ProScholar Insights (PSI)
Volume 4, Issue 2 (Spring 2025)
Pages: 109 – 125

PROSCHOLAR INSIGHTS

ISSN (Print): 3006-838X
ISSN (Online): 3006-7723
DOI: 10.62997/psi.2025b-42087

Research Article **Open Access Journal**

Effect of Hands on Learning on the Development of Scientific Skills in First Graders

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This article may be cited as Ali, M. S., & Mehmood, S. T. (2025). Effect of Hands on Learning on the Development of Scientific Skills in First Graders. *ProScholar Insights, 4*(2), 109-125. https://doi.org/10.62997/psi.2025b-42087

Abstract: Mathematics plays an important role in developing students' scientific skills from the 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 examine the effect of Hands on Learning on the development of scientific skills in terms of numerical skills, 2). to measure the effect of conventional method on the development of scientific skills in terms of numerical skills, and 3).to compare the effect of Hands on Learning with conventional method on the development of scientific skills in terms of numerical skills. The study employed a true experimental research design. Seventy two one graders from BHS Hatli were randomly selected and divided into two groups: an experimental group taught using Hands-on Learning and a control group taught using the conventional method, over a period of eight weeks. Subject Achievement test was validated, pilot tested and the reliability of the test confirmed by a Cronbach's Alpha value of 0.83. Thirty-two (32) lessons were planned for this study. Data were collected in the form of pre-test and post-test and analyzed by using both descriptive statistics and inferential statistics through SPSS-25 software. The findings of the study showed a positive effect of Hands on Learning on the development of scientific skills. The result revealed that Hands on Learning was more effective method than conventional method in developing students' scientific skills and is recommended for use in early mathematics classrooms for developing students' scientific skills.

Keywords: Hands on Learning, Conventional Method, Scientific Skills in Mathematics, Numerical Skills

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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). According to Parviainen (2019) mathematics education develops accuracy, concentration, reasoning, analytical thinking, creative thinking, critical thinking and intellectual independence among students. Kooloos et al. (2022) also stated that mathematics education played an important role in developing students' basic skills in mathematics at the very early stage and teachers help and facilitate them to think, reflect and think about thinking by using activity-based pedagogy. According to Acton (2020) there are numbers of teaching pedagogies that are used for teaching mathematics at early stages such as expository method, play way method, manipulation, project method, demonstration, laboratory method, simulation, problem solving method, cooperative learning, guided learning, game-based learning and hands on learning. Chikuni (2018) stated that Hands on Learning is the best teaching method for teaching mathematics at early stages. It is used in Europe, Singapore and China for teaching of mathematics at early stages. According to Li (2023) Hands on Learning (HoL) involves learning through direct experiences rather than solely relying on books, lectures, or other traditional approaches. It has greater retention of material, enhances creativity, more enjoyable, develops a sense of achievement and develops critical thinking. It guided the students to gain knowledge by experience. Sarı and Olkun, (2024) stated that Hands on Learning can be used for developing scientific skills in Mathematics at early stages in terms of numerical skills such as number sense, counting skills, basic skills in arithmetic.

According to Mullis and Martin (2020) there are number of studies which show that performance of students in Mathematics subject at the very early stage was very low. They had the ability only to memorize formula or contents but could not utilize those concepts in their daily life. According to them, in TIMSS 2019 Pakistan ranked second to last in mathematics among 58 countries. Only 27 percent of Pakistani Children met the low international benchmark, 8 percent met the intermediate benchmark, and 1 percent met the high benchmark in mathematics. 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. These low performances of students in mathematics were due to the fear of students in learning mathematics and teachers' teaching methods (Jazim et al., 2017; Mbatha, 2018; Makondo & Makondo, 2020). 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. These methods were not helpful for developing students' scientific skills in mathematics in terms of numerical skills. 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 (number sense, counting skills and basic arithmetic skills) in first graders.

Statement of the Problem

A number of students continue to struggle with foundational scientific skills in mathematics due to traditional teaching methods that emphasize rote memorization rather than conceptual understanding. The TIMSS (2019) results highlight determined challenges in mathematics achievement, highlighting the need for more effective instructional methods. Hands-on Learning (HoL) has emerged as a promising method that promotes active engagement, critical thinking, and deeper comprehension by allowing students to interact with mathematical concepts through direct experiences. Although HoL has been successfully applied in various STEM disciplines, its specific impact on the development of scientific skills in mathematics in terms of numerical skills at early stages remains underexplored. There is a need to investigate whether incorporating hands-on activities in mathematics instruction can enhance first graders' numerical understanding. Therefore, this study aims to investigate the effect of Hands-on Learning on the development of scientific skills in mathematics.

Objectives of the Study

The objectives of the study were;

1. To examine the effect of Hands on Learning on the development of scientific skills in terms of numerical skills.
2. To measure the effect of conventional method on the development of scientific skills in terms of numerical skills.
3. To compare the effect of Hands on Learning with conventional method on the development of scientific skills in terms of numerical skills.

Research Hypotheses

$H_0$1: There is no significant effect of Hands on Learning on students' scientific skills in terms of numerical skills (number sense, counting skills, and basic arithmetic skills).

$H_0$2: There is no significant effect of conventional method on students' scientific skills in terms of numerical skills (number sense, counting skills, and basic arithmetic skills).

$H_0$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills (number sense, counting skills and basic arithmetic skills) taught by Hands on Learning and those taught by conventional method.

Delimitations of the Study

The study was delimited to:

1. Government Boys High 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)
4. Numerical Skills in terms of number sense, counting skills and basic arithmetic skills.

Literature Review

Effective methods of teaching Mathematics at early stages are essential for assisting students in enhancing their problem-solving skills, logical reasoning, and mathematical proficiency (Cai et al., 2015). 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. There are several methods that are used by teachers at early stages in teaching mathematics such as conventional method, problem solving method, game-based learning, play-way method, demonstration method and Hands on Learning (Clements & Sarma, 2020; Nwoke, 2021) . Among these all, two methods conventional method and Hands on Learning will be discussed below:

Conventional Method of Teaching Mathematics

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). Slavin (2019) describes the conventional method as teacher-centered, with students passively receiving information through structured lessons focused on memorization. The teacher explains concepts and demonstrates problem-solving, with little emphasis on application or critical thinking. Student interaction is limited, and questions are often confined to the teacher's planned activities.

Hands on Learning (HoL)

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. According to Pais (2012) 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. According to Robb (2016) Hands on Learning consisted of six steps/stages such as preparation, engagement, exploration, reflection, application and assessment. According to Thiri and Guirguis (2024) Hands-on Learning 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.

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. Providing students with appropriate tools and materials is crucial for hands-on mathematical learning through construction. Supplying various manipulative, 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 (Hebbecker et al., 2020).

There are several activities related to Hands on Learning. Here are Hands on Learning activities related to scientific skills in Mathematics in terms of numerical skills such as Counting Collections, Roll and Add, Matching Number Cards, Build a Tower, Spin and Add/Subtract, Sorting Numbers, Number Bingo, Building with Blocks and Resolving Basic Word Problems (Brown & Green, 2023; Hensberry et al., 2018; Long & Bouck, 2023)

Scientific Skills in Mathematics

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 (Vo, & Simmie, 2025). These skills help students develop a deep understanding of mathematical concepts and the ability to apply them to real-world situations. There are several scientific skills in Mathematics according to different scholars. Some of them are as under:

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.

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).

Meta-cognitive Skills: Meta-cognition 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).

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).

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).

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.

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 (Wüstenberg et al., 2016).

Mathematical Reasoning: Mathematical reasoning encompasses logical deduction, problem-solving abilities, and the skill to apply mathematical principles to practical situations for young learners.

Numerical Skills

Numerical skills serve as the cornerstone of mathematical education for young learners, focusing on the understanding and manipulation of numbers (Çelikdemir et al., 2024). They 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).

Number 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).

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.

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).

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. According to 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). 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). 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). 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).

Related Research

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. The study conducted by Cruse (2012) examined the effect of hands-on activities on early math learning and found that using tools like counters, shape building, and math games improved math fluency, engagement, and retention in young students. The research by Maanu et al. (2024) also

showed that hands-on methods such as interactive games and real-world problem-solving boosted student engagement, motivation, and interest in math, making abstract concepts easier to grasp. Another study conducted by Meilon et, al. (2019) stated that to grasp mathematical concepts, students need skills like reasoning and communication. Hands-on activities support these by allowing learners to sort, analyze, and apply math in real-life contexts. Hands-on learning involves students directly interacting with materials, allowing them to explore, ask questions, and build knowledge through experience, especially effective in teaching mathematics using manipulative. This approach enhances student performance, encouraging creativity, collaboration, and problem-solving, while increasing interest and achievement compared to traditional learning methods (Dahlan & Wibisono, 2021). Additionally, a study conducted by Shi et al. (2023) showed that by using FNIRS and performance tests, hands-on experiences enhanced middle school students' geometry problem-solving, especially benefiting those with lower academic performance.

This discussion may be concluded as mathematics is a key subject that promotes critical thinking, logical reasoning, and problem-solving abilities. It is recognized for its precision, broad applicability, and role in addressing real-life challenges. Through the study of mathematics, students develop essential scientific skills like number sense, counting skills and basic arithmetic skills. Effective math instruction such as HoL is vital for improving students understanding and engagement in Mathematics.

Methodology and Design of the Study

The study was experimental in nature. Pre-test and post-test equivalent group design was used. The study was delimited to the mathematics students of Grade-1 in Government Boys High School Hatli Kotli Azad Jammu and Kashmir.

Population and Sample of the Study

Mathematics' students of Grade-1 in district Kotli were the target population of the study. Government Boys High School Hatli was chosen randomly as a sample of the study. Seventy two (72) mathematics' students of Grade-1 were chosen and divided into two groups; Group-A (Experimental Group) and Group-B (Control Group) through randomization. Each group consisted of 36 students.

Research Instrument

The Subject Achievement Test (Pre-test & Post-test) for developing students' scientific skills in terms of numerical skills was used as a research instrument. It consisted of 33 Marks. There were two sections of Subject Achievement test such as Section-A (Objective) of 11 marks (6 marks for multiple choice questions, 2 marks for completion statements, 2 marks for alternative responses and 1 mark for matching columns) and Section-B (Close-ended and Open-ended Questions) of 14 marks (7 items of 14 marks and 2 items of 8 marks). The Subject Achievement Test was pilot-tested and validated by educational experts. The reliability of Subjective Achievement Test was assessed through Cronbach's Alpha and its value was 0.884.

Data Collection

Data were collected in the form of pre-test and post-test from both experimental and control group by the researcher. Pre-test was administered among 72 students of grade-1 before teaching mathematics. After 8 weeks' treatment, post-test was administered from both experimental and Control group and results were collected.

Data Analysis

The collected 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) through SPSS Version 25. The analysis and interpretation of data is presented as:

1. Analysis of Data for Effect of Hands on Learning on outcome variable Scientific Skills in terms of Numerical Skills (Objective 1)

Descriptive Analysis

Table 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
Overall Numerical Skills	Pre Test	36	6.00	29.00	19.11	5.888	
	Post Test	36	19.00	33.00	29.44	3.418	10.33

Table 1 shows the significant improvement in students' mean scores which increased from 6.83 to 9.86 (mean difference = 3.03) in number sense, 8.69 to 9.97(mean difference = 1.28) in counting skills, 3.61 to 9.64 (mean difference = 6.03) in basic arithmetic skills. Additionally, the overall mean scores of numerical skills increased from 19.11 to 29.44(mean difference = 10.33), indicating a positive effect of Hands on Learning on students' scientific skills in terms of numerical skills from pre-test to post-test.

Hypothesis Testing

$H_0$1: There is no significant effect of Hands on Learning on students' scientific skills in terms of numerical skills (number sense, counting skills, and basic arithmetic skills).

Table 2

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

Variables	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			
Counting Skills	Pre Test	36	8.69	2.352	2.839	35	0.007
	Post Test	36	9.97	1.483			
Basic Arithmetic Skills	Pre Test	36	3.61	3.101	9.736	35	0.007
	Post Test	36	9.64	1.839			
Overall Numerical Skills	Pre Test	36	19.11	5.888	8.779	35	0.000
	Post Test	36	29.44	3.418			

Table 2 shows a significant effect of Hands-on Learning on students' scientific skills in terms of numerical skills. The pre-test and post-test comparisons show statistically significant improvements in number sense ($t = 8.220$, $p = 0.000$), counting skills ($t = 2.839$, $p = 0.007$), and basic arithmetic skills ($t = 9.736$, $p = 0.007$). Overall, numerical skills also showed significant improvement ($t = 8.779$, $p = 0.000$). These findings suggest that Hands-on Learning has a positive effect on students' numerical skills, leading to the rejection of the null hypothesis "$H_0$1: There is no significant effect of Hands on Learning on students' scientific skills in terms of numerical skills (number sense, counting skills, and basic arithmetic skills)". Moreover, the significant p-values indicate the effectiveness of Hands-on Learning in enhancing students' numerical abilities.

2. Analysis of Data for Effect of Conventional Method on Outcome Variable Scientific Skills in terms of Numerical Skills (Objective 2)

Descriptive Analysis

Table 3

Descriptive Statistics for Conventional Method on Outcome Variable Numerical Skills

Variables	Test	N	Min.	Max.	M	SD	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	
Overall Numerical Skills	Pre Test	36	7.00	25.00	15.17	3.917	3.82
	Post Test	36	10.00	33.00	18.99	4.187	

Table 3 illustrates the effect of conventional method on all variables of scientific skills in terms of numerical skills including number sense, counting skills and basic arithmetic skills. The results show significant improvement in students' mean scores which increased from 6.14 to 7.89 (mean difference = 1.75) in number sense, 6.14 to 7.22(mean difference = 1.08) in counting skills, 2.92 to 4.00 (mean difference = 1.08) in basic arithmetic skills. Additionally, the overall mean scores of numerical skills increased from 15.17 to 18.99 (mean difference = 3.82), indicating a positive effect of conventional method on students' scientific skills in terms of numerical skills from pre-test to post-test. Hence, the students scored more test in all variables of scientific skills in post-test as compared to pre-test which ultimately means that there was a positive effect of conventional method on students' scientific skills in terms of numerical skills.

Hypothesis Testing

$H_0$2: There is no significant effect of conventional method on students' scientific skills in terms of numerical skills (number sense, counting skills, and basic arithmetic skills).

Table 4

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

Variables	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			
Counting Skills	Pre Test	36	6.14	1.397	3.993	35	0.000
	Post Test	36	7.22	2.140			
Basic Arithmetic Skills	Pre Test	36	2.92	1.713	4.638	35	0.000
	Post Test	36	4.00	1.957			
Overall Numerical Skills	Pre Test	36	15.17	3.917	9.761	35	0.000
	Post Test	36	18.89	4.187			

Table 4 shows a significant effect of conventional method on students' scientific skills in terms of numerical skills. The pre-test and post-test comparisons show statistically significant improvements in number sense ($t = 10.247$, $p = 0.000$), counting skills ($t = 3.993$, $p = 0.000$), and basic arithmetic skills ($t = 4.638$, $p = 0.000$). Overall, numerical skills also showed significant improvement ($t = 9.761$, $p = 0.000$). These findings suggest that conventional method has a positive effect on students' numerical skills, leading to the rejection of the null hypothesis "$H_0$2: There is no significant effect of conventional method on students' scientific skills in terms of numerical skills (number sense, counting skills, and basic

arithmetic skills)". Moreover, the significant p-values indicate the effectiveness of Hands-on Learning in enhancing students' numerical abilities.

3. Analysis of Data for Comparing Effect of Hands on Learning with Conventional Method on the Development of Scientific Skills in terms of Numerical Skills (Objective 3)

Descriptive Analysis

Table 5

Descriptive Analysis for Effect of Hands on Learning with Conventional Method on the Development of Scientific 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
Overall (Numerical Skills)	19.11	29.44	10.33	15.17	18.89	3.72

Table 5 shows that the experimental group, which received Hands-on Learning, demonstrated significant improvement in scientific skills in terms of numerical skills, including number sense, counting skills, and basic arithmetic skills, compared to the control group. The experimental group's mean scores increased substantially from pre-test to post-test, with differences of 3.03 in number sense, 1.28 in counting skills, and 6.03 in basic arithmetic skills, resulting in an overall difference of 10.33 in numerical skills. In contrast, the control group showed modest improvements, with differences of 1.75 in number sense, 1.08 in counting skills, and 1.08 in basic arithmetic skills, resulting in an overall difference of 3.72 in numerical skills. Furthermore, the experimental group showed significant improvement as compared to that of control group in overall numerical skills with a difference of 10.33 (experimental group) versus 3.72 (control group). Hence, the experimental group's significant improvement compared to the control group suggests a positive effect of Hands-on Learning on students' scientific skills in terms of numerical skills, outperforming the conventional method used in the control group.

Hypothesis Testing (Objective 3)

Before testing the research hypothesis, 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, the null hypothesis "$H_0$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills (number sense, counting skills and basic arithmetic skills) taught by Hands on Learning and those taught by conventional method" was tested to compare the achievement scores of Hands on Learning (experimental group) with Conventional Method (control group).

Table 6

Independent Sample t-test for Outcome Variable Number Sense on Pre-test

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

Table 6 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$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills (number sense) taught by Hands on Learning and those taught by conventional method." On pre-

test is accepted. 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.

Table 7

Independent Sample t-test for Outcome Variable Number Sense on Post-test

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

Table-3.3 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 "$H_0$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills (number sense) taught by Hands on Learning and those taught by conventional method" on post-test is rejected. 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.

Table 8

Independent Sample t-test for Outcome Variable Counting Skills 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 8 presented 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$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills (counting skills) taught by Hands on Learning and those taught by conventional method" on pre-test is rejected. 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.

Table 9

One Way ANCOVA and Eta-test for Outcome Variable Counting Skills on Post-test

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

Table 9 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$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills (counting skills) taught by Hands on Learning and those taught by conventional method" on post-test is rejected. Moreover, the Eta value (η=0.365) indicates a moderate to strong association between Hands on Learning and counting skills. 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.

Table 10

Independent Sample t-test for Outcome Variable Basic Arithmetic Skills 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 10 illustrated 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$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills (basic arithmetic skills) taught by Hands on Learning and those taught by conventional method" on pre-test is accepted. 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.

Table 11

Independent Sample t-test for Outcome Variable Basic Arithmetic Skills on Post-test

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

Table 11 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 "$H_0$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills (basic arithmetic skills) taught by Hands on Learning and those taught by conventional method" on post-test is rejected. 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.

Table 12

Independent Sample t-test for Mean Scores' Difference on Outcome Variable Scientific Skills in terms of Numerical 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	19.11	5.888	3.346	70	0.001
	Control	36	15.17	3.917			

Table 12 presented 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$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills taught by Hands on Learning and those taught by conventional method" on pre-test is rejected. 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 1

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

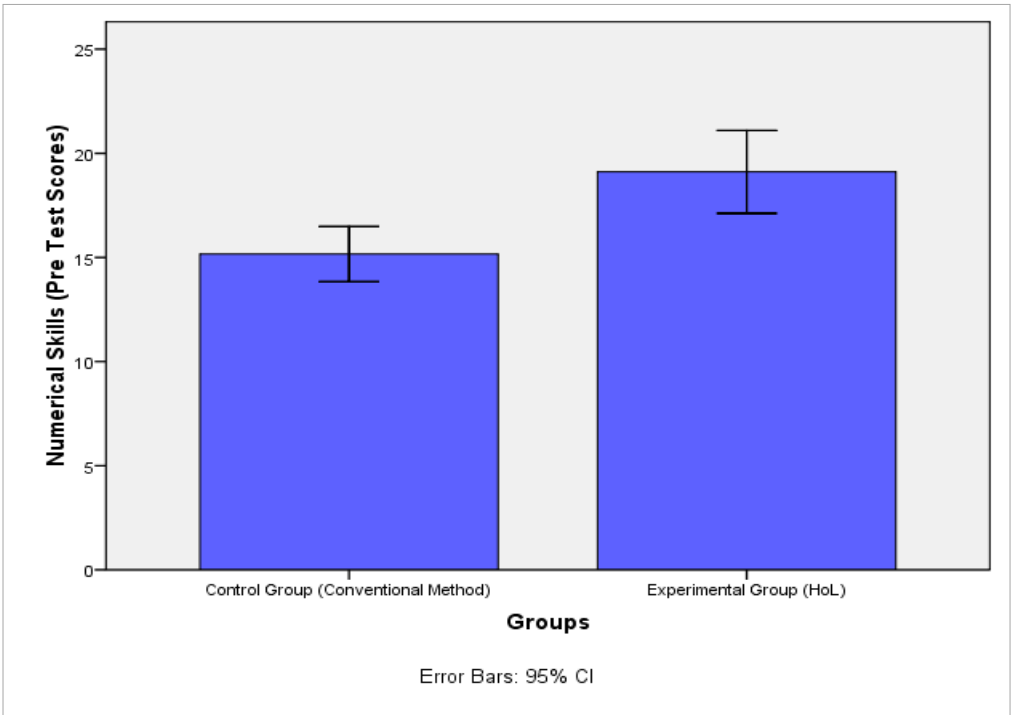

Figure 1 illustrates the results in table-3.8. The graph in the above figure showed that there was a significant difference in the mean scores of experimental group (M=19.11) and control group (15.17) before treatment. It is also observed that the error bars do not overlap suggesting a significant difference between the mean scores of both groups in improving students' scientific skills in terms of 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 13

One Way ANCOVA and Eta Test for Mean Scores' Difference on Outcome Variable Scientific Skills in terms of Numerical Skills Taught by Hands on Learning and Conventional Method on Post-test

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

Table 13 revealed 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 "$H_0$3: There is no significant difference in the development of students' scientific skills in terms of numerical skills (number sense, counting skills and basic arithmetic skills) taught by Hands on Learning and those taught by conventional method" on post-test is rejected. . Moreover, the Eta value (η=0.662) indicates a moderate to strong association between Hands on Learning and numerical skills. Hence, the results show that the instruction based on Hands on Learning is more effective for improving students' scientific skills in terms of numerical skills as compared to instructions based on Conventional Method.

Graphical Representation

Figure 2

Graphical Representation of One Way ANCOVA-test Results for Mean Scores' Difference on Students' Scientific Skills in terms of Numerical Skills on Post-test

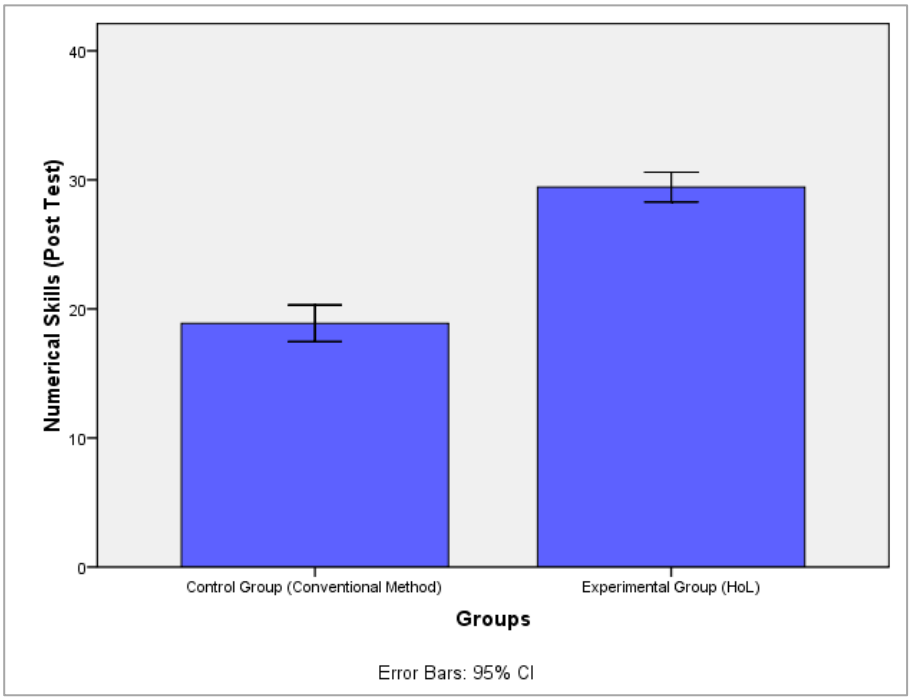

Figure 2 reveals the results in table-3.9. The graph in the above figure showed that there is a significant difference in the mean scores of experimental group (M=29.44) and control group (18.89) after treatment. It is also observed that the error bars do not overlap suggesting a significant difference between the mean scores of both groups in improving students' scientific skills in terms of numerical skills. The direction of the mean difference between these two groups present that Hands on Learning is more effective in improving students' scientific skills as compared to Conventional Method. Moreover, the Eta value (η=0.662) that Hands on Learning is more effective in improving students' scientific skills in terms of numerical skills.

Discussion

Quality education necessitates a harmonious alignment between curriculum, teaching methodologies, learning activities, and assessment systems. This alignment is crucial for fostering mathematical skills among students. The development of scientific skills in mathematics requires the acquisition of knowledge and skills, which is a fundamental aspect of mathematics education (Firdaus et al., 2015). Research has consistently shown that Hands-on Learning plays a pivotal role in enhancing scientific skills, mathematical literacy, logical thinking, reasoning, and problem-solving abilities among students (Maanu, 2024; Risdiyanti et al., 2024). Hands-on Learning is also instrumental in promoting mathematics achievement and developing students' ability to apply mathematical concepts to real-life situations. The present study, "Effect of Hands-on Learning on the Development of Scientific Skills in First Graders," aimed to investigate the impact of Hands-on Learning on developing scientific skills in mathematics among first-grade students. The study focused on numerical skills, spatial skills, and mathematical reasoning and thinking skills. A true experimental research design was employed, with seven research objectives and 30 research hypotheses guiding the investigation. Data were collected before and after the treatment, and 83 findings were explored. The results of the study revealed that the performance and achievement scores of students improved significantly after the intervention through Hands-on Learning in numerical skills. The descriptive statistics showed a notable improvement in students' numerical skills, and the inferential statistics, based on paired sample t-test, presented a significant difference in the mean scores of students' numerical skills instructed through Hands-on Learning. The post-test scores (N=36, M=29.44, SD=3.418) were significantly higher than the pre-test scores (N=36, M=19.11, SD=5.888), with a t-value of 8.779 and a p-value of 0.000, which is less than 0.05. This indicates that the improvement in students' numerical skills

was statistically significant. The findings of the study are consistent with previous research that highlights the effectiveness of Hands-on Learning in developing numerical skills among students. Studies conducted by Friso-van den Bos et al. (2013), Nickerson (2011), Kanapathy and Azhari (2024), all support the finding that Hands-on Learning is an effective approach to improving students' numerical skills. These studies demonstrate that hands-on activities, such as counting with physical items or utilizing fingers, can lead to considerable improvements in arithmetic skills. Additionally, hands-on exercises that involve forward and backward counting with manipulatives can improve numerical abilities and bridge the gap between tangible and abstract mathematical reasoning. The present study provides evidence that favors Hands-on Learning over conventional methods for developing scientific skills among first graders. The findings suggest that Hands-on Learning is more effective in developing students' number sense, counting skills, and basic arithmetic skills. While conventional methods may play a role in developing scientific skills to some extent, Hands-on Learning is more effective in all respects.

Overall, the study highlights the significance of Hands-on Learning in enhancing scientific skills, mathematical literacy, and logical thinking among students. The findings suggest that educators should prioritize hands-on activities in their teaching practices to improve student outcomes in mathematics. By doing so, educators can provide students with a strong foundation in mathematical skills, preparing them for future success in mathematics and other STEM fields.

Conclusions

Following conclusions were drawn:

1. In this study, it was concluded 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 scientific skills of students in terms of numerical skills (Tables: 1-2).
2. It was also 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 students scientific skills in terms of numerical skills (Tables: 4-5).
3. In the study, it was concluded 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. 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 (Tables: 5-13 & Figures: 1-2).

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. 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.
3. It is also recommended that curriculum developer may develop mathematics curricula that incorporate Hands on Learning activities and promote scientific skills in Mathematics.
4. Further research may be conducted for the validation and improvement of this study. To check the effectiveness of this method in the subject of Mathematics, other research may be conducted on different levels such as ECCE and Elementary level.

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