	**17**	09	06	04	**19**
8.	Yasir Ali	08	05	07	**20**	10	06	09	**25**
9.	Muhammad Manan	08	05	07	**20**	09	06	06	**21**
10.	Ayan Khalid	07	04	07	**18**	08	06	05	**19**
11.	Ghoar Shoukat	06	03	06	**15**	09	05	07	**21**
12.	Amad-ul-Islam	05	06	06	**17**	07	07	05	**19**
13.	Mursaleen Khan	06	05	06	**17**	08	06	07	**21**
14.	Farman Ali	08	04	08	**20**	08	07	04	**19**
15.	Muhammad Ameen	06	02	07	**15**	06	05	06	**17**
16.	Abdul Raheem	06	05	08	**19**	08	07	04	**19**
17.	Shamsheer Bashir	08	03	07	**18**	08	07	06	**21**

18.	Arooj Fatima	06	04	04	**14**	07	04	04	**18**
19.	Sonaina Zulfiqar	08	06	07	**21**	10	07	05	**22**
20.	Anayia Munir	08	05	07	**20**	10	06	06	**22**
21.	Salar Naeem	05	04	05	**14**	07	06	07	**20**
22.	Falak	07	03	05	**15**	09	03	05	**17**
23.	Seyam	08	04	06	**18**	10	04	04	**18**
24.	Farya	09	04	08	**21**	08	05	08	**21**
25.	Muqdis	06	03	06	**15**	08	05	06	**19**
26.	Saba Saroosh	10	06	08	**24**	11	08	06	**25**
27.	Zobia	06	06	07	**19**	07	07	06	**20**
28.	Hajab Fatima	09	06	07	**22**	10	08	09	**27**
29.	Habiba	08	06	08	**22**	09	07	08	**24**
30.	Iqra Kanwal	08	06	08	**22**	10	08	05	**23**
31.	Huma Bibi	10	06	08	**24**	11	08	06	**25**
32.	Almas Shoukat	10	06	08	**24**	12	08	07	**27**
33.	Alyia Sadaqat	09	08	08	**25**	10	10	07	**27**
34.	Faiza Kousar	08	06	08	**22**	09	08	07	**24**
35.	Farzana Kousar	10	07	08	**25**	11	08	06	**25**
36.	Yashfa	04	02	06	**12**	06	04	04	**14**

Appendix-ix

Statistical Data (Mathematical Thinking) of Experimental Group

Sr. No.	Name of Participants	Pre-test Scores	Post-test Scores
		Math. Thinking (33)	Math. Thinking (33)
1.	Muhammad Bilal	08	24
2.	Shahban Aslam	07	19
3.	Sammer Ali	13	19
4.	Hasan Ali	08	22
5.	Zayan Iftikhar	16	19
6.	Ali Mustafa	08	14
7.	Muhammad Shahbaz	11	23
8.	Azan Javid	17	21
9.	Shayan	11	24
10.	Abaid	16	20
11.	Umair	16	24
12.	Aqib	14	21
13.	Husnain Ayub	10	24
14.	Ahmad	15	23
15.	Arbab Shamraiz	11	22
16.	Anas Kabir	17	21
17.	Akash Imran	17	20
18.	Muhammad Saim	13	22
19.	Arman Ali	07	19
20.	Arman Waseem	08	22

21.	Uswa Haroon	17	25
22.	Hadia Noor	17	26
23.	Samia Kosar	10	22
24.	Alisha Abid	13	21
25.	Seher Saghir	18	19
26.	Aneeqa Yasin	11	16
27.	Zarash Tahir	11	22
28.	Memoona Kazim	14	18
29.	Anayia Kabir	10	24
30.	Hania Parvaiz	13	25
31.	Hareem	09	20
32.	Amina	12	21
33.	Shahzima	12	23
34.	Ghumama Afraz	14	26
35.	Raif Imran	14	23
36.	Rehber Aslam	13	23

Appendix-x

Statistical Data (Mathematical Thinking) of Control Group

Sr. No.	Participants	Pre-test Scores	Post-test Scores
		Math. Thinking (33)	Math. Thinking (33)
1.	Umair Shoukat	14	18
2.	Abdul Wahab	11	14
3.	Haider Ali	09	12
4.	Zaryab	02	07
5.	Subhan	11	14
6.	Awais Ali	06	11
7.	Muhammad Riaz	11	18
8.	Yasir Ali	12	17
9.	Muhammad Manan	07	11
10.	Ayan Khalid	09	14
11.	Ghoar Shoukat	10	13
12.	Amad-ul-Islam	09	17
13.	Mursaleen Khan	09	10
14.	Farman Ali	11	15
15.	Muhammad Ameen	05	09
16.	Abdul Raheem	12	15
17.	Shamsheer Bashir	10	12
18.	Arooj Fatima	13	18
19.	Sonaina Zulfiqar	18	25
20.	Anayia Munir	18	21

21.	Salar Naeem	14	20
22.	Falak	11	15
23.	Seyam	11	15
24.	Farya	14	20
25.	Muqdis	12	16
26.	Saba Saroosh	12	16
27.	Zobia	15	18
28.	Hajab Fatima	17	18
29.	Habiba	10	14
30.	Iqra Kanwal	12	14
31.	Huma Bibi	17	20
32.	Almas Shoukat	17	20
33.	Alyia Sadaqat	18	20
34.	Faiza Kousar	12	15
35.	Farzana Kousar	14	18
36.	Yashfa	08	09

Annexure-xi

Lesson Planning (Experimental group)

Lesson Plan No. 1

Grade: 1^{st}	Time: 1 Hour
Subject: Mathematics	**Topic:** Numbers 0-9

1. Introduction:

In the previous grade of early child care education (ECCE), the students have learnt about numbers up to 50 in numerals form. Numbers are used to count, compare and measure things. Numbers 1-9 would be revised in this lesson. In this lesson, '0' will be identified as a number. They will also learn numbers up to 9 in words.

2. Procedure

A. Preparation (4 Minutes)

The teacher will prepare the topic "0-9" with instruction based on "Hands on Learning", aligned with the following ILOs and teaching materials.

i. ILOs:

By the end of the lesson, all the students will be able to:

- identify numbers 1-9.
- identify '0' as a number.
- read numbers up to 9 in numerals and in words.
- write numbers up to 9 in numerals and in words.
- count objects up to 9 and represent in numbers.
- match the numbers 0-9 with objects.
- Count numbers forward from 1 to 9.
- count numbers backward from 9 to 1.
- arrange numbers in ascending and descending order (up to 9).
- identify which number (up to 9) comes before and after a given number.
- identify which number (up to 9) comes between two given numbers.

ii. Teaching Method:

Textbook, worksheets of objects and numbers, white sheets, color pencils, pointer, whiteboard, marker and duster.

B. Engagement (25 Minutes)

i. Introduce and Contextualize

The teacher will show a chart of objects to the students and ask them to count each object of every boxes. After this he will also provide concrete objects such as pencils, beads, buttons etc. to students and give them the concept of counting objects. He will show a chart having two plates; one plate will have some apples and other will be empty. He will also ask them to count the apples. Through the empty plate, he will give the concept of '0'. The teacher will show them different charts such as chart of counting forward and backward numbers, chart of numbers up to 9 arranging in ascending and descending order and chart of numbers after, before and between up to 9.

ii. Description

At this stage, the teacher will discuss all charts with students in detail. He will also tell them how to read and write counting (0-9) in numerals and words form. He will give presentation of reading and writing numbers (0-9). He will also give the concept of matching objects with their relative numbers. Concept of counting (up to 9) forward and backward will be given by the teacher. Now, the teacher will give the concept of reading and writing numbers after, before and between up to 9. He will also tell them how to make number cards and flash cards.

iii. Engagement Activities

At this stage, the teacher will engage the following activities:

Activity-1: Identification of Numbers 1-9

The teacher may ask the students to count the number of chairs, lights, tables and number of students in the classroom. He will divide the whole class in four groups naming Group-A, Group-B, Group-C and Group-D. Group- A will be given some pencils and ask them to count them and write the number in numerals and in words form. Group-B will be given flash cards of numbers and numbers up to 9 in numeral form. The teacher will ask them to match the numbers up to 9 with numbers in numeral form. Group-C will be given flash cards of numbers and numbers up to 9 in word form. The teacher will ask them to match the numbers up to 9 with numbers in word form. Group-D will be given some flash cards and ask them to make cards with number from 1-9 and fill them with different colours.

Activity-II: Identification of "Zero" as a Number

The teacher will ask the students of on group to come in front of class and stand in circle. In this way, he will give them the concept of "0" to students. He will draw "0" on the white board. Now, the teacher will draw 5 shapes of apples on the white board. He will ask one student to rub all shapes of apples one by one from the board. When no shape of apple will be left on the board, he will ask the students how many shapes of apples are left on the board. They will tell them that there is no shape of apple on the board. In this way he will also give the concept of "0". The teacher will put some beads on the table and ask one student to come in front of class and remove all beads one by one from the table. This is another example of giving the concept of "0". Now the teacher will place 4 jars and 3 pencils on a table. He will ask one student to come and put a pencil in each jar and ask them how many pencils are left and how many jars are empty. The empty jar will show that there is no pencil in it which means there is zero pencil. Now he will ask each group (Group-A, Group-B, Group-C and Group-D) to draw zero and fill it with red, blue, green and yellow colours respectively.

Activity-III: Counting Forward, Backward, Ascending and Descending Order up to 9

Here, the teacher will assign the following activities to the students. Group-A will be given activity of counting forward, Group-B will be given activity of counting backward, Group-C will be given the activity of arranging numbers in ascending order and Group-D will be given the activity of arranging numbers in descending order. For this purpose, he will ask Group-A to count the objects while touching them. He will also ask them to put some beads in the jar and count them. In this way, he will give the concept of counting forward. He will ask Group-B to count the objects in reverse order while touching them. Backward counting / reverse counting will be taking out the beads from the jar. Now, the teacher will place some concrete objects of different sizes on the table and ask Group-C to arrange the objects from the smallest to the greatest and will ask Group-D to arrange the objects from the greatest to the smallest according to their heights. Now, the teacher will ask them take two card boards and cut each of them into 9 equal parts. Write numerals from 1 to 9 on each card. Paste these cards on a chart paper in ascending and descending order.

Activity-IV: Numbers after, before and between up to 9.

Now the teacher will provide number cards (0 to 9) and place them upside down on the table. He will call students on by one in front of the class and ask him / her to pick up any number card, read the number loudly and tell which number comes before and after that number. He will also give one number to each group and ask them to write a number before and after that number on the card and paste them on the chart.

C. Exploration (10 Minutes)

During the exploration phase, students will participate in hands on activities to learn about numbers 0-9. Activities (Number Tracing, Counting Blocks, Number Bingo & Number Scavenger Hunt) will be assigned to students.

D. Reflection (5 Minutes)

At this stage, the teacher will ask some questions to the students in order to assess their understanding, interest in the lesson and to develop scientific skills through thinking or focusing their attention on something. Following questions may be asked:

Q. 1: What did you learn about numbers 0-9 today?

Q.2: What was your favorite activity?

Q.3: What did you find challenging to understand?

E. Application (10 Minutes)

During the application phase, student apply their knowledge of numbers 0-9 in real life situations. The teacher will use number cards to create a number sequence (0-9) on the working sheets. The teacher will engage them in a counting game where they can take turns counting from 0-9.

F. Assessment (4 Minutes)

At this stage, the teacher may ask the following questions:

Q.1: About what numbers we have learnt today?

Q.2: Is "0" a number?

Q.3: What do you think about 'Three', is it in numeral form or word form?

3. Home Work (2 Minutes)

The teacher will ask them to make flash cards of numbers up to 9 and fill them with different colours.

Lesson Plan No. 2 (Experimental group)

Grade: 1st	Time: 1 Hour
Subject: Mathematics	**Topic:** Numbers 10-20

1. Introduction:

In the previous lesson, the students have learnt about numbers up to 9 in numerals and words form. Numbers are used to count, compare and measure things. Numbers 10-20 would be learnt in this lesson. In this lesson, '10' will be identified as a 2-digit number. They will also learn numbers from 10 to 20 in numeral and words form.

2. Procedure

A. Preparation (4 Minutes)

The teacher will prepare the topic "10-20" with instruction based on "Hands on Learning", aligned with the following ILOs and teaching materials.

i. ILOs:

By the end of the lesson, all the students will be able to:

- identify 10 as 2-digit number
- identify numbers 10-20.
- read numbers from 10 to 20 in numerals and in words.
- write numbers from 10 to 20 in numerals and in words.
- count and match the numbers from 10 to 20 with objects.
- count numbers forward from 10 to 20.
- count numbers backward from 20 to 10.
- arrange numbers in ascending and descending order (up to 20).
- identify which number (10-20) comes before and after a given number.
- identify which number (10-20) comes between two given numbers.

ii. Teaching Method:

Textbook, worksheets of objects and numbers, white sheets, color pencils, pointer, whiteboard, marker and duster.

B. Engagement (25 Minutes)

i. Introduce and Contextualize

The teacher will show a chart of objects to the students and ask them to count each object of every boxes. After this he will also provide concrete objects such as pencils, beads, buttons etc. to students and give them the concept of counting objects He will give the concept of '10' by providing 9 pencils and 1 ice-cream stick. He will rubber 9 pencils and 1 ice cream stick in a bundle with a rubber band. He will tell them that one bundle is called 1-ten and 10 is the smallest 2-digit number. The teacher will also show them different charts such as chart of counting forward and backward numbers, chart of numbers from 10 to 20 arranging in ascending and descending order and chart of numbers after, before and between 10-20.

ii. Description

At this stage, the teacher will discuss all charts with students in detail. He will also tell them how to read and write counting (10-20) in numerals and words form. He will give presentation of reading and writing numbers (10-20). He will also give the concept of matching objects with their relative numbers. Concept of counting (10-20) forward and backward will be given by the teacher. Now, the teacher will give the concept of reading and writing numbers after, before and between 10-20. He will also tell them how to make number cards and flash cards.

iii. Engagement Activities

The teacher will perform the following activities in the classroom by dividing the whole class in four groups naming Group-A, Group-B, Group-C and Group-D for each activity. He will provide them different objects (pencils, coins, bundle of match sticks), flash cards (numbers 10-20 in numeral, numbers 10-20 in words), colours (red, green, orange & pink) for the execution of activities.

Activity-1: Identification of Numbers 11-20

The teacher may ask the students to count the number of students in the classroom. He will divide the whole class in four groups naming Group-A, Group-B, Group-C and Group-D. Group- A will be given more than 10 pencils and ask them to count them and write the number in numerals and in words form. Group-B will be given flash cards of numbers and numbers from 10 to 20 in numeral form. The teacher will ask them to match the numbers from 10 to 20 with numbers in numeral form. Group-C will be given flash cards of numbers and numbers from 10 to 20 in word form. The teacher will ask them to match the numbers from 10 to 20 with numbers in word form. Group-D will be given some flash cards and ask them to make cards with number from 10 to 20 and fill them with different colours.

Activity-II: Identification of "10" as a 2- Digit Number

The teacher will ask 9 students to come in front of class. Now, he will ask another student to come and stand with 9 students. He will tell them that this one group of students is called 1-ten and 10 is the smallest 2-digit number. In this way, he will give them the concept of "t0" to students. He will write down "10" in numeral and word form on the white board. The teacher will put some beads on the table and ask one student to come and count 10 beads. This is another example of giving the concept of "10". Now the teacher will place 6 red pencils and 4 blue pencils on a table. He will ask one student to come and put all pencils in a jar and ask them how many pencils are in the jar. The jar will show that there are 10 pencils in it. In this way, he will give the concept of 10 as a 2-digit number, Now, he will ask each group (Group-A, Group-B, Group-C and Group-D) to make 10 on flash cards and fill it with red, blue, green and yellow colours respectively.

Activity-III: Counting Forward, Backward, Ascending and Descending Order up to 20

Here, the teacher will assign the following activities to the students. Group-A will be given activity of counting forward, Group-B will be given activity of counting backward, Group-C will be given the activity of arranging numbers in ascending order and Group-D will be given the activity of arranging numbers in descending order. For this purpose, he will ask Group-A to write down counting from 10 to 20. In this way, he will give the concept of counting forward. He will ask Group-B to write down counting in reverse order. In this way, concept of backward counting will be given to students. Now, the teacher will place some concrete objects of different sizes on the table and ask Group-C to arrange the objects from the smallest to the greatest and will ask Group-D to arrange the objects from the greatest to the smallest according to their heights.

Activity-IV: Numbers after, before and between up to 20.

Now the teacher will provide number cards (10 to 20) and place them upside down on the table. He will call students on by one in front of the class and ask him / her to pick up any number card, read the number loudly and tell which number comes before and after that number. He will also give one number to each group and ask them to write a number before and after that number on the card and paste them on the chart.

C. Exploration (10 Minutes)

During the exploration phase, students will participate in hands on activities to learn about numbers 10-20. Following activities will be assigned to students:

- Number Tracing
- Counting Blocks
- Number Bingo
- Number War
- Number Scavenger Hunt

D. Reflection (5 Minutes)

At this stage, the teacher will ask some reflective questions to the students in order to assess their understanding, interest in the lesson and to develop scientific skills through thinking or focusing their attention on something. Following questions may be asked:

Q. 1: What was your favorite activity?

Q.2: What did you find challenging to understand?

E. Application (10 Minutes)

During the application phase, student apply their knowledge of numbers 10-20 in real life situations. The teacher will use number cards to create a number sequence (10-20) on the working sheets. The teacher will engage them in a counting game where they can take turns counting from 10-20.

F. Assessment (10 Minutes)

At this stage, the teacher may ask the following questions:

Q.1: About what number we have learnt today?

Q.2: Is “10” a one-digit or two-digit number?

Q.3: which number comes before 13?

3. Home Work (2 Minutes)

The teacher will ask them to make flash cards of numbers up to 9 and fill them with different colours.

Lesson Planning (Experimental group)
Lesson Plan No. 3

Grade: 1st	Time: 1 Hour
Subject: Mathematics	**Topic:** Numbers 21-50

1. Introduction:

In the previous lesson, the students have learnt about numbers from 10-20 in numerals and words form. Numbers are used to count, compare and measure things. Numbers 21-50 would be learnt in this lesson. They will also learn numbers from 21 to 50 in numeral and words form.

2. Procedure

A. Preparation (4 Minutes)

The teacher will prepare the topic "Number 21-50" with instruction based on "Hands on Learning", aligned with the following ILOs and teaching materials.

i. ILOs:

By the end of the lesson, all the students will be able to:

- identify numbers 21-50.
- read numbers from 21 to 50 in numerals and in words.
- write numbers from 21 to 50 in numerals and in words.
- count and match the numbers from 21 to 50 with objects.
- count numbers forward from 21 to 50.
- count numbers backward from 50 to 21.
- arrange numbers in ascending and descending order (up to 50).
- identify which number (21-51) comes before and after a given number.
- identify which number (21-50) comes between two given numbers.

ii. Teaching Method:

Textbook, worksheets of objects and numbers, white sheets, color pencils, pointer, whiteboard, marker and duster.

B. Engagement (25 Minutes)

i. Demonstration

The teacher will show a chart of objects which will be rubbed in bundle of tens to the students and ask them to count each bundle. After this he will also provide concrete objects such as pencils, beads, buttons etc. to students and give them the concept of counting objects. He will give the concept of numbers 21-50 by providing 5 bundles such as bundle of pencils, ice-cream sticks, matches sticks, 10 beads in a plastic bundle and bundle of 10 roses. He will ask one student to come and pick 1 bundle of pencil, 1 bundle of roses and 1 ice-cream stick. He will tell them two bundles of tens and one more make 21. In this way, he will give the concept of learning numbers up to 50. The teacher will also show them different charts such as chart of counting forward and backward numbers, chart of numbers from 21 to 50 arranging in ascending and descending order and chart of numbers after, before and between 21-50.

ii. Description

At this stage, the teacher will discuss all charts with students in detail. He will also tell them how to read and write counting (21-50) in numerals and words form. He will give presentation of reading and writing numbers (21-50). He will also give the concept of matching objects with their relative numbers. Concept of counting (21-50) forward and backward will be given by the teacher. Now, the teacher will give the concept of reading and writing numbers after, before and between 21-50. He will also tell them how to make number cards and flash cards.

iii. Engagement Activities

The teacher will perform the following activities in the classroom by dividing the whole class in four groups naming Group-A, Group-B, Group-C and Group-D for each activity. He will provide them different objects (pencils, coins, bundle of match sticks), flash cards (numbers 10-20 in numeral, numbers 10-20 in words), colours (red, green, orange & pink) for the execution of activities.

Activity-1: Identification of Number 21-50

The teacher may ask the students to count the number of students in the classroom. He will divide the whole class in four groups naming Group-A, Group-B, Group-C and Group-D. Group- A will be given 2 bundles of objects and some pencils and ask them to count them and write the number in numerals and in words form. Group-B will be given flash cards of numbers and numbers from 21-35 in numeral form. The teacher will ask them to match the numbers from 21-35 with numbers in numeral form. Group-C will be given flash cards of numbers and numbers from 36-50 in word form. The teacher will ask them to match the numbers from 36-50 with numbers in word form. Group-D will be given some flash cards and ask them to make cards with numbers 30, 40 and 50 fill them with different colours.

Activity-II: Counting Forward, Backward, Ascending and Descending Order up to 50

Here, the teacher will ask Group-A to write down counting from 21-30. In this way, he will give the concept of counting forward. He will ask Group-B to write down counting in reverse order from 50-41. In this way, concept of backward counting will be given to students. Now, the teacher will place some concrete objects of different sizes on the table and ask Group-C to arrange the objects from the smallest to the greatest and will ask Group-D to arrange the objects from the greatest to the smallest according to their heights. Now, the teacher will ask them take three card boards and cut each of them into 10 equal parts. Write numerals from 21-50 on each card. Paste these cards on a chart in ascending and descending order.

Activity-III: Numbers after, before and between up to 50.

Now, the teacher will provide number cards (21 to 50) and place them upside down on the table. He will call students on by one in front of the class and ask him / her to pick up any number card, read the number loudly and tell which number comes before and after that number. He will also give one number to each group and ask them to write a number before and after that number on the card and paste them on the chart.

C. Exploration (10 Minutes)

During the exploration phase, students will participate in hands on activities to learn about numbers 21-50. Following activities will be assigned to students:

- Number Tracing
- Counting Blocks
- Number Bingo
- Number Scavenger Hunt

D. Reflection (5 Minutes)

At this stage, the teacher will ask some questions to the students in order to assess their understanding, interest in the lesson and to develop scientific skills through thinking or focusing their attention on something. Following questions may be asked:

Q. 1: What was your favorite activity?

Q.2: How many tens are in 40?

Q.3: Tell, the numbers 41, 42, 43, 44, 45 are in ascending or descending order.

Q.4: Which numbers come before 36?

E. Application (10 Minutes)

During the application phase, student apply their knowledge of numbers 21-50 in real life situations. The teacher will use number cards to create a number sequence (21-50) on the working sheets. The teacher will engage them in a counting game where they can take turns counting from 31-40.

F.Assessment (4 Minutes)

At this stage, the teacher may ask the following questions:

Q.1: About what topic we have read today?

Q.2: Is “40” a 2-digit number?

Q.3: What do you think about ‘Thirty’, is it in numeral form or word form?

Q.4: Arrange numbers from 25 to 35 in ascending order.

3. Home Work (2 Minutes)

The teacher will ask them to make flash cards of numbers “30, 40 & 50” and fill them with different colours.

Lesson Planning (Experimental group)
Lesson Plan No. 4

Grade: 1st	Time: 1 Hour
Subject: Mathematics	**Topic:** Numbers 51-100

1. Introduction:

In the previous lesson, the students have learnt about numbers from 21-50 in numerals and words form. Numbers are used to count, compare and measure things. Numbers 51-100 would be learnt in this lesson. They will also learn numbers from 51 to 100 in numeral and words form.

2. Procedure

A. Preparation (4 Minutes)

The teacher will prepare the topic "Number 51-100" with instruction based on "Hands on Learning", aligned with the following ILOs and teaching materials.

i. ILOs:

By the end of the lesson, all the students will be able to:

- identify numbers 51-100.
- identify 100 as a 3-digit number.
- read numbers from 51 to 100 in numerals and in words.
- write numbers from 51 to 100in numerals and in words.
- count and match the numbers from 51 to 100with objects.
- count numbers forward from 51 to 100.
- count numbers backward from 100 to 51.
- arrange numbers in ascending and descending order (up to 100).
- identify which number (51-100) comes before and after a given number.
- identify which number (51-100) comes between two given numbers.

ii. Teaching Method:

Textbook, worksheets of objects and numbers, white sheets, color pencils, pointer, whiteboard, marker and duster.

B. Engagement (25 Minutes)

i. Demonstration

The teacher will show a chart of objects which will be rubbed in bundle of tens to the students and ask them to count each bundle. After this he will also provide concrete objects such as pencils, beads, buttons etc. to students and give them the concept of counting objects. He will give the concept of numbers 51-100 by providing 5 bundles such as bundle of pencils, ice-cream sticks, matches sticks, beads in a plastic bundle and bundle of roses. Each bundle will contain 20 objects. He will ask one student to come and pick 1 bundle of pencil, 1 bundle of roses and 1 bundle of ice-cream stick. He will tell them two bundles of twenty and more 11 make 51. In this way, he will give the concept of learning numbers up to 100. He will give the concept of '100' by providing them 10 rupees notes. He will tell them 10 notes of Tens make one hundred and it is a 3-digit number. The teacher will also show them different charts such as chart of counting forward and backward numbers, chart of numbers from 51 to 100 arranging in ascending and descending order and chart of numbers after, before and between 51-100.

ii. Description

At this stage, the teacher will discuss all charts with students in detail. He will also tell them how to read and write counting (51-100) in numerals and words form. He will give presentation of reading and writing numbers (51-100). He will also give the concept of matching objects with their relative numbers. Concept of counting (51-100) forward and backward will be given by the teacher. Now, the teacher will give the concept of reading and writing numbers after, before and between 51-100. He will also tell them how to make number cards and flash cards.

iii. Engagement Activities

The teacher will perform the following activities in the classroom by dividing the whole class in four groups naming Group-A, Group-B, Group-C and Group-D for each activity. He will provide them different objects (pencils, coins, bundle of match sticks), flash cards (numbers 51-100 in numeral, numbers 51-100 in words), colours (red, green, orange & pink) for the execution of activities.

Activity-1: Identification of Number 51-100

The teacher may ask the students to count the number of students in the classroom. He will divide the whole class in four groups naming Group-A, Group-

B, Group-C and Group-D. Group- A will be given 2 bundles of objects and some pencils and ask them to count them and write the number in numerals and in words form. Group-B will be given flash cards of numbers and numbers from 51-80 in numeral form. The teacher will ask them to match the numbers from 51-80 with numbers in numeral form. Group-C will be given flash cards of numbers and numbers from 81-100in word form. The teacher will ask them to match the numbers from 81-100 with numbers in word form. Group-D will be given some flash cards and ask them to make cards with numbers 60, 70, 80, 90 and 100 fill them with different colours.

Activity-II: Identification of "100" as a 3- Digit Number

The teacher will provide beads of different colours and instruct them to make 10 groups of beads of the same colours and will ask them how many tens are in 10 groups of beads. The same activity can be replaced by asking them to make drawing of 10 blocks of tens on their work sheet and color it with different colours. In this way, he will give them the concept of "100" to students. He will write down "100" in numeral and word form on the white board. Now, he will ask each group (Group-A, Group-B, Group-C and Group-D) to make 100 on flash cards and fill it with red, blue, green and yellow colours respectively.

Activity-II: Counting Forward, Backward, Ascending and Descending Order up to 100

Here, the teacher will ask Group-A to write down counting from 51-100. In this way, he will give the concept of counting forward. He will ask Group-B to write down counting in reverse order from 80 to 50. In this way, concept of backward counting will be given to students. Now, the teacher will place some concrete objects of different sizes on the table and ask Group-C to arrange the objects from the smallest to the greatest and will ask Group-D to arrange the objects from the greatest to the smallest according to their heights. Now, the teacher will ask them take five card boards and cut each of them into 10 equal parts. Write numbers in numerals from 51-100 on each card. Paste these cards on a chart in ascending and descending order.

Activity-III: Numbers after, before and between up to 100.

Now the teacher will provide number cards (21 to 50) and place them upside down on the table. He will call students on by one in front of the class and ask him / her to pick up any number card, read the number loudly and tell which number comes before and after that number. He will also give one number to each group and ask them to write a number before and after that number on the card and paste them on the chart.

C. Exploration (10 Minutes)

During the exploration phase, students will participate in hands on activities to learn about numbers 51-100. Following activities will be assigned to students:

- Number Tracing
- Counting Blocks
- Number Bingo
- Number Scavenger Hunt

D. Reflection (5 Minutes)

At this stage, the teacher will ask some questions to the students in order to assess their understanding, interest in the lesson and to develop scientific skills through thinking or focusing their attention on something. Following questions may be asked:

Q. 1: What was your favorite activity?

Q.2: How many tens are in 90?

Q.3: Tell, how many digits are in 100?

E. Application (10 Minutes)

During the application phase, student apply their knowledge of numbers 21-50 in real life situations. The teacher will use number cards to create a number sequence (50-100) on the working sheets. The teacher will engage them in a counting game where they can take turns counting from 80-90.

F. Assessment (4 Minutes)

At this stage, the teacher may ask the following questions:

Q.1: About what topic we have learnt today?

Q.2: Is "100" a 3-digit number?

Q.3: What do you think about 'ninety', is it in numeral form or word form?

Q.4: Arrange numbers from 85 to 75 in descending order.

3. Home Work (2 Minutes)

The teacher will ask them to make flash cards of numbers "70 & 100" and fill them with different colours.

Lesson Planning (Experimental group)
Lesson Plan No. 5

Grade: 1st	Time: 1 Hour
Subject: Mathematics	**Topic:** Concept of Place Value in Two (2) Digit Numbers

1. Introduction:

In the previous lesson, the students have learnt about numbers from 51-100 in numerals and words form. In this lesson, students will learn about place value of a specific digit in 2-digit number.

2. Procedure

A. Preparation (4 Minutes)

The teacher will prepare the topic "Concept of Place Value in Two (2) Digit Numbers" with instruction based on "Hands on Learning", aligned with the following ILOs and teaching materials.

i. ILOs:

By the end of the lesson, all the students will be able to:

i. identify the place value of the specific digit in a 2-digit number.

ii. decompose a number up to 99 to identify the value of a number in Tens and Ones place.

ii. Teaching Method:

Textbook, worksheets of objects and numbers, white sheets, color pencils, pointer, whiteboard, marker and duster.

B. Engagement (25 Minutes)

i. Demonstration

The problem scenario will be demonstrated in front of students about place value and its decomposition process. Some questions will be asked about problem for brain storming.

ii. Description

At this stage, the teacher will discuss the problems in detail by giving examples.

iii. Engagement Activities

At this stage, the teacher will perform the following activities by giving them worksheets.

Activity-1: Concept of Place Value by Using Beads and Sticks to Make an Abacus.

Activity-II: Decompose 36 into Tens and Ones.

Activity-III: Decomposition of 39 and 93.

Activity-IV: Coloring the Given 20 Blocks by Decomposing 12 into Tens and Ones and "X" the remaining Blocks.

C. Exploration (10 Minutes)

During the exploration phase, students will participate in hands on activities to learn about place values of 2 digit numbers. Following activities will be assigned to students:

- Money Activity
- Base Ten Blocks
- Number Lines

D. Reflection (5 Minutes)

At this stage, the teacher will ask some questions to the students in order to assess their understanding, interest in the lesson and to develop scientific skills through thinking or focusing their attention on something. Following questions may be asked:

Q. 1: What was your favorite activity?

Q.2: Tell, what is the place value of 9 in 90?

Q.3: Tell, 3 in 30 is on one's place or ten's place?

E. Application (10 Minutes)

During the application phase, student apply their knowledge of 2-digit place value in real life situations. The teacher will use Base Ten Blocks to create a 2-digit place value from (50-100) on the working sheets. The teacher will engage them in a money game activity to create a 2-digit number.

F. Assessment (4 Minutes)

At this stage, the teacher may ask the following questions:

Q.1: About what topic we have learnt today?

Q.2: one in "10" is at what place?

3. Home Work (2 minute)

The teacher will ask them to make flash cards of numbers "40 & 60" and show their place values.

Lesson Planning (Experimental group)
Lesson Plan No. 6

Grade: 1st	Time: 1 Hour
Subject: Mathematics	**Topic:** Comparison of One (1) and Two (2) Digit Numbers

1. Introduction:

In the previous lesson, the students have learnt about place value in 2-digit numbers. In this lesson, students will learn about comparing 1-digit and 2-digit numbers with 1-digit and 2-digit numbers respectively.

2. Procedure

A. Preparation (4 Minutes)

The teacher will prepare the topic "Comparison of One (1) and Two (2) Digit Numbers" with instruction based on "Hands on Learning", aligned with the following ILOs and teaching materials.

i. ILOs:

By the end of the lesson, all the students will be able to:

- identify 1-digit numbers.
- recognize 2-digit numbers
- compare 1-digit with 1-digit and 2-digit with 2-digit numbers

ii. Teaching Method:

Textbook, worksheets of objects and numbers, white sheets, color pencils, pointer, whiteboard, marker and duster.

B. Engagement (25 Minutes)

i. Demonstration

The problem scenario will be demonstrated in front of students about 1-digit and 2-digit numbers and its comparison will be done. Some questions will be asked about problem for brain storming.

ii. Description

At this stage, the teacher will discuss the problems in detail by giving examples.

iii. Engagement Activities At this stage, the teacher will perform the following activities by giving them worksheets. **Activity-1:** Exploring 1-digit numbers from the worksheet. **Activity-II:** Exploring 2-digit numbers from the worksheet. **Activity-III:** Compare 1-digit with 1-digit numbers. **Activity-IV:** Compare 2-digit with 2-digit numbers.
C. Exploration (10 Minutes) During the exploration phase, students will participate in hands on activities to learn about place values of 2-digit numbers. Several activities (Number Tracing, Counting Blocks, Number Bingo and Number Scavenger Hunt) will be assigned to students.
D. Reflection (5 Minutes) At this stage, the teacher will ask some questions to the students in order to assess their understanding, interest in the lesson and to develop scientific skills through thinking or focusing their attention on something. Following questions may be asked: Q. 1: What was your favorite activity? Q.2: In which activity, you faced problems to understand the given concept?
E. Application (10 Minutes) During the application phase, student apply their knowledge by comparing one and two-digit place value in real life situations. The teacher will share the working sheets of comparing numbers. The teacher will engage them in a money game activity to create a 2-digit number.
F. Assessment (4 Minutes) At this stage, the teacher may ask the following questions: Q.1: About what topic we have learnt today? Q.2: one in "10" is at what place?

3. Home Work (2 minute)

The teacher will ask them to make flash cards of numbers "40 & 60" in numeral and word forms and compare them.

Appendix-xii

Model Lesson Planning (Conventional Method)

Grade: 1st	Time: 1 Hour
Subject: Mathematics	**Topic:** Numbers 0-9

1. Objectives

- Recognize and identify numbers 0-9.
- Count and sequence numbers 0-9.
- Develop understanding of number concepts

2. Materials

- Chalkboard and chalk, Number flashcards & Worksheets (0-9).

3. Introduction (05 minutes)

- Review counting with students.
- Introduce the topic of numbers 0-9.
- Write numbers 0-9 on the chalkboard.

4. Presentation (20 minutes)

- Show students number flashcards (0-9) and ask them to identify the numbers.
- Write numbers 0-9 on the chalkboard and have students repeat after you.
- Use the chalkboard to demonstrate counting and sequencing numbers 0-9.

5. Practice (20 minutes)

- Distribute worksheets with numbers 0-9.
- Have students practice writing numbers 0-9.
- Circulate around the room to assist students as needed.

6. Assessment (10 minutes)

- Observe students during the practice activity to assess their understanding.
- Review worksheets completed during practice to assess students.

7. Conclusion (03 minutes)

- Review numbers 0-9 with students.
- Ask students to share one thing they learned during the lesson.

8. Home Work (02 minutes)

Write down counting 0-9 on your note book from home.

Appendix-xiii

Rubric for 2 & 4 Marks Test Items

Rubric for 2 Marks Test Items

Criteria	Performance Level	Score	Description
Accuracy	Fully Correct	2	The answer is correct with proper calculations and reasoning.
	Partially Correct	1	The process and reasoning are correct but answer is incorrect.
	Incorrect / Not Attempted	0	Incorrect process and reasoning with incorrect answer. No valid attempt.

Rubric for 4 Marks Test Items

Criteria	Performance Level	Score	Description
Accuracy	Fully Correct	4	The answer is correct with proper calculations and reasoning.
	Correct with Minor Error	3	The final answer is correct, but minor steps or explanations are missing.
	Partially Incorrect	2	Significant steps are correct, but the final answer is wrong.
	Minimal Correct	1	Minimal correct work shown.
	Incorrect / Not Attempted	0	Incorrect process and reasoning with incorrect answer and no valid attempt.

Appendix-xiv

Office of the Headmaster Government Boys High School Hatli AJ&K

Ref. No: GBHSH / 07 / 2025 Date: 25 / 01 / 2025

Subject: Research Study Certificate

This is to certify that Mr. Malik Shoukat Ali PhD (Education) Scholar IIU Islamabad successfully completed his research study entitled "**Effect of Hands on Learning on the Development of Scientific Skills in First Graders**" in this school. He has delivered thirty-two (32) lessons each of Hands on Learning and conventional method to both experimental and control group of grade 1 Mathematics students w.e.f. September 2024 to November 2024 (8 weeks).

I personally observed his lessons and found him extremely well prepared. In my opinion, he is hardworking, punctual, devoted, best teacher up to the mark of satisfaction of students and undersigned.

Wish him best of luck

25/01/2

Principal

Headmaster
Govt. B..ys H/S Hattli
Fatehpur Thakyala District Kotli A.K

Govt. Boys High School Hatli Kotli

Appendix-xv

List of Experts

Dr. Sheikh Tariq Mehmood, Assistant Professor, Department of Educational Leadership and Management, Faculty of Education, International Islamic University Islamabad.

Dr. Zarina Akhtar, Assistant Professor, Department of Teacher Education, Faculty of Education, International Islamic University Islamabad.

Dr. Makhdoom Ali Syed, Chairman, Department of Education, University of Kotli AJ&K.

Dr. Muhammad Asghar Ali, Chairman, Department of Education, Women University of AJ&K, Bagh.

Dr. Muhammad Zyarab, Chairman, Department of Education, Ibadat International University Islamabad.

Dr. Naqeeb-ul Khaleel Shaheen, Assistant Professor, Department of Education, University of Kotli AJ&K.

Dr. Khatiba, Assistant Professor, Department of Education, University of Kotli AJ&K.

Dr. Muhammad Ishfaq, Assistant Professor, Department of Physics, University of Kotli AJ&K.

Sajjad Ahmed Malik, Principal, Government College for Elementary Teachers (Male) Kotli AJ&K.

Zahoor Ahmad, Principal / Head Examiner Mathematics, Board of Intermediate and Secondary Education Mirpur.

Somia Ilyas, Subject Specialist Mathematics, Government College for Elementary Teachers (Female) Kotli AJ&K.