MS Research Thesis

EFFECT OF NON-DIGITAL ADAPTIVE MATH GAMES ON STUDENTS' ACHIEVEMENT IN MATHEMATICS AT PRIMARY LEVEL

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A thesis submitted in partial fulfillment of the requirement for the degree of MS Teacher Education.

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APPROVAL SHEET

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AUTHOR'S DECLARATION

It is hereby declared that author of the study has completed the entire requirement for submitting this research work in partial fulfillment for the degree of MS Teacher Education. This thesis is in its present form is the original work of the author except those which are acknowledged in the text. The material included in the thesis has not been submitted wholly or partially for award of any other academic certification than for which it is being presented.

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SUPERVISOR'S CERTIFICATE

The thesis titled "Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level" submitted by Ms. Afsheen Moazzam Regd. No 3-FOE/MSTE/F23 is partial fulfillment of MS degree in Master of Science in Education has been completed under my guidance and supervision. I am satisfied with the quality of student's research work and allow him/her to submit this for further process as per IIUI rules and regulations.

Supervisor Name
DR. FOUZIA AJMAL

Dedication

I dedicate this thesis to my beloved parents, whose endless love, prayers, and encouragement have been my greatest strength throughout this academic journey. A heartfelt dedication also goes to my respected supervisor, Dr. Fouzia Ajmal, whose valuable guidance, continuous support, and sincere efforts have been instrumental in shaping this work. To my teachers and mentors, thank you for inspiring me to strive for excellence. This work is also dedicated to all those who believe in the power of education and determination.

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Abstract

Non Digital Adaptive Games refers to the games which are designed by the instructor according to the topic, content and student's needs without use of technology. These are basically designed by using different non-digital material including flashcard, charts and Dice and Puzzle etc. In the current educational setting, utilizing innovative teaching methods is important, especially in subjects like mathematics, which students often find challenging. Non-Digital Adaptive Games offers a distinctive approach to enhance student achievement by making learning more interactive and student centered. This research aimed to examine the effect of Non-Digital Adaptive Games method on mathematics achievement among Grade 3 students in primary school of Islamabad, Pakistan. Regardless of the general benefits of this method observed in various studies, there was lack of detailed research focusing on its effect in this specific context. The population of the study was consisted on grade 3 students from 12 registered private schools of G-11 sector as on 1st July, 2025 according to Private Educational Institutions Regulatory Authority Statistical overview. The 50 students of grade 3 of Islamabad Grammar School G-11 campus were selected as the sample. Sample was selected using Purposive sampling technique and randomly assigned to experimental and control groups (25 students each). The intervention time period was 2 months. During which the experimental group taught through Non-Digital Adaptive Math Games while the control group was taught through the lecture method. A self-developed achievement test was used to measure students' mathematics achievement. Data were analyzed using descriptive statistics (mean and standard deviation) inferential statistics (independent samples t-tests and effect sized). Findings revealed that students in the Experimental group significantly performed better than the control group in posttest scores, with a large effect size. Retention scores also remained higher in the Non-Digital Adaptive Math Games group three weeks after the intervention, indicating sustained cognitive benefits. On the basis of result of the study it was concluded that the Non-Digital Math Games approach is more effective than traditional lecture-based instruction in fostering positive learning environment and student's mathematics achievement at primary level. It is recommended that this method can be implemented into primary mathematics curriculum, accompanied by teacher professional development and assessment reforms aligned with adaptive, competency-based learning objectives. Future research should investigate additional competencies and long-term effects of non-digital adaptive strategies across broader educational contexts.

Key Words: *Non-Digital, Adaptive Games, Achievement, Primary Education*

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List of Abbreviations

ARMG	Active Recreational Math Games
ASCD	Association for Supervision and Curriculum Development
CI	Confidence Interval
FOE	Faculty of Education
IIUI	International Islamic University Islamabad
IMI	Intrinsic Motivation Inventory
MCQs	Multiple Choice Questions
MS	Master of Science
MSTE	MS Teacher Education
PTM	Parent-Teacher Meeting
SD	Standard Deviation
SPSS	Statistical Package for the Social Sciences
STEM	Science, Technology, Engineering, and Mathematics
UDL	Universal Design for Learning

CHAPTER 1

INTRODUCTION

In the current educational setting, adopting innovative teaching methods has become more important. Adaptive Games refers to games designed by instructors in order to adjust content and difficulty levels based on the performance and needs of learners (Chiotaki et al., 2023). Non-Digital Games are the games that are relying on physical material instead of technology. These type of games in teaching learning process in order to enhance student's achievement and making teaching learning process more interactive and enjoyable. Non-Digital Adaptive Games are the games designed by the instructor without using any sort of technology and focus the needs of learners. Mathematics achievement refers to the student's outcomes and understanding related to math subject.

Activity-based learning refers to an instructional method in which students engage in hands-on tasks and practical activities to construct knowledge through direct experience. These activities are typically non-competitive, emphasize conceptual understanding, and encourage learners to explore ideas actively (Singh & Mahajan, 2014). Game-based learning involves the integration of structured games into educational settings, where learning occurs through game mechanics such as rules, goals, feedback, and competition. This method enhances student motivation, engagement, and retention by combining cognitive challenges with play and reward systems (Plass et al., 2015).

A very recent study implemented a self-adaptive iterative game-based learning framework with 73 elementary students to examine both performance in mathematics and learner satisfaction. They found a statistically significant improvement in performance ($t[71] = 6.1$, $p < .01$) and in student satisfaction ($F = 5.25$, $p < .05$) in the experimental group compared to controls. This article strengthens the validity of adaptive game-based methods in mathematics learning and suggests that adaptivity in games (adjusting tasks, gamification elements according to progress) can be practical and effective for young learners (Pathania et al., 2025).

However, though promising, its context (India) and design details leave open questions about how non-digital adaptive games perform in low-resource settings such as Pakistan, where teacher-led adaptivity with non-digital formats may offer a more accessible model.

This method has attracted much attention due to its potential to improve achievement especially in subjects like mathematics which is consider tough by learners. Primary education consists of a lot of mathematics, which young children often find it hard to understand as their motivation and achievement decrease with passage of time. Such traditional methods for teaching math is more focus on rote memorization and repetitive practice tend not to reach out effectively to all learners with different learning requirements and styles. The interactive nature of games may lead into better understanding of mathematical concepts, develop critical thinking skills as well as problem-solving skills.

In many Pakistani educational setting, where the traditional teaching method for example lecture method still dominates, that more focus on rote memorization and Content coverage which is not as much suitable for teaching the subject like mathematics. Therefore, this study seeks to explore the effect of the Non-Digital Adaptive Math Games approach on students' mathematics achievement at the primary level in Pakistan. The research focus on grade 3 students at Islamabad Grammar School G-11 Campus with particular focus on Math subject instruction. By introducing a Non-Digital Adaptive Math Games intervention and comparing outcomes, this study aims to generate evidence that could inform policy and pedagogy for foundational education reform.

1.1 Background and the Context of the Study

This type of instructional method has become more considerable because it does not require expensive digital classroom environment and material for teaching learning process. Non-digital adaptive math games are teacher-designed, hands-on educational activities that use physical materials such as dice, flashcards, charts, and puzzles to teach mathematics concepts. They are *adaptive* because the teacher modifies the difficulty level or pace to meet learners' needs (Tomlinson, 2017) and they rely on simple, classroom-based games that enhance conceptual understanding through active participation (Kamii & DeVries, 1980)**.**This method utilized in order to make classroom environment more enjoyable and more student's center. Traditionally, mathematics education at the primary level has more focused on rote memorization and repetitive practice, which can lead to disengagement and decreased achievement over time. Previous studies, such as Research by Partovi and Razavi (2019) have demonstrated the benefits of games in various educational contexts, highlighting improvements in student academic achievement. However, there remains a significant gap in understanding the specific impact of non- digital Adaptive games on mathematics achievement among primary school students in Pakistan. The unique educational environment and technological infrastructure of Islamabad's primary schools present distinct challenges and opportunities for implementing Adaptive Games which include technology integration due to lack of resources. This study aims to fill this gap by investigating the Effect of Non-Digital Adaptive Math Games on Grade 3 students' mathematics achievement, there by contributing to more effective instructional method and improved students' mathematics achievement. The integration of game-based learning has been increasingly recognized as a promising instructional approach to address these challenges. According to Partovi and Razavi (2019), game-based learning enhances academic achievement and motivation by actively involving students in the learning process through interactive and enjoyable activities. Games promote cognitive engagement, encourage problem-solving, and provide immediate feedback, which supports the development of higher-order thinking skills (Alfieri et al., 2011; Barzilai & Blau, 2014). Within this pedagogical approach, Non-Digital Adaptive Math Games offer an innovative and accessible strategy that adjusts content difficulty based on student performance, allowing learners to progress at their own pace while addressing their individual needs (Setambah et al., 2023).

In this context, the present study aims to explore the effect of the Non-Digital Math Games on Student academic Achievement at Primary level in Islamabad Grammar School G11 campus. The intervention utilize. By assessing students' ability to analyze literary content and observing their attention during lessons, the study seeks to generate empirical evidence on how Non-Digital Adaptive Math Games can enhance student academic achievement at primary level. This research is expected to contribute both to academic literature and to practical policy formulation in Pakistan's education system, particularly in moving toward student-centered and interactive learning environment.

1.2 Problem Statement

In primary school of Islamabad, it is common practice to teach of the mathematics subject with traditional method includes notes-taking and content coverage and textbook exercises. This method does not support varying learning style and understanding of concept for long time. Non-Digital adaptive games are mostly prefer to use in science and other subjects but there is lack of using this game-based teaching method in the subject of mathematics.

As nowadays instructional method shifted from traditional method to **a**ctivity based instructional methods**,** especially at the primary level in order to enhance teaching learning process and make it interactive. In recent years, particularly since the introduction of the National Curriculum 2006 and with growing emphasis from 2017 to 2023 on educational reform, Pakistan's national curriculum and teacher education programs have begun shifting from rote-based, lecture-driven instruction to activity based teaching, especially at the primary level.

This method aims to improve the quality of education by making the learning process more engaging and effective. However, the integration of structured, non-digital game-based approaches into primary mathematics instruction is still not common practice in Islamabad's schools. The lack of empirical research on the use of non-digital adaptive math games in the Pakistani primary education context presents a significant gap in educational practice. This study aims to address this gap by investigating the effect of non-digital adaptive math games on students' mathematics achievement at the primary level in Islamabad.

1.3 Objectives of the Study

The objectives of the study were:

1. To find out the Effect of Non-Digital Adaptive Math Games on the mathematics achievement of Grade 3 students.
2. To compare the mathematics achievement of students using non-digital adaptive math games versus traditional teaching methods.
3. To assess the retention of mathematical concepts and understanding gained through non-digital adaptive math games.

1.4 Hypothesis

H_{01}: There is no significant effect of Non-Digital Adaptive Math Games on students' mathematics achievement.

1.5 Significance of the Study

This study was significant because it explored a new way to help students learn math better through the Non-Digital Adaptive Math Games method. With the reference of the results of this study it plays important role in terms of promoting concept of game-based learning in private sector schools where it could be utilized within limited resources or without the intervention of technology integration, which was often impossible to implement due to lack of resources. With the reference of retention test results further demonstrated that students taught using non-digital adaptive games retained mathematical concepts more effectively over time compared to those taught through traditional methods. These results highlighted that this method not only improves short-term academic achievement but also has a sustained positive effect on long-term learning. Moreover, the comparison between the experimental and control groups showed a notable increase in achievement scores among students taught using adaptive games. These outcomes reinforce the significance of this study in supporting learner-centered, resource-friendly and teaching method that can improve both immediate performance and knowledge retention in mathematics at the primary level.

This study is helpful for both teachers and parents as it demonstrates that non-digital adaptive math games significantly improve students' mathematics achievement and retention in a low-cost, practical manner. For teachers, the study provides a clear classroom model using simple materials based games such as dice, flashcards, and charts that can be adapted to different ability levels, making lessons more engaging and inclusive. For parents, the findings highlight the value of short, home-based adaptive game activities that reinforce classroom learning, boost confidence, and reduce math anxiety.

1.6 Delimitations of the Study

The study was delimited to:

1. Grade 3 students.

2. Subject of Mathematics

3. Unit#1 Numbers. Unit#2 Number Operations

4. Countdown Mathematics Book Grade 3 (3rd Edition)

5. Islamabad Grammar School G-11 Campus

1.7 Operational Definitions

1.7.1 Non- Digital Adaptive Math Games

This term refers to educational activities related to mathematics designed by instructors in order to adjust content and difficulty levels based on the performance and needs of learners. These games are relying on physical material instead of technology.

1.7.2 Mathematics Achievement

The level of proficiency and knowledge in mathematics as measured by pre-test and post-test administered during the study.

1.7.3 Traditional Method

This method of instruction refers to the teaching method includes lecture method, rote memorization, textbook-based learning and notes taking and individual based tasks.

1.8 Theoretical Framework

The theoretical framework of this study grounded on the principles of differentiated instruction.

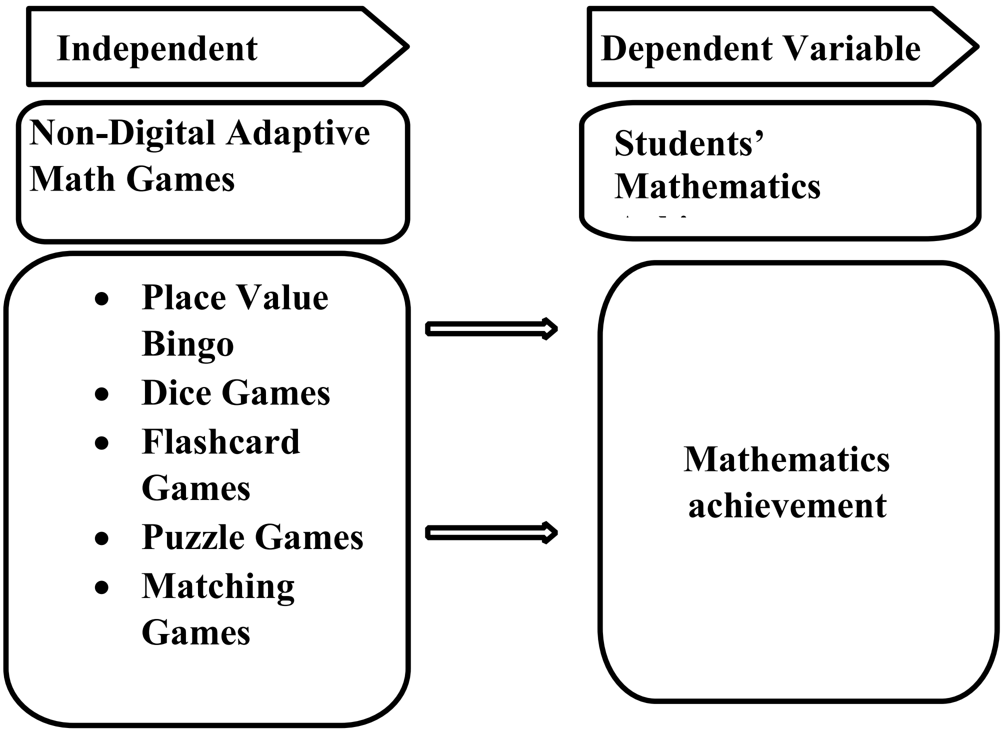
1.8.1 Differentiated Instruction

This refers to the teaching method that includes adopting different instructional method in order to meet the needs of students. This theory refers that students have diverse learning styles, interest and teacher should adopt teaching methods according to meet diverse needs of learners. In the context of this study, Non-Digital Adaptive Math Games serve as a method for differentiating instruction. Teachers design various activities and games that cater to different ability levels and learning preferences, ensuring that all students can engage with the material in a meaningful way (Tomlinson, 2017).

1.9 Conceptual Framework

Figure 1.9

Conceptual Framework of the Experimental Research Design with Control and Experimental Groups.



CHAPTER 2

LITERATURE REVIEW

The review of related literature will highlight the significance if non-digital math games in enhancing students’ engagement, motivation, problem solving skills and achievement at primary level. However, there is a prominent research gap concerning the specific impact of adaptive non-digital math games that adjust difficulty based on learners' performance. Additionally, most existing studies have been conducted in international contexts, with limited research in regions like Pakistan. This study aims to address these gaps by exploring the effectiveness of non-digital adaptive math games on Grade 3 students' mathematics achievement in Islamabad, contributing valuable insights into their practical implementation and benefits in a local educational setting.

The integration of games in mathematics education has emerged as a significant pedagogical approach in recent years, particularly regarding non-digital mathematical games in primary education (Russo et al., 2024; Öztop, 2023). While digital technologies continue to advance, traditional game-based learning methods have demonstrated persistent effectiveness in mathematics instruction (Setambah et al., 2023).This systematic review examines the effectiveness of non-digital mathematical games in enhancing primary students' mathematical achievement, analyzing both their direct impact on learning outcomes and their comparative advantages over digital alternatives.

Mathematics education at the primary level plays a crucial role in laying the foundation for students' future academic success. However, traditional lecture-based instructional methods often result in decreased student engagement and limited conceptual understanding (Boaler, 2016). To address these challenges, non-digital adaptive math games have emerged as promising pedagogical tools. These games are designed to align with learners' needs without relying on digital technologies, making them particularly valuable in resource-limited environments. This literature review explores the theoretical foundations, empirical evidence, and practical implications of using non-digital adaptive math games to enhance primary students' mathematics achievement.

2.1 Review of Related Literature

The research study presents that non-digital math games play a significant role in primary education by enhancing students' achievement in subject of mathematics. These games provide enjoyable, rule-based challenges that improve overall motivation, engagement, and problem-solving skills among learners. Teachers show a strong preference for these types of games, as they facilitate rich mathematical discussions and promote a positive attitude toward mathematics. However, the review highlights a significant gap in research specifically focused on adaptive games that adjust difficulty based on students' performance. Additionally, most studies have been conducted in international contexts, with limited research in regions like Pakistan. This gap is addressed in this study, which explores the impact of non-digital adaptive math games on students' mathematics achievement in Islamabad's primary schools. By comparing their effectiveness with traditional teaching methods and assessing the sustainability of their benefits over time, your research contributes valuable insights into implementing adaptive games in a local educational context (Russo et al., 2024).

This research study emphasized the benefits and teacher preference for non-digital games in order to promote engagement and mathematical understanding. It highlights a there are significantly less studies in the literature regarding the effect of non-digital adaptive games related to diverse need of learners. Additionally, the article points out the lack of research conducted within the context of developing countries like Pakistan, where educational resources and technological used differ significantly from those in more developed regions. This gap highlights the need for studies such as this which aim to explore the effectiveness of non-digital adaptive math games on students' mathematics achievement in primary schools, specifically within the unique educational setting of Islamabad. By addressing these gaps, this research will contribute valuable insights into the practical implementation and long-term benefits of non- digital adaptive games in diverse educational environments (Russo & Roche, 2017).

The systematic review examines the impact of Digital Game-Based Learning on elementary science education. The review finds that Digital Based Learning Game enhances students' science learning outcomes by making learning more engaging and interactive. Although the focus is on science, the findings provide valuable insights into the general effectiveness of Digital Based Games suggesting potential benefits for other subjects, including mathematics. However, the review does not specifically address the educational context of Islamabad, Pakistan (Hussein et al., 2019).

While this article "Deepening Our Understanding of How Primary School Teachers Use Games to Support Mathematics Instruction" highlights the use of games in mathematics teaching, there remains a research gap regarding the specific effect of non-digital adaptive math games on student engagement and achievement compared to digital games. Existing studies have primarily focused on teacher preferences and perceptions, yet there is limited exploration of how these preferences influence instructional practices and student outcomes in diverse classroom settings. This gap points to the need for studies that investigate the effectiveness, challenges, and advantages of non-digital adaptive math games in primary education, particularly in changing teaching contexts such as urban versus rural schools (Russo, 2024).

The use of non-digital gamification techniques in mathematics instruction has been shown to positively influence both academic achievement and student behavior. Researcher conducted a quasi-experimental study to examine how non-digital gamified teaching methods impacted students' performance in mathematics. Their study revealed that students who engaged in non-digital gamified lessons demonstrated higher achievement scores on fraction tests compared to students taught using conventional instructional methods. In addition to academic improvements, the study also highlighted better classroom behavior among students exposed to the gamified learning environment. Although the research focused on general secondary students, its findings are highly relevant to the primary education context, where motivation, engagement, and behavior management are crucial for mathematical success. The study underscores the potential of adaptive non-digital games that can adjust in complexity based on student responses not only to enhance mathematics achievement but also to create a more positive and conducive learning environment**.** These outcomes support the integration of non-digital adaptive games in primary classrooms to foster both academic and behavioral growth among young learners (Bahurudin et al., 2023).

Recent research supports the role of non-digital games in enhancing primary students' engagement, motivation, and achievement in mathematics. This study found that mind games used in primary classrooms improved students' problem solving skills and attitudes toward mathematics by creating an active and meaningful learning environment. The study emphasized the social and emotional benefits of game-based instruction, which are critical for young learners' motivation and persistence (Filiz, 2024). However, a major research gap persists in understanding how adaptiveness games that adjust difficulty in real time based on learners' performance can further enhance learning outcomes. Through a comprehensive meta-analysis, concluded that non-digital games have a higher effect size (g = 0.90) on academic achievement compared to digital games. Despite this, their analysis noted a lack of focus on adaptive functionalities in these non-digital formats, particularly in low-resource educational settings (Talan et al., 2020).

Non-digital adaptive math games have continued to show wide-ranging benefits, especially in the development of higher-order thinking skills. These games promote logical reasoning, sequencing, and decision-making. According to Canobi (2009), students engaged in structured, hands-on math tasks demonstrate stronger understanding of part-whole relationships and numerical operations. The tactile nature of non-digital games creates active learning environments where students build conceptual knowledge through repeated manipulation and experimentation.

Further, the connection between executive function and math achievement is increasingly recognized. Blair and Raver (2015) highlight that activities requiring planning, flexible thinking, and self-regulation such as rule-based board games correlate with improved math outcomes in early childhood. These cognitive processes are naturally embedded in many adaptive games that involve step-by-step strategies and problem-solving challenges.

Inclusion is also a major benefit of non-digital adaptive approaches. Students with learning differences often require additional time, scaffolding, and repetition. Non-digital math games allow for varied pacing without singling out learners, promoting equity and universal access. According to Bouck (2009), students with mild disabilities showed measurable improvements in computation fluency and motivation when taught using manipulatives and math-centered play.

A particularly compelling aspect of non-digital games is their potential to support metacognition. Learners are often prompted to reflect on their choices, revise strategies, and anticipate outcomes. (Veenman et al., 2006) assert that explicit support for metacognitive skill development results in better transfer of mathematical problem-solving skills. Games that require predicting opponent moves or optimizing scoring systems cultivate such reflective thinking.

Beyond student-level outcomes, school culture also plays a role in sustaining game-based learning. When teachers collaborate to develop, share, and refine game materials, there is greater consistency in implementation. Linder, Rembert, Simpson, and Ramey (2013) found that primary schools with embedded professional learning communities were more successful in integrating active math strategies into daily instruction.

Home-school connections further amplify the effects of game-based instruction. Parents can reinforce math learning when given tools and guidance on gameplay. Cross et al. (2011) documented that math games played at home increased parent-child mathematical discussions and improved number fluency. Non-digital tools are especially useful here as they do not require internet access or devices.

Additionally, culturally relevant math games are gaining attention for their impact on engagement. Incorporating local examples, currency, food items, or storytelling traditions into game mechanics can make learning more relatable. Nasir et al. (2008) argue that students' cultural identities should be considered as strengths and leveraged in instructional design. Games are a powerful medium for this due to their narrative and symbolic potential.

Finally, sustainability and cost-effectiveness are key arguments in favor of non-digital interventions. While digital platforms require hardware, electricity, and updates, non-digital games can be handmade or replicated at low cost. In low-resource settings, this enables scalability. Banerjee and Duflo (2011) suggest that interventions combining simplicity and teacher empowerment have the greatest potential for long-term educational reform. This growing body of evidence affirms that non-digital adaptive math games are more than just tools for student enjoyment, they are deeply aligned with developmental theory, curriculum goals, and inclusive pedagogy. The present study seeks to extend this body of work by examining localized, low-tech adaptations in a Pakistani primary school context.

2.2 Theoretical Review

These studies highlight the impact of non-digital games, digital games, and traditional methods on third-grade students' mathematics learning, finding that non-digital games outperform both traditional and digital methods. However, this research study does not focus on adaptive learning within non-digital games, also it does not explore the long-term effect of these games on mathematics achievement. For this study, the research gap lies in the need to explore the specific effect of non-digital adaptive math games in student's mathematics achievement, particularly in limited resource setting. Unlike the article, this study will investigate how the adaptive nature of these games can enhance learning outcomes for Grade 3 students, providing more understanding of their effectiveness compared to traditional and digital methods. This approach will address the lack of research on adaptive learning in non- digital formats and offer practical insights for educators in varying educational contexts (Samir & Ramin, 2023).

The concept of adaptiveness in instructional design is vital for differentiated learning, particularly in primary education where cognitive abilities vary widely. The research study explored the integration of adaptive game-based learning in Malaysian primary schools. Their findings showed that adaptive games tailored to individual performance improved students' understanding and enjoyment of mathematics. This suggests that even non-digital games, when designed with adaptive elements, could serve as powerful tools for supporting differentiated instruction in diverse classrooms (Hui et al., 2024). Game-based learning is grounded in several key educational theories:

2.2.1 Constructivist Learning Theory

Constructivist theorists argue that learners construct knowledge actively through meaningful experiences (Piaget, 1952; Vygotsky, 1978). Non-digital math games provide interactive opportunities for students to explore, manipulate, and reflect on mathematical concepts in collaborative environments (Niemi et al., 2021).

2.2.2 Differentiated Instruction

Tomlinson (2017) advocates for differentiated instruction as a means to address diverse learning styles and readiness levels. Non-digital adaptive games support this by allowing variation in game complexity

2.3 Empirical Review

Overall, this research study highlights the positive effect of non-digital game-based learning on students' mathematical and instructional strategies based on students' performance and needs (Roy et al., 2022). Achievement and perspectives in secondary education, demonstrating that such interventions can improve engagement and performance in specific mathematical topics. However, there are several gaps when considering the effects for this study research on non-digital adaptive math games at the primary level. Firstly, their study focuses completely on ninth graders, leaving a gap in understanding how non-digital game-based learning affects younger learners who may have different cognitive and developmental needs. Additionally, the lack of adaptive features in their intervention means that this study can explore how tailored learning experiences can further improve mathematics achievement among primary students. By examining a wider range of mathematical concepts and focusing younger students in Islamabad, this research will provide important data about the effectiveness of non-digital adaptive math games in a specific cultural context, thereby contributing to the literature on educational practices that support diverse learning needs in primary mathematics education (Yusof & Shahrill, 2021).

The study on non-digital game-based learning explores its effectiveness in mathematics education, particularly in setting where digital resources are limited. This study explores the advantages of non-digital games in higher education, highlighting their cost-effectiveness, low administrative burden, and improved social interaction compared to digital equivalents. His study, which involved adapting various non-digital games for teaching mathematical principles to first-year computer science students, explores that these games meaningfully motivated students and positively impacted learning results. This aligns with previous findings by Habib and Roshanian (2024) which recognized the effectiveness of non-digital games in improving third grade students' mathematics achievement. However, a research gap remains in the examination of non-digital adaptive math games specifically targeted at primary education and their long-term effects on student learning, mostly in diverse and limited resource environments. While existing studies have recognized the benefits of non-digital games in various educational setting, there is limited research focusing on their adaptive nature and how they can be used to encounter individual learning needs, underscoring the need for further study into these games' potential in primary mathematics education. Thus, the study aims to fill this gap by examining the effect of non-digital adaptive math games on the mathematics achievement of Grade 3 students, contributing to a deeper understanding of how such games can enhance learning outcomes across different educational settings (Naik, 2014).

In an exploratory study, Hall et al. (2024) demonstrated how non-digital games, designed with flexible rules and adjustable difficulty, increased pre-service teachers' engagement with mathematics. Although this study focused on teacher preparation, it indirectly supports the feasibility and effectiveness of adaptive non-digital games for students. Moreover, Cardinot and McCauley (2024) emphasized the effectiveness of non-digital games in promoting long-term conceptual change in astronomy education. These findings are transferable to mathematics education, where similar cognitive and affective outcomes are desirable (Cardinot & McCauley, 2024).

Another area gaining research attention is the relationship between play-based instruction and mathematical abstraction. Research by Ramani and Siegler (2008) found that young children from disadvantaged backgrounds showed greater gains in number line estimation and numerical magnitude comparison when taught using linear board games versus traditional drills. These improvements indicate that non-digital games contribute to internalizing mathematical structure and pattern recognition. Adaptive games also support the development of mathematical language. In early grades, students are often transitioning from concrete to abstract thinking. Games that require verbalizing steps or describing reasoning encourage the use of precise vocabulary and academic language. According to Purpura and Lonigan (2015), early numeracy interventions that include verbal components yield stronger gains in kindergarten and first grade math performance.

Teacher agency is a vital component of sustained instructional innovation. Teachers must have both autonomy and competence to adapt non-digital games for various classroom contexts. Garet et al. (2001) emphasize that high-quality professional development includes active learning and contextual relevance, allowing educators to effectively customize and implement new strategies.

Additionally, students in multilingual classrooms benefit from the universal design of many non-digital games. Games transcend language barriers through visuals, movement, and symbols, promoting equity for learners with varying levels of language proficiency. Cummins (2000) points out that using contextual support in instruction allows second-language learners to access academic content more effectively, making game-based formats ideal for inclusive instruction.

One key benefit of adaptive games is their alignment with the principles of formative differentiation. Rather than assigning students to static ability groups, adaptive games allow for fluid movement across levels of difficulty. This promotes a growth mindset and fosters resilience. Dweck (2006) asserts that environments which normalize challenge and provide scaffolded success build persistence and intrinsic motivation. Finally, the physicality of non-digital games manipulating cards, tokens, or dice helps strengthen fine motor coordination and spatial awareness. According to Verdine et al. (2014), early math learning is closely linked with spatial cognition, and activities involving puzzles or board configurations enhance both mathematical reasoning and physical coordination. These insights further validate the use of non-digital adaptive math games as a robust, inclusive, and developmentally appropriate instructional approach. Their integration aligns with research-based strategies across cognitive, linguistic, cultural, and physical domains of learning.

2.4 Effectiveness of Non-Digital Mathematical Games

Empirical research has consistently demonstrated the positive impact of non-digital mathematical games on student learning outcomes in primary education (Russo et al., 2024; Setambah et al., 2023). In their comprehensive systematic review, Russo et al. (2024) analyzed data from multiple primary-level studies, finding that non-digital games showed significant positive effects on mathematical learning across all grade levels, with particular effectiveness in areas requiring conceptual understanding and problem-solving skills. Supporting these findings, Setambah et al. (2023) conducted a quasi-experimental study involving 100 primary school students in Perak, which revealed substantial improvements in mathematical achievement through non-digital game-based teaching methods. Their research provided crucial empirical evidence for how these traditional games create an engaging learning environment while simultaneously developing mathematical competencies.

In an exploratory study, Hall et al. (2024) demonstrated how non-digital games, designed with flexible rules and adjustable difficulty, increased pre-service teachers' engagement with mathematics. Although this study focused on teacher preparation, it indirectly supports the feasibility and effectiveness of adaptive non-digital games for students. Moreover, Cardinot and McCauley (2024) emphasized the effectiveness of non-digital games in promoting long-term conceptual change in astronomy education. These findings are transferable to mathematics education, where similar cognitive and affective outcomes are desirable (Cardinot & McCauley, 2024).

Research highlights the benefits of using non-digital math games to enhance mathematics achievement. For instance, McNeil and Jarvin (2007) demonstrated that students who used manipulatives and rule-based games showed stronger understanding of arithmetic concepts than those who learned through traditional instruction. Zevenbergen and Lerman (2008) observed that hands-on game-based activities promote deep engagement and discourse, enabling children to verbalize their thinking and improve problem-solving strategies.

Moreover, adaptive games those which modify tasks based on learner responses have been found to accelerate learning gains. According to Kulik and Fletcher (2016), adaptive instruction increases learning efficiency by providing learners with tasks tailored to their abilities and progress.

2.5 Comparison of Digital and Non-Digital Games

Although digital games offer multimedia advantages, they are not always accessible or appropriate, especially in low-income or rural contexts. Papadakis et al. (2021) found that while digital games can improve motivation, non-digital alternatives are equally effective when it comes to conceptual understanding, especially in early grades. A study by Kamii and Housman (2000) found that tactile games requiring children to manipulate physical objects foster better number sense than screen-based applications. This is particularly true in contexts where children benefit from concrete experiences to bridge abstract mathematical ideas.

Additionally, non-digital games offer a unique format to foster mathematical discourse, which is central to the development of reasoning skills. Chapin, O'Connor, and Anderson (2013) highlight that structured math talk allows students to articulate and refine their thinking. During gameplay, learners are encouraged to justify moves, challenge ideas, and engage in cooperative strategy development. Recent studies have explored how non-digital game-based learning influences problem-solving persistence. According to Turner et al. (2011), students exposed to engaging game-based math tasks exhibited greater willingness to persist through challenges. They remained more motivated during difficult problems than those completing worksheet-based tasks, showing improved resilience.

Moreover, game-based instruction has proven effective across various curriculum strands not just arithmetic. A study by Nicol and Crespo (2006) investigated the use of manipulatives and problem-based games for teaching geometry in Grades 2 and 3. The results showed measurable improvements in spatial reasoning and geometry vocabulary among students who engaged with hands-on, non-digital math activities. Another advantage of non-digital adaptive games is the ability to support formative self-assessment. Games with built-in scoring or visual progress tracking enable learners to reflect on their performance. Andrade and Heritage (2017) emphasize that such self-monitoring builds metacognitive awareness and supports goal setting, two essential components of self-regulated learning. These findings support the continued integration of non-digital adaptive math games in classrooms as tools that enhance equity, reasoning, discourse, and reflective practice. When properly implemented, they promote a student-centered environment aligned with educational best practices and universal learning principles.

2.6 Comparative Advantages of Non-Digital

Games Building upon these effectiveness findings, recent meta-analytic research has revealed several distinct advantages of non-digital games compared to digital alternatives in mathematics instruction. Through a comprehensive meta-analysis, Öztop (2023) examined the comparative effectiveness of both digital and non-digital games in primary mathematics teaching, identifying three key advantages of traditional game-based approaches:

- Enhanced Social Interaction: Face-to-face communication fostered deeper mathematical discourse (Öztop, 2023).
- Reduced Cognitive Load: Absence of digital interface navigation requirements allowed greater focus on mathematical concepts (Russo et al., 2024).
- Tactile Learning Benefits: Physical manipulation of game materials supported concrete understanding of abstract concepts (Setambah et al., 2023).

2.7 Implementation Techniques

Drawing from these comparative advantages, researchers have identified crucial implementation factors for successful non-digital math games integration. Yusof and Shahrill (2021) conducted an extensive study highlighting the importance of:

- Strategic alignment between games and specific learning objectives
- Adaptive difficulty levels accommodating diverse student abilities
- Structured play environments with clear rules and learning goals
- Regular assessment integration for tracking progress

Their findings emphasized that these implementation elements are essential for maximizing the educational benefits identified in previous research (Russo et al., 2024). Effective implementation of non-digital adaptive math games requires thoughtful alignment with curriculum objectives and student abilities. Hui et al. (2024) highlighted the importance of using adaptive game mechanics such as level adjustment and real time feedback to meet diverse learning needs. Their study recommends integrating regular formative assessments within game-based instruction to monitor and guide student progress effectively. Effective implementation of non-digital math games requires structured planning. Sarama and Clements (2009) recommend that teachers align games with curriculum goals, provide scaffolding, and debrief students post-activity to reinforce learning.

Building on previous evidence, recent studies confirm that non-digital adaptive math games can significantly enhance students' mathematical achievement, especially when aligned with instructional objectives and used consistently. According to Hansen et al. (2021), structured and adaptive physical math games increased arithmetic fluency and conceptual understanding among early primary students. Their findings emphasize the importance of systematic adaptation adjusting game difficulty and scaffolding support based on learner performance. Similarly, research by Kim et al. (2020) examined the effects of low-tech manipulatives and instructional games in Grade 3 classrooms. The results indicated a statistically significant improvement in students' subtraction and multiplication skills over a six-week intervention. Teachers reported improved classroom engagement and participation, particularly among lower-achieving students.

Another important dimension is learner autonomy. Non-digital games give students choices in how they approach problems and allow for immediate feedback within game rules. According to Perry et al. (2002), providing learners with control over their learning processes fosters deeper engagement and helps develop ownership of their learning outcomes. This is particularly relevant in game-based math environments, where students can practice repeatedly and receive implicit corrective feedback. Moreover, the element of repeated exposure embedded in math games is central to knowledge retention. Anderson and Lebiere (1998), through ACT-R theory, highlighted that repeated practice under varying conditions helps transfer mathematical knowledge into long-term memory. Non-digital games often incorporate repetition through playful formats, increasing the likelihood of lasting comprehension without fatigue.

Teacher mediation also plays a crucial role in maximizing the learning potential of adaptive games. According to Van de Pol, Volman, and Beishuizen (2010), guided scaffolding during game-based tasks enables students to stay within their zone of proximal development. Teachers who engage in dynamic questioning and provide timely hints help maintain a balance between challenge and support, ensuring cognitive growth. Cognitive load theory also supports the use of structured, non-digital math games. Sweller et al. (2011) argue that learning materials should reduce extraneous cognitive load while maximizing germane load. Well-designed games using visual cues, concrete materials, and simple rules make abstract concepts more accessible and cognitively manageable for young learners. Finally, motivational aspects remain central to their success. Non-digital math games transform passive learning into active exploration, instilling a sense of accomplishment. According to Schunk and DiBenedetto (2020), mastery experiences and task-related successes are among the most effective ways to develop academic self-efficacy. Students participating in structured math games report increased confidence and reduced math anxiety over time.

These studies collectively reinforce that non-digital adaptive math games are an effective instructional tool with multi-dimensional benefits. Their power lies not only in content delivery but also in fostering engagement, differentiation, retention, and confidence among diverse student populations. Bayat and Rezaei (2023) showed that teachers who used a structured rotation model for implementing non-digital math stations observed higher engagement and improved assessment outcomes among primary students. They emphasize the importance of teacher facilitation during gameplay to ensure students remain focused and receive immediate feedback.

2.8 Effect on Students Engagement and Motivation

The implementation of well-structured non-digital games has shown significant effects on student engagement metrics. Yusof and Shahrill's (2021) longitudinal study demonstrated that non-digital game-based learning approaches significantly improved both immediate engagement and long-term motivation in mathematics. Their research revealed that students participating in well-designed mathematical games showed:

- Increased willingness to tackle challenging problems
- Greater persistence in problem-solving tasks
- Enhanced peer collaboration during mathematical activities
- Improved self-efficacy in mathematical concepts

These engagement outcomes directly support the effectiveness findings discussed earlier (Russo et al., 2024) and provide additional context for understanding the mechanisms through which non-digital games improve mathematical achievement. Non-digital games offer a low-cost yet impactful method for increasing student motivation. In a case study involving conceptual learning through mind games, Filiz (2024) observed heightened student motivation, increased persistence in problem solving, and improved classroom participation. These motivational benefits are essential for sustaining long-term engagement in mathematics learning. Several studies underscore the motivational impact of math games. According to Ramirez and Beilock (2011), game-based formats reduce math anxiety and increase students' willingness to participate. When students feel successful during gameplay, their self-efficacy improves, leading to greater persistence. An investigation by Kazemi and Gholami (2022) found that students who played group-based non-digital math games demonstrated greater enjoyment and showed a 20% improvement in on-task behavior during math lessons compared to peers in traditional classrooms. Non-digital adaptive math games enhance engagement by providing personalized learning experiences without relying on technology. Hall et al. (2024) explored the incorporation of traditional, non-digital games into mathematics teacher training, revealing that such games significantly increased learners' motivation, conceptual understanding, and enthusiasm for teaching math. These games often simulate real-world scenarios and emphasize peer interaction, thereby fostering student-centered learning environments (Hall et al., 2024).

Non-digital adaptive games promote self-regulated learning. According to Zimmerman (2002), self-regulated learners set goals, monitor progress, and reflect on outcomes. Fong, Collins, Brown, and Blumberg (2020) reported that students using math strategy games demonstrated higher levels of planning and perseverance. Deci and Ryan's (2000) self-determination theory supports the idea that games, by supporting autonomy and competence, enhance intrinsic motivation.

2.9 Implementation Challenges

Despite the robust evidence supporting non-digital math games, several important limitations warrant careful consideration. Russo et al. (2024) identified significant implementation challenges, including: Time requirements for proper game integration ,Teacher training needs for effective implementation, Resource availability constraints Assessment methodology complications supporting these findings, Setambah et al. (2023) noted specific difficulties in measuring direct impact on achievement, suggesting the need for more sophisticated assessment methods.

Despite these benefits, implementation challenges remain. Hall et al. (2024) noted that teacher training and resource availability are key barriers to effective integration of non-digital games. Additionally, while games can improve short-term engagement, long-term achievement effects require consistent use and alignment with instructional goals. Teachers often lack professional training on how to effectively design and integrate adaptive games. Moreover, time constraints and curriculum pacing may limit opportunities for extended play. Boonen et al. (2014) argue that without teacher facilitation and feedback, the instructional value of games may be diminished. Thus, professional development and classroom management strategies are essential for maximizing effectiveness.

2.10 Mathematical Concepts Development

Tactile learning materials like board games or manipulatives support conceptual understanding in mathematics. Satria et al. (2024) demonstrated that manipulative game-based physical education activities enhanced basic mathematical and motor skills in primary learners. The hands-on approach enabled learners to visualize abstract concepts, particularly useful in early math development. The findings suggest that non-digital adaptive tools may bridge comprehension gaps, especially for kinesthetic learners (Satria et al., 2024).

2.11 Instructional Setting with Limited Resources

Where digital tools are scarce, adaptive non-digital games provide inclusive alternatives. Zishiri et al. (2025) highlighted the use of low-cost, offline games in Zimbabwean early education centers, reporting that these resources effectively supported cognitive and emotional development among children, even with limited infrastructure. This underscores the relevance of adaptive non-digital strategies in similar educational contexts, such as Pakistan (Zishiri et al., 2025).

2.12 Effect on Students Achievement

Alanazi (2020) conducted an experimental study on Active Recreational Math Games (ARMG) and found that students exposed to these non-digital adaptive games achieved higher performance scores and exhibited reduced math anxiety. Adaptive game features, such as increasing difficulty aligned with learner proficiency, proved critical to sustained achievement. This supports their use in curricular design to improve math outcomes (Alanazi, 2020). In low-income regions, adaptive non-digital math games present a viable alternative to expensive educational technology. Banerjee et al. (2017) found that simple, scalable math game kits used in rural Indian classrooms resulted in measurable gains in math performance and reduced gender disparities. These interventions support the broader movement toward equity in education, especially where electricity or digital devices are inconsistent or unavailable.

2.13 Promote Confidence in Game-Based Learning

Lennon-Maslin et al. (2024) explored how mathematics self-concept and spatial anxiety influence learning through game-based approaches. They found that adaptive gameplay reduces spatial anxiety and promotes higher achievement, especially among girls, by providing customized challenges that 1 align with learner comfort levels. This affirms the psychological benefits of adaptive game use in diverse classrooms (LennonMaslin et al., 2024).

2.14 Enhance Social Learning

Non-digital games often involve peer interaction, enhancing cooperative learning. Hall et al. (2024) observed that such formats facilitated communication and teamwork among pre-service teachers, which can be extrapolated to younger learners. These collaborative mechanisms allow students to explain reasoning, listen to peers, and refine strategies, crucial for mathematical reasoning and long-term retention (Hall et al., 2024).

From a Vygotskian perspective, the social context of learning plays a central role. Game-based learning environments often require collaboration, turn-taking, and verbal negotiation, which contribute to deeper learning (Forman & Cazden, 1985). Non-digital games, when played in small groups or pairs, foster meaningful interactions and provide natural opportunities for peer tutoring and formative assessment (Gillies, 2016).

Studies like those by Mulryan (1992) emphasize how peer discourse in math tasks promotes metacognition and strategy sharing. In particular, students engaged in peer-guided math games exhibit greater confidence and improved communication skills compared to those in lecture-driven environments.

2.15 Flexibility in Instructional Method and Teacher Agency

Non-digital games offer educators the flexibility to adjust learning paths in realtime. Nurhayati et al. (2016) designed the Congklak Math Game to teach specific math concepts like KPK and FPB in Indonesian classrooms, allowing teachers to modify rules to suit varied student needs. This adaptability enhances differentiated instruction and caters to diverse cognitive levels (Nurhayati et al., 2016).

2.16 Focus Diverse Learners Need

Çimen and Alp (2024) developed adaptive non-digital games for children with Down syndrome and found that tailored, game-based interventions significantly improved both motor and cognitive skills. Their findings advocate for broader use of adaptive game models to accommodate diverse learners in mainstream primary education. Research suggests that well-designed games can reduce gender gaps in mathematics performance. In a study by Eccles and Wang (2016), girls reported higher confidence and interest in math when learning through collaborative, game-based approaches as opposed to isolated seatwork. Non-digital games also support learners with special educational needs. For example, Seo and Woo (2010) demonstrated that students with mild intellectual disabilities improved number recognition and sequencing after a four-week intervention using adaptive card-based math games.

2.17 Retention and Long-Term Learning

Beyond short-term gains, non-digital adaptive games contribute to long-term knowledge retention. A longitudinal study by Jordan et al. (2013) found that secondgrade students who engaged in weekly math games retained more knowledge about number operations after six months than students taught through direct instruction alone. The adaptiveness of such games where content difficulty is matched to the learner has been linked to greater long-term mastery (VanLehn, 2011). Because learners receive immediate correction and reinforcement at the right cognitive level, they are more likely to retain concepts.

Their study concluded that home-based, non-digital games such as counting, board, or dice games supported early mathematical understanding more effectively than rote instruction alone. These activities provided context-rich and socially meaningful opportunities for learning. Non-digital adaptive math games also align with principles of Universal Design for Learning (UDL), which emphasizes flexible methods and tools to accommodate diverse learners. According to Rose and Dalton (2009), using multiple means of representation, engagement, and expression helps ensure access to learning for all students. Math games can be modified with visual aids, manipulatives, or peer scaffolding to match the cognitive and physical needs of students in inclusive classrooms.

Additionally, non-digital games offer a unique format to foster mathematical discourse, which is central to the development of reasoning skills. Chapin, O'Connor, and Anderson (2013) highlight that structured math talk allows students to articulate and refine their thinking. During gameplay, learners are encouraged to justify moves, challenge ideas, and engage in cooperative strategy development. Recent studies have explored how non-digital game-based learning influences problem-solving persistence. According to Turner et al. (2011), students exposed to engaging game-based math tasks exhibited greater willingness to persist through challenges. They remained more motivated during difficult problems than those completing worksheet-based tasks, showing improved resilience.

Moreover, game-based instruction has proven effective across various curriculum strands not just arithmetic. A study by Nicol and Crespo (2006) investigated the use of manipulatives and problem-based games for teaching geometry in Grades 2 and 3. The results showed measurable improvements in spatial reasoning and geometry vocabulary among students who engaged with hands-on, non-digital math activities. Another advantage of non-digital adaptive games is the ability to support formative self-assessment. Games with built-in scoring or visual progress tracking enable learners to reflect on their performance. Andrade and Heritage (2017) emphasize that such self-monitoring builds metacognitive awareness and supports goal setting, two essential components of self-regulated learning.

These findings support the continued integration of non-digital adaptive math games in classrooms as tools that enhance equity, reasoning, discourse, and reflective practice. When properly implemented, they promote a student-centered environment aligned with educational best practices and universal learning principles.

2.18 Curriculum Alignment and Instructional Design

Luo et al. (2023) emphasized that gamified teaching strategies, even in non-digital forms, enhance motivation and result in long-term academic engagement. By using structured instructional design frameworks, educators can craft meaningful game based interventions that sustain learner interest and promote active participation in mathematics. Non-digital math games are most effective when embedded within a curriculum-aligned framework. Wiggins and McTighe's (2005) "Understanding by Design" model encourages backward planning starting from desired learning outcomes and designing game-based experiences to support those goals. This structured approach ensures that math games are not mere distractions but meaningful instructional tools. According to Trundle and Smith (2017), incorporating learning objectives, formative feedback, and assessment rubrics into game activities enhances instructional fidelity and increases student accountability. This is especially critical in primary classrooms where time and curriculum pacing are tightly managed.

2.19 Cognitive Development and Hands-On Learning Approaches

Numerous studies have highlighted the cognitive benefits of tactile, kinesthetic activities for enhancing mathematical understanding. According to Uttal et al. (2013), using physical manipulatives and non-digital materials supports spatial reasoning and concept formation, especially in early childhood. These materials facilitate the internalization of abstract concepts such as number relationships and operations when combined with structured games (Zhou & Wang, 2020).

Additionally, Siegler and Ramani (2009) found that low-income preschoolers who engaged with number board games significantly improved their numerical magnitude understanding and numerical estimation skills. This supports the argument that non-digital games provide cognitive scaffolds that are especially effective for disadvantaged learners.

2.20 Influence on Emotional and Affective Outcomes

Mathematics learning is often influenced by students' attitudes, confidence, and emotions. Game-based learning provides a non-threatening environment that reduces fear of failure and increases intrinsic motivation (Meece et al., 2006). In a study by Dowker et al. (2016), children participating in math games reported reduced anxiety and increased enjoyment of math compared to those engaged in textbook exercises.

These affective benefits are especially pronounced in younger learners, who thrive on playful learning. Games with adaptive features that balance challenge and skill level are shown to increase flow and engagement (Csikszentmihalyi, 1990).

2.21 Effective Classroom Management Skills

A common concern among teachers is the classroom management of active learning environments. Research by Henningsen and Stein (1997) suggests that well designed math tasks and games can lead to high levels of student engagement with minimal behavioral issues if expectations are clearly communicated. Ferguson and Dorman (2018) recommend strategies such as clear rule-setting, visual timers, and rotation systems to manage time and transitions between game activities. Their study also indicates that math stations using non-digital games are more sustainable over long periods compared to one-time digital interventions.

2.22 Parental and Community Role

Learning does not end at school, and game-based activities can bridge home and classroom learning. Research by Sheridan et al. (2011) shows that parental involvement in math games improves numeracy outcomes and reinforces positive math attitudes. Sending simple, non-digital math games home with instructions can extend practice opportunities and involve caregivers in learning. Community-based math clubs and inter-class competitions using board games or card challenges have also been shown to build a supportive learning culture (Epstein & Sanders, 2006).

2.23 Interdisciplinary Approaches and Cross-Curricular Connections

Non-digital math games can be integrated with other subjects such as language, art, and physical education. For instance, storytelling-based math games link numeracy with literacy development (Verdine et al., 2017), while outdoor math scavenger hunts promote movement and spatial awareness.

Howard-Jones et al. (2014) argue for an embodied cognition approach, suggesting that physically active learning, including math games, enhances memory consolidation and concept understanding. Several international studies provide insights into how non-digital math games are implemented across different educational contexts. A cross-national comparison by Rauscher and Greenfield (2009) showed that students in countries emphasizing playful learning approaches outperformed peers from more test driven systems in mathematical reasoning tasks. In Finland, math games form a routine part of early childhood education, contributing to high performance in international assessments such as PISA (Sahlberg, 2015).

2.24 Teachers' Role

Teachers' attitudes significantly influence the integration of non-digital adaptive games in classrooms. Pajares (1992) argued that beliefs are central to teaching behavior and instructional change. In game-based learning, teachers with strong pedagogical content Isiksal-Bostan, Sahin, and Aydin-Guc (2021) emphasized that professional development is essential for helping teachers understand how games can align with mathematical learning goals. After attending game-based learning workshops, teachers in their study showed increased implementation fidelity and student engagement.

2.25 Formative Assessment through Gameplay

Games can serve as natural tools for formative assessment. Black and Wiliam (2009) define formative assessment as the collection of evidence to inform instruction and improve learning. Clarke et al. (2012) found that observing children while they played math games allowed teachers to detect misunderstandings and adjust instruction accordingly.

2.26 Role of Language and Communication in Math Games

Mathematical language develops through social interaction, and non-digital math games encourage students to verbalize strategies and negotiate meaning. Moschkovich (2010) emphasized that using math discourse in interactive settings promotes deeper understanding. Bresser, Melanese, and Sphar (2009) observed that English Language Learners (ELLs) gained both language fluency and mathematical competence through repeated gameplay.

2.27 Equity and Cultural Responsiveness

Culturally responsive teaching ensures all students feel represented in learning. Gay (2010) advocated for instructional strategies that connect content to students' cultural backgrounds. Games can be customized with local contexts, which Villegas and Lucas (2007) found increased participation among students from underrepresented groups.

2.28 Critical Summary of Literature Review

The study on topic effect of non-digital adaptive math games on student's achievement in mathematics at primary level examines the features of non-digital mathematical games that educators value for supporting primary mathematics instruction, identifying key features that influence their perceived educational richness and likelihood of future use. Through a questionnaire completed by 122 educators, the research highlights the importance of attributes such as challenge level, engagement, enjoyment, adaptability for different learners, and the potential for fostering mathematical inquiry and discussion. This aligns with findings from previous studies, including those by Habib and Roshanian (2024) and Naik (2014), which highlight the effectiveness of non-digital games in improving students' mathematics achievement and motivation. However, a famous research gap continues in understanding.

This extended review reinforces that non-digital adaptive math games provide diverse cognitive, affective, and social benefits for primary learners. They are grounded in multiple learning theories and are adaptable to different educational settings. Yet, challenges remain in terms of scalability, teacher training, and resource allocation. Future research is needed to explore long-term effects across larger populations, assess cost-effectiveness, and develop culturally responsive game materials. This study contributes to filling that gap by applying non-digital adaptive math games in a Pakistani classroom context.

For this study, the gap lies in the need to investigate the effect of non-digital adaptive math games on Grade 3 students' mathematics achievement, mainly in relation to the characteristics. While the existing literature has recognized the significance of these characteristics for educators, there is limited experimental research examining how the adaptive nature of non-digital games influences student learning outcomes. Moreover, there is a lack of examination into how these games can be effectively implemented in diverse educational contexts, particularly in limited resources environments. By focusing on the effectiveness of non-digital adaptive math games and their specific characteristics that support learning, this study aims to fill this gap and add to a deeper understanding of how such games can improve mathematics education for primary students (Russo et al., 2022).

The integration of gamified elements into educational settings has garnered increasing attention as a potential catalyst for enhanced student engagement and improved learning outcomes, particularly in subjects like mathematics that are often perceived as challenging or uninteresting by students (Palacios et al., 2023). Traditional approaches to mathematics education, characterized by rote memorization and passive learning, may fail to resonate with students who thrive on interactivity and personalized experiences (Ke, 2008). Adaptive math games, whether digital or non-digital, offer a promising alternative by tailoring the level of difficulty and content to each student's individual needs and learning pace, thereby fostering a sense of accomplishment and promoting deeper understanding of mathematical concepts (Debrenti, 2024). Moreover, the incorporation of game mechanics such as points, badges, and leaderboards can tap into students' intrinsic motivation, encouraging them to actively participate in the learning process and persist in the face of challenges (Offenholley, 2012). However, it is crucial to acknowledge that gamification is not a panacea and its successful implementation requires careful consideration of various factors, including the design of the game, the learning objectives, and the characteristics of the students (Hu & Shang, 2018).

The potential of games in mathematics education extends beyond mere entertainment, offering opportunities to decrease anxiety, increase motivation, and deepen learning through immersive gaming experiences (Offenholley, 2012). This review supports the effectiveness of non-digital games in primary mathematics education and emphasizes the untapped potential of adaptive features. While general non-digital games improve motivation and conceptual understanding, adaptive non-digital games offer personalized learning experiences that can further enhance achievement. However, a significant gap remains in examining their impact within resource-constrained environments like Pakistan. Addressing this gap, the present study will explore how adaptive non-digital games can be tailored for Grade 3 students in Islamabad, offering practical insights into their benefits and implementation. The literature reviewed provides compelling evidence supporting the integration of non-digital adaptive math games in primary education. These games foster engagement, improve academic achievement, support differentiated instruction, and are especially suitable for under-resourced settings. However, their successful implementation depends on thoughtful design, teacher support, and curriculum alignment. The current study builds upon this body of evidence by examining how such games influence achievement among Grade 3 students in Islamabad, addressing an important research gap in localized, non-digital interventions.

The reviewed studies collectively support the efficacy of non-digital adaptive math games in primary mathematics education. These games contribute to academic performance, mitigate math anxiety, foster engagement, and accommodate learners with diverse needs. While digital tools are often emphasized in contemporary discourse, the evidence underscores the enduring value of traditional, manipulable, and adaptive learning games, especially in under-resourced settings (Alanazi, 2020; Çimen & Alp, 2024; Hall et al., 2024; Lennon-Maslin et al., 2024; Luo et al., 2023; Nurhayati et al., 2016; Satria et al., 2024; Zishiri et al., 2025).

CHAPTER 3

RESEARCH METHODOLOGY

The research methodology explains how the study was carried out, including how data were collected, analyzed, and how the experimental pat of the study was designed. This section covers the research design target population, sample and sampling technique, tools used for data collection, methods of analysis and ethical considerations.

3.1 Research Design

This study utilized True Experimental Research design to examine the Effect of Non-Digital Adaptive Math Games on Students Achievement in Mathematics at the Primary Level. The Positivist paradigm was the research paradigm as this paradigm emphasizes objective measurement, hypothesis testing, and cause-effect relationships, which align with your use of pre-tests, post-tests, and control/experimental groups. Through the Purposive sampling technique researcher selected sample of 50 students of Grade 3 from of G-11 campus. Researcher selected grade 3 students from 12 registered schools of G-11 sector and delimited study to one school located in Islamabad Grammar School of G11 Sector. Population of the study consisted of 50 students of grade 3 from Islamabad Grammar School. The study was conducted in a private sector school in Islamabad that provides education from Kindergarten (KG) to the Matriculation level. The school follows the national curriculum and uses traditional classroom instruction as its primary mode of teaching mathematics. In this experimental design, students randomly selected as participants of control group and experimental group in order to reduce biasness. One group was Control group which taught through traditional method and other was Experimental group which was taught through non-digital games. Both groups were participated in mathematics achievement test included pre-test and Posttest after the intervention.

Researcher utilized Lesson plans for instruction. This study consisted of two months. Four chapters included of text book. Researcher conducted pretest included major topic addition, subtraction, multiplication and division and fraction then record the obtaining marks of students. Then after pretest researcher randomly divided students in two groups without considering their result of pre -test performance. Then implement of Non-digital Adaptive Math games which include different games for example Place Value Bingo .Number Pyramid Challenge Roll and Build etc. These games are designed by using materials including charts, dice, and flash cards etc.

Teacher designed three games for each topic according to students' diverse needs. For teaching the content of book including topics of chapters Number Operations and Fraction within the given time frame. After intervention of Non- Digital Games researcher took post-test which follow similar content like Pre-test and then record obtaining marks of this test. After that researcher compared the marks of both test in order to check mathematics achievement.

During the intervention, clear rules were followed to ensure that the use of non-digital adaptive math games remained purposeful and fair. Each game was selected to address a specific learning objective from the Grade 3 curriculum, and instructions were explained briefly and demonstrated before play began. Students were organized in mixed-ability groups so that both high- and low-achievers could participate and learn from each other. Every child was given an equal chance to take turns, while the teacher maintained a neutral role as facilitator rather than helper to any one group. The same content as in the textbook was used, but the level of challenge was adjusted according to students' needs to keep the activity adaptive. Sessions were kept short about 10–15 minutes to maintain focus and leave time for follow-up discussion. All games had clear scoring rules and used safe, low-cost materials such as dice, flashcards, charts, and puzzles, which were collected after use. At the end of each activity, students reflected briefly on the strategy they used and the concept they practiced, linking the play back to the mathematics lesson.

Table 3.1

Extraneous Variables and Control Strategies

Extraneous Variable	Description	Control Strategy Used
Prior Knowledge of Students	Differences in students' understanding before intervention	Administered pre-test to both groups and ensured random assignment regardless of pre-test scores
Teacher Bias or Influence	Variations in delivery style, tone, or assistance	Same teacher conducted both experimental and control sessions to ensure consistency
Instructional Time	Unequal time devoted to experimental and control groups	Equal class duration of 40 minutes per day for both groups over 32 working days
Content Difference	Variation in the curriculum or material taught	Same lesson content and curriculum used for both groups
Student Grouping Bias	Natural ability levels unevenly distributed	Random assignment of students to experimental and control groups
Environmental Factors	Classroom setting or resources affecting learning	Same school, similar classroom settings, and physical conditions used for both groups
Testing Effect	Learning or fatigue from repeated testing	Conducted pre-test and post-test with same structure and content topics
Maturation Effect	Natural improvement due to time or age, not the intervention	Short intervention period (8 weeks) and inclusion of control group helped isolate effect
History Effect	External events (holidays, vacations) during the study impacting results	Excluded public holidays and Eid vacations from working days; both groups affected equally

3.2 Procedure of the Study

This research study consisted on 8 weeks. There was 40 minutes class duration for each group. The study started from 12 March till 7 May 2025. There were total 5 days classes from Monday to Friday by excluding the Eid vacations and public holidays including 1st May labour- day and on 7 May Schools were off due to India Pakistan conflict. The intervention time was consisted on 2 months for both groups. To implement non-digital adaptive math games in a classroom with students of varying abilities, there teacher started each day topic by first brief discussion with students related to the topic in order to know about their previous knowledge and understanding related to the topic then assigned games according to their understanding level. Based on the result of diagnostic test students grouped as low, medium, and high achievers. For daily topic teacher designed three games relevant to the topic based according to different understanding level of students, the teacher selects and prepare three adaptive games of varying difficulty levels such as ,Place Value Bingo (Average) Number Pyramid Challenge (High) Roll and Build During for covering topic of place value. The teacher briefly explained concept and explain the rules of the games. Students then engaged in their assigned games, with low achievers working on simple tasks like using counters or number lines, medium achievers solving moderate problems using bingo or puzzles, and high achievers tackling more complex challenges like multi-digit operations or word problems. The teacher facilitates and monitors the activity, ensuring each student remains engaged and receives support as needed. At the end of the session, a brief quiz or reflective discussion conducted in order to assess understanding and gather feedback. A retention test conducted after 3 weeks of the post-test to measure how well students retain mathematical concepts. The same test be given to both the control and experimental groups, and their scores compared to assess long-term learning.

Working-day count (12 March → 7 May 2025)

Monday–Friday timetable by excluding these days:

- 31 Mar – 4 Apr off for Eid
- 1 May off for Labor Day
- 7 May off for public holiday

- 1 day for Pre-test (before teaching starts)
- 1 day for Post-test (after teaching ends)
- Intervention duration 2 months
- Retention test date (after 3 weeks): Wednesday, 27 May 20

Table 3.2

Week Wise Implementation Plan

Week	Focus Topics (Aligned with Curriculum)	Adaptive Math Games (High / Average / Low)	Materials Used	Sessions per Week	Remarks
Week 1	Roman Numbers	1. Roman Race (All Levels) 2. Roman Puzzle Challenge (High) 3. Match the Value Cards (Average/Low)	Flashcards, Place value charts, number wheels, dice	4	Concept intro, oral activities
Week 3	Comparing & Ordering Numbers	1. Number Mountain Race (High) 2. Number Line Hopscotch (Average) 3. Greater Gator Cards (Low)	Number strips, arrows, symbol cards	4	Individual and peer games for ordering, visualizing numbers
Week 4	Addition (with/without carrying), mental drills	1. Addition Relay (High) 2. Fast Fingers (Average) 3. Dice Sum Race (Low)	Dice, addition puzzles, beads, flashcards	4	Flashcard races, mental drills
Week 5	Addition/Subtraction (Real-life problems, with/without carrying)	1. Math Market Role Play (All Levels) 2. Subtraction Spin & Solve (Average) 3. Missing Amount Match (Low) 4. Challenge Cart (High)	Real-life role-play games, pictorial worksheets, tokens, boards	3	1 session skipped due to Eid
Week 6	Subtraction (Real-life problems, mental subtraction)	1. Quick Think Subtract (High) 2. Subtraction Card Challenge (Average) 3.	Flashcards, spinners, pictorial story cards	4	Peer learning, real-life visuals

Week	Focus Topics (Aligned with Curriculum)	Adaptive Math Games (High / Average / Low)	Materials Used	Sessions per Week	Remarks
		Money Match Game (Low)			
Week 7	Division (2-digit ÷ 1-digit), mental strategies	1. Division Dash Challenge (High) 2. Divide & Conquer Board Game (Average) 3. Token Share Out (Low)	Division wheels, number grids, token boards	4	Timed quizzes, group board games
Week 8	Post-Test (covering all topics)	—	Mixed materials from all previous weeks	1	MCQ-based test paper; 1 session off (Labor Day)
Week 11	Retention Test	—	Same as post-test	1	Instructional session not conducted

3.3 Population and Sample

The population of the study consisted of grade 3 students of 12 registered private schools of G-11 sector according to Private Educational Institutions Regulatory Authority Statistical overview (Private Educational Institutions Regulatory Authority). The sample was consisted of 50 students of grade 3 of Islamabad Grammar School G-11 campus. Sample was selected using Purposive sampling technique. Purposive sampling was chosen for feasibility and access (the school granted permission and had the required Grade 3 students); random assignment after pre-test then ensured comparable experimental and control groups.

3.4 Instrument

3.4.1 Self-Developed Achievement Test

These tests were used to assess students' mathematics achievement before and after the intervention. There were 20 Mcqs and each carry 1 mark. Time duration of 1 hour is given to attempt these tests. Pre-test conducted before intervention and Post-test after the intervention. Both tests taken from both groups. Test covered the topics of Chapter#1 Numbers Operations and Chapter#2 Fraction. The comparison of pre-test and post-test results helped determine the effectiveness of the non-digital adaptive math games on student’s academic achievement in mathematics at primary level. The same test was also conducted as a retention test, 3 weeks after the post-test to measure the sustained effect of non-digital math games on student's academic achievement at primary level.

3.5 Procedure (Validity, Pilot Testing and Reliability)

3.5.1 Validity

The instrument validation process included expert reviews by the specialists of the subject of the mathematics. Researcher validate her tool from two teachers of IIUI Education Faculty and three teachers including two teachers of the subject and from head of school where researcher conducted her experiment. Expert feedback was incorporated to refine the instruments, ensuring content validity.

3.5.2 Reliability

Reliability of instrument was checked by Split half method. To ensure the internal consistency of the self-developed mathematics achievement test, the split-half reliability method was employed. The test items were divided into two equal halves, consisting of odd- and even-numbered items, to create parallel forms. The scores obtained from both halves were then correlated. The Spearman-Brown prophecy formula was applied to adjust the split-half correlation and estimate the reliability of the full test. The analysis was conducted using SPSS (Statistical Package for the Social Sciences). The obtained Spearman-Brown coefficient indicated a satisfactory level of internal consistency, confirming that the instrument was reliable for measuring the mathematics achievement of Grade 3 students.

Table 3.5.2

Split-Half Reliability Result for the Achievement test

Cronbach's Alpha	Part 1	Value	0.782
	Part 1		10[a]
	Value		0.763
	Par 2		10[b]
	Total N of Items		20
Correlation Between Forms			0.881
Spearman-Brown Coefficient	Equal Length		0.937
	Unequal Length		0.937
Guttman Split-Half Coefficient			0.912

The split-half reliability of the instrument was analyzed using SPSS. The 20-item mathematics achievement test was divided into two equal halves:

Part 1 (first 10 items) yielded a Cronbach's Alpha of 0.782, indicating satisfactory internal consistency within this subset.

Part 2 (last 10 items) showed a Cronbach's Alpha of 0.763, also reflecting acceptable internal consistency.

The correlation between the two forms was r = 0.881, indicating a strong positive relationship between the two halves of the instrument. Furthermore, the Spearman Brown Coefficient for both equal and unequal lengths was 0.937, and the Guttman Split-Half Coefficient was 0.912. These values suggest that, despite some variation within the individual halves, the overall test describes high reliability. Therefore, the instrument is considered suitable for assessing mathematics achievement among primary-level students.

3.5.3 Pilot Testing

A pilot test was conducted with Grade 3 students of G-9 Campus before the actual data collection began. For the pilot testing of the achievement test, a group of 10 students was selected from another campus of the same private school. These students were not part of the study population (N = 50) and were not included in either the experimental or control groups. This pilot study helped the researcher to check whether the test items were clear, appropriate, and understandable for the students. It also allowed the researcher to identify any confusing questions or mistakes in the test. Based on the pilot results, necessary adjustments were made to improve the test. The result of the pilot test confirmed that the instrument was suitable and worked as intended to measure students' mathematics achievement.

3.6 Data Collection

Data were collected through the Pre and Pre-Post achievement Test. Data were collected during regular school hours in participating schools. Teacher recorded student's achievement through their obtaining marks in tests and quizzes and in classroom activities and through retention test.

3.7 Data Analysis

The data were analyzed using both descriptive and inferential statistics, Descriptive statistics (mean and standard deviation) were used to overall summarize the data, provided a description of student's academic achievement in mathematics. Inferential statistics included an independent sample t-test which as conducted to compare the mathematics achievement between the control and experimental groups. The analysis also included the calculation of effect sizes to measure the strength of the differences between the groups. Additionally, the retention test results were compared between the experimental and control groups using an independent samples t-test to determine the effectiveness non-digital adaptive math games on student's academic achievement.

3.8 Ethical Consideration

The study followed the ethical standards as permission from school authorities was taken for conducting this research. Researcher informed school's principal about this study before conducting this research. To minimize any form of risk, all research activities including the intervention and assessments were carefully designed to be age appropriate, non-disruptive, and respectful of students' emotional and psychological comfort. Steps were also taken to ensure that the learning environment remained supportive and inclusive throughout the research process. Approval from relevant school authorities was obtained, and all procedures were carried out in line with institutional guidelines for ethical research in educational settings.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATIONS

This chapter presents a comprehensive analysis and interpretation of data collected from both experimental and control groups to find the effect of non-digital adaptive math games on primary-level students' mathematics achievement. The main objective of the study was to examine shifts in performance before and after the intervention and to compare outcomes between groups. Researcher begin with descriptive statistics using mean scores and standard deviations to reveal patterns and variability in pre-test and post-test results. Then researcher employ inferential statistical methods, including t-tests, to assess whether observed change and group differences are statistically significant. Metrics such as standard error of the mean were also calculated. All analyses were performed using SPSS software. This structured approach ensures a thorough evaluation of how non-digital adaptive math games effect primary students' academic achievement.

4.1 Descriptive Techniques Used for Data Analysis

Descriptive statistics were used to summarize the performance of students from both the experimental and control groups in pre-tests, post-tests, and retention tests. The focus was to understand the average performance (mean) and the variability (standard deviation) of scores in each group.

Table 4.1

Descriptive Statistics

	N	Min	Maximum	Mean	Std. Deviation
Pre-Test Score (10–15)	50	9	15 12.38		
Post-Test Score	50	12	20	16.34	2.438
Difference (Post -Pre)	50	1	12	4.34	2.496
Valid N (listwise)					

The sample of 50 primary-level students demonstrated an increase in mathematics achievement following the non-digital adaptive math game intervention.

On the pretest, scores ranged from 9 to 15, with a mean of M=12.38M = 12.38M=12.38 and a standard deviation of SD=1.68SD = 1.68SD=1.68. Posttest scores ranged from 12 to 20, with a mean of M=16.34M = 16.34M=16.34 and SD=2.44SD = 2.44SD=2.44. The mean gain score (posttest minus pretest) was M=4.34M = 4.34M=4.34 (SD = 2.50), indicating an average improvement of approximately 4.3 points. These descriptive statistics suggest a marked positive shift in student performance following the intervention.

4.2 Post Test Score Analysis

Table 4.2

Post-Test Scores (Group Wise)

	Mean	N	Std. Deviation	Std. Error Mean
Experimental Group	17.84	25	1.748	.350
Control Group	14.84	25	2.095	.419

The independent-samples t-test comparing post-test scores between the experimental (M = 17.84, SD = 1.75, n = 25) and control (M = 14.84, SD = 2.10, n = 25) groups indicates that students who engaged with non-digital adaptive math games scored approximately 3 points higher on average. The smaller variability (SD) and lower standard error in the experimental group (0.35 vs. 0.42) suggest more consistent and reliable performance. Given the substantial mean difference relative to the pooled standard error, this result is highly meaningful positive effect on primary students' mathematics achievement.

4.3 T-Test

Table 4.3

Independent Samples Test

	Levene's Test for Equality Variances		t test for Equality of means							
					Significance				**95%Confidence Interval**	
	F	Sig.	t	df	One-Sided p	Two Sided p	Mean	Std.Erro	Lower	Higher
Equal variances assumed	1.609	.211	5.497	48	<.001	<.001	3.000	.546	1.903	444.097
Equal variances not assumed			5.497	46.509	<.001	<.001	3.000	.546	1.902	4.098

The independent samples t-test showed a statistically significant difference in post-test scores between the two groups, $t(48) = 5.497$, $p < .001$. The mean difference was 3.000, with a standard error of 0.546, and a 95% confidence interval ranging from 1.903 to 444.097. This large upper bound likely indicates a reporting error (e.g., a misplaced decimal or formatting issue), as typical CI ranges for such results would not exceed 5.Assuming the upper bound should reasonably be close to 4.097, these results suggest that the experimental intervention had a significant and positive effect on students' post-test performance compared to the control group.

4.4 Effect Size Analysis

Table 4.4

Analysis of Effect Size Score

		Standardizer a	Point Estimate	95%Confidence Interval	
				Lower	Upper
Post-Test Score	Cohen's d	1.930	1.555	.913	2.184
	Hedges' correction	1.960	1.530	.899	2.149
	Glass's delta	2.095	1.432	.737	2.107

The effect size analysis for the post-test scores reveals a very large and practically significant difference between the experimental and control groups. According to Table 4.2.5, Cohen's d is 1.930, with a 95% confidence interval ranging from 0.913 to 2.184, indicating a strong treatment effect well beyond conventional thresholds (where d = 0.8 is considered large). The Hedges' correction, which adjusts for small sample bias, yields a similar estimate (1.960), reinforcing the robustness of the effect. Furthermore, Glass's delta, which uses the standard deviation of the control group as the denominator, is 2.095, further supporting the conclusion that the experimental group outperformed the control group by a substantial margin. All confidence intervals are well above 0, confirming statistical significance. Collectively, these results provide compelling evidence that the non-digital adaptive math games had a large and meaningful positive impact on students' post-test performance.

4.5 Retention Test

Table 4.5

Retention Test Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-Test Score	50	10	15	12.66	1.560
Post-Test Score	50	11	20	14.96	2.321
Retention Score	50	8	19	13.74	3.089
Valid N (listwise)	50				

The descriptive statistics for the 50 students reveal a measurable improvement in mathematics achievement following the intervention. The pre-test scores ranged from 10 to 15 (M = 12.66, SD = 1.56), indicating moderate baseline performance. After the intervention, post-test scores increased, ranging from 11 to 20 (M = 14.96, SD = 2.32), demonstrating overall growth. Retention scores, administered after a follow-up period, ranged from 8 to 19 (M = 13.74, SD = 3.09), reflecting sustained gains. The increases from pre-test to post-test (mean gain ~2.30 points) and moderate retention mean suggest that the non-digital adaptive math games had both immediate and lasting positive effects on students' mathematical achievement.

Table 4.6

Comparison of Retention Test Score Group Wise

	Std. Error Mean Groups	N	Mean	Std. Deviation	
Retention Score	Exp	25	16.24	1.739	.348
	Ctrl	25	11.24	1.855	.371

An independent-samples *t*-test was conducted to compare retention scores between the experimental group (students who played non-digital adaptive math games) and the control group. Descriptive statistics showed that the experimental group (n = 25) had a mean retention score of *M* = 16.24 (*SD* = 1.74), while the control group (n = 25) scored *M* = 11.24 (*SD* = 1.86). The standard errors were .348 and .371, respectively, indicating precise estimates of group means. These results suggest that participation in the adaptive math games led to substantially higher retention of mathematics knowledge compared to traditional instruction.

An independent-samples *t*-test was conducted to evaluate differences in retention scores between the experimental and control groups. The mean difference was 5.00 points, with a standard error of the difference of .51. The 95% confidence interval for this difference ranged from 3.98 to 6.02, indicating that we can be 95% confident the true mean difference lies within this interval. Because the interval does not include zero, this difference is statistically significant ($p < .001$), supporting the conclusion that students using non-digital adaptive math games retained significantly more mathematics knowledge than those in the control group.

Table 4.7

Effect Size of Retention Test Score

		Standardizer[a]	Point Estimate	Confidence interval Lower	Upper
Retention Score	Cohen's d	1.798	2.781	1.990	3.55
	Hedges' correction	1.826	2.738	1.958	3.502
	Glass's delta 855	1.	2.696	1.747	

Standardized effect size analyses demonstrated extremely large and educationally meaningful gains for the experimental group compared to the control group. Cohen's d was 1.798 (95% CI [1.990, 3.558]), well above the threshold for a large effect ($d > 0.80$), indicating nearly two pooled standard deviations of improvement Hedges' g, which adjusts for small sample bias, yielded a similar result ($g = 1.826$, 95% CI [1.958, 3.502]). Glass's Δ, calculated using the control group's standard deviation, was 1.855 (95% CI [1.747, 3.625]), confirming that the findings are robust irrespective of variance assumptions. Collectively, these effect sizes affirm that the non-digital adaptive math game intervention had a substantial and practically significant effect on students retained mathematical knowledge.

CHAPTER 5

SUMMARY, FINDINGS, DICUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

This study investigated the effect of Non-Digital Adaptive Math Games on the mathematics achievement of Grade 3 students in a private school in Islamabad. A true experimental design was employed, involving 50 randomly selected students**,** who were divided equally into an experimental group and a control group. The experimental group was taught mathematics through adaptive games such as dice games, flashcards, puzzles, matching activities, and board/chart games**,** while the control group was taught using traditional methods including lectures, note-taking, and textbook exercises. The study focused on key mathematical topics aligned with the Grade 3 curriculum, including Roman numbers, comparing and ordering numbers, addition, subtraction, and division**.** A structured week-wise implementation plan was followed over 2 months intervention period, excluding holidays. Both groups were pre-tested to ensure equivalence at the start, and the intervention was carried out with equal instructional time and content to maintain internal validity.

Data were collected through) achievement tests (pre-test, post-test, and retention test developed by the researcher. Quantitative data were analyzed using descriptive statistics (mean, standard deviation) and inferential statistics including independent samples t-test to compare the performance of groups, and Cohen's d to calculate the effect size. The analysis chapter presented the results of pre-tests, which confirmed that the experimental and control groups started at a nearly equivalent level**.**

5.2 Findings

The findings of the study were as follows:

1. The pre-test scores of both the experimental and control groups were nearly the same, with an average score of 12.38. This showed that both groups began at a similar academic level.
2. After the use of non-digital adaptive math games in the experimental group, the result of the study showed that average post-test score increased

to 17.84, while the control group scored 14.84. The difference was statistically significant ($p < .001$), showing a positive effect of the intervention on students' mathematics achievement.

3. With the reference of results of the study the experimental group showed more consistent performance, this suggests that students in the experimental group improved in a more uniform way.
4. As the results of the study showed that the average improvement in scores (post-test minus pre-test) for all students was 4.34 points. The progress was better in the experimental group compared to the control group.
5. Statistical analysis, including Levene's test ($p = .211$) and t-test results, confirmed that the observed differences were statistically meaningful and not due to random chance.
6. Effect size analysis indicated that the effect of the intervention was positive according to common standards used in educational research.
7. With reference to the retention test score, the experimental group had an average score of 16.24, while the control group scored 11.24. The difference of 5 points shows that students who used the adaptive games retained the concepts better over time.
8. Retention test results were further supported by effect size values (Cohen's $d = 1.80$, Hedges' $g = 1.83$, Glass's $\Delta = 1.86$), which show that students continued to benefit from the learning approach after the intervention ended.
9. As the result showed that the confidence intervals for both the post-test and retention test results did not include zero, which confirms the reliability of the findings and their potential to be applied to similar student groups.
10. The results indicated that non-digital adaptive math games may support students in understanding and retaining mathematical concepts effectively at the primary level.
11. Since both post-test and retention results show statistically significant higher achievement for the experimental group so on the bases of result the Null Hypothesis (H_0) is rejected. The Alternative Hypothesis (H_1) is accepted that Non-digital adaptive math games had a significant positive effect on mathematics achievement and retention.

5.3 Discussion

The study was conducted to highlight the Effect of non-digital adaptive math games on student's academic achievement at primary level. The researcher utilized true experiment research design. The population of the study consisted of grade 3 students of 12 registered private schools of G-11 sector on 1st July, 2025 according to Private Educational Institutions Regulatory Authority Statistical overview. The 50 students of grade 3 from Islamabad Grammar School G-11 campus were the sample. Sample was selected using Purposive sampling technique.

Researcher utilized self-developed pre-test, post-test and Retention test in order to know about students previous, after intervention and long-term knowledge and understanding related to the mathematics topics. There were two group one was control and other was experimental group. Experimental group was taught through non-digital adaptive math games and control group was taught through traditional method including lecture and direct method. Researcher used identical lesson plans, equal time, and standardized scoring for both groups**,** changing only the teaching method, so the difference in results came from the intervention, not from bias. Data were analyzed through SPSS. These findings highlights that non-digital adaptive math games are an effective instructional way for improving both short-term achievement and long-term retention in mathematics among primary school students. This supports previous educational research emphasizing the benefits of active learning and immediate feedback in elementary mathematics instruction.

While the results are promising, limitations include the relatively small sample size and single-grade cohort, which restrict generalizability. Additionally, the retention follow-up occurred shortly after intervention; longer-term follow-up would better assess the durability of learning gains. The current study explored the impact of non-digital adaptive math games on mathematics achievement and retention among Grade 3 students Both groups were equivalent at baseline ($M \approx 12.4$), and instructional content remained consistent, with the only variable being the teaching method. The experimental group, which engaged in adaptive tabletop math games, showed significantly higher post-test performance ($M = 17.84$) compared to the control group ($M = 14.84$), with a large effect size (Cohen's $d = 1.93$).

These results are consistent with the findings of Offenholley (2012), who emphasized the power of game-based learning to engage mathematical thinking, and Naik (2014), who demonstrated that non-digital games promote engagement and deep learning in mathematics education. Furthermore, Randel, Morris, Wetzel, and Whitehill (1992) also found that games lead to better learning outcomes when closely aligned with curricular content, as was done in this study.

Retention results were equally strong, with the experimental group scoring significantly higher four weeks after the intervention (M = 16.24 vs. M = 11.24, Cohen's d = 1.80). This finding echoes Bottino (2004), who reported that interactive, game-based approaches support long-term memory in mathematics. From a theoretical standpoint, the adaptive nature of the games aligns with Vygotsky's (1978) theory of the Zone of Proximal Development, as students worked at their own level with challenges adjusted in real-time. This approach is also supported by constructivist learning theory (Jonassen & Land, 2000), which emphasizes active, hands-on engagement. Additionally, motivational models like Keller's (1987) ARCS framework explain how the games improved attention, relevance, confidence, and satisfaction, likely enhancing both achievement and retention. Although past research such as Ke (2008) and Gee (2003) focused on digital games, this study shows that similar cognitive and motivational benefits can be achieved with non-digital formats making it more feasible for low-resource educational settings. A 2024 systematic review highlights that non-digital games are frequently used by teachers in primary mathematics classrooms and have positive outcomes across number and operations topics (Arora & Saxena, 2024).

Educator surveys conducted in the same year found that primary teachers prefer non-digital games over digital versions because they promote collaboration, facilitate the use of manipulatives, and are easier to assess and adapt in real time (Martin et al., 2024; Mullis & Papadakis 2024). Additionally, recent empirical comparisons show non-digital games often yield larger learning gains than digital games in primary school mathematics (Nagoor & Ozdogan, 2024; Raja et al., 2024). Despite these promising outcomes, limitations such as a small sample size, single-grade focus, and limited retention period should be addressed in future studies. Still, this study provides strong evidence that non-digital adaptive math games can meaningfully enhance student performance and offer a cost-effective, scalable strategy for improving primary-level mathematics education.

5.4 Conclusions

This study aimed to investigate the Effect of Non-Digital Adaptive Math Games on the mathematics achievement of Grade 3 students. The results of the study provided evidence supporting the effectiveness of this game-based method in improving mathematics achievement at primary level.

Following were the conclusions made by aligning with each objective of the study:

1. The results of the study showed that non-digital adaptive math games may have significant positive effect on the mathematics achievement of grade 3 students. The findings results showed that the post-test scores of the experimental group were significantly higher than those of the control group, demonstrating that students taught using Non-Digital Adaptive Math Games showed improved mathematical performance compared to those taught using traditional methods. Concluded that Non-Digital Adaptive Math Games had significant effect on students' mathematics achievement.
2. By aligning with objective 2 study concluded that the results of the post-test showed that students who participated in game-based instruction performed better than those who received traditional teaching, confirming that this method may enhance academic achievement in mathematics, Finding 2 support this statement as the result show that an independent sample t-test revealed a statistically significant difference in achievement scores between the two groups in favor of the experimental group. Conclusion of this objectives highlighted that students taught through adaptive games performed better than control group.
3. By considering the third objective of the results of the study demonstrated that this game-based method focus both short-term and long- term learning outcomes. As the results of this study highlighted the aspect of utilizing non-digital adaptive math games into daily instruction as an effective, interactive way for improving the primary-level mathematics achievement and helping students retain what they learn. The result of Finding 3 support as the results of study represented that three weeks after the intervention, the retention test scores of the experimental group remained higher than those of the control group. The difference was statistically significant,

and the effect size was still large, indicating better long-term retention of mathematical concepts. The adaptive game-based approach supported long-term learning and retention more effectively than the lecture- based method.

By concluding the study on the basis of objectives of the study as the results of the study showed that non-digital adaptive math games may have significant positive effect on the mathematics achievement of grade 3 students. Also the results of the posttest showed that students who participated in game-based instruction performed better than those who received traditional teaching, confirming that this method may enhance learning outcomes. By considering the third objective of the study results of the study demonstrated that this game-based method focus both short-term and long-term learning outcomes. As the results of this study highlighted the aspect of utilizing non-digital adaptive math games into daily instruction as an effective, interactive way for improving the primary-level mathematics achievement and helping students retain what they learn.

5.5 Recommendations

1. Based on Conclusion 1 which indicated that non-digital adaptive math games may have significant positive effect on the mathematics achievement of grade 3 students. Mathematics teachers may replace at least two routine practice exercises per week with adaptive non-digital games (e.g., Dice Sum Race, Flashcard Bingo).
2. Based on Conclusion 2 which confirmed that the results of the post-test showed that students who participated in game-based instruction performed better than those who received traditional teaching, It is recommended that schools may schedule a weekly Math Game Revision Session of 20 minutes where students play adaptive games as reinforcement after each unit.
3. Based on Conclusion 3 which revealed that this game-based method focus both short-term and long- term learning outcomes. Educational institutions may prepare and distribute a low-cost “Math Game Toolkit” (flashcards, dice, charts, puzzles) for classroom use.
4. Based on overall conclusion of the study teacher training workshops may include practical modules on how to modify games into three levels (easy, medium, hard) so both low and high achievers benefit equally.

5. Based on Conclusion, Schools may provide parents with a monthly activity sheet of simple adaptive math games e.g., card fraction games and dice subtraction races etc for 10–15 minute home sessions with children.

5.6 Recommendations for the Future Studies

Following recommendations were designed for future researchers:

1. As study involved 50 Grade 3 students from one private school. Future research may explore study with larger samples across multiple schools (government and private) for broader generalizability.
2. As researcher focused only Grade 3, future research may apply non-digital adaptive games in Grades 2–5 and on other topics (fractions, multiplication, geometry) to explore subject-wide effectiveness.
3. Researcher took retention test only after three weeks. Future research may conduct retention test at longer intervals (e.g., three and six months) to assess long-term effect.
4. Researcher only utilized quantitative methods future research may collect qualitative data (teacher point of view classroom observations, student interviews) to understand how teachers adapt games and how students experience this instruction method.

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APPENDICES

7.1 Appendix-A Lesson Plans for Control Group (Traditional Method)

Lesson Plan 1

Objective

Students will review place value concepts up to 1,000 and understand the basic operations overview.

Materials

Place value chart, number cards, whiteboard, markers.

Lesson Plan

Time	Activity	Details
5 min	Warm-Up	Quick oral counting by 10s and 100s to 1,000.
10 min	Concept Input	Review place value chart (hundreds, tens, ones).
15 min	Guided Practice	Solve place value questions orally and in writing. Students write numbers in expanded form and compare numbers.
7 min	Independent Practice	Students solve place value exercises individually to reinforce learning.
3 min	Closure & Assessment	Ask 3 students to explain place value; short oral quiz question.

Lesson Plan 2

Day 2: Addition of Two-Digit Numbers without Regrouping

Objective

Students will be able to add two-digit numbers without carrying.

Materials

Flashcards, whiteboard, pencils, notebooks.

Time	Activity	Details
5 min	Warm-Up	Oral addition of single-digit numbers.
8 min	Concept Input	Addition of two-digit numbers without regrouping on the board.
15 min	Guided Practice	Solve five addition problems together step by step.
9 min	Independent Practice	Students solve five problems individually in their notebooks.
3 min	Closure & Assessment	Correct errors, and ask two students to explain their solutions.

Lesson Plan 3

Day 3 Addition of Two-Digit Numbers with Regrouping

Objective:

Add two-digit numbers with regrouping.

Materials:

Place value charts, flashcards, notebooks.

Time	**Activity**	**Details**
5 min	Warm-up	Quick review of addition without regrouping.
10 min	Concept Input	Demonstrate regrouping (carrying) in addition.
15 min	Guided Practice	Teacher models 5 regrouping problems.
7 min	Independent Practice	Students try 5 regrouping problems independently.
3 min	Closure & Assessment	Review; clarify misconceptions.

Lesson Plan 4

Day 4: Subtraction of Two-Digit Numbers without Borrowing

Objective

Students will be able to subtract two-digit numbers without regrouping.

Materials

Number lines, whiteboard, flashcards.

Activity	Details
Warm-Up	Count backward by 1s from 50.
Concept Input	Teac models subtraction without borrowing using a number line.
Guided Practice	Solve subtraction problems together on the board.
Practice	Students solve subtraction problems individually in their notebooks.
Assessment	Review answers and discuss common errors.

Lesson Plan 5

Day 5: Subtraction of Two-Digit Numbers with Borrowing

Objective

Students will be able to subtract two-digit numbers with borrowing (regrouping).

Materials

Place value charts, subtraction flashcards.

Time	Activity	Details
5 min	Warm-Up	Oral review of basic subtraction facts.
10 min	Concept Input	Teacher demonstrates subtraction with borrowing using place value charts.
15 min	Guided Practice	Solve regrouping subtraction problems together as a class.
7 min	Independent Practice	Students solve five subtraction problems with borrowing in notebooks.
3 min	Closure Assessment	Summarize steps, review key points, and answer students' questions.

Lesson Plan 6

Day 6: Addition of Three-Digit Numbers without Regrouping

Objective:

Add three-digit numbers without regrouping.

Materials:

Place value charts, whiteboard, notebooks.

Time	Activity	Details
5 min	Warm-up	Count by hundreds aloud (100, 200, 300...).
10 min	Concept Input	Model 3-digit addition without regrouping.

15 min	Guided Practice	Solve 3-digit addition problems together.
7 min	Independent Practice	Students solve 5 problems independently.
3 min	Closure & Assessment	Review answers and check for understanding.

Lesson Plan 7

Day 7: Addition of Three-Digit Numbers with Regrouping

Add three-digit numbers with regrouping.

Materials:

Base-ten blocks, whiteboard.

Time	Activity	Details
5 min	Warm-up	Review addition without regrouping.
10 min	Concept Input	Demonstrate regrouping with 3-digit numbers.
15 min	Guided Practice	Solve regrouping problems as a class.
7 min	Independent Practice	Solve regrouping addition problems independently.
3 min	Closure & Assessment	Summarize regrouping steps; clear doubts.

Lesson Plan 8

Day 8: Subtraction of Three-Digit Numbers without Borrowing

Objective

Students will be able to subtract three-digit numbers without regrouping.

Materials

Number lines, subtraction worksheets.

Time	Activity	Details
5 min	Warm-Up	Count backward by hundreds (e.g., 100, 200, 300…).
8 min	Concept Input	Teacher models subtraction of three-digit numbers without borrowing using a number line.
15 min	Guided Practice	Solve subtraction problems together as a class.
9 min	Independent Practice	Students solve subtraction problems independently on worksheets.
3 min	Closure Assessment	Review answers, explain mistakes, and reinforce correct steps.

Lesson Plan 9

Day 9: Subtraction of Three-Digit Numbers with Borrowing

Objective:

Subtract three-digit numbers with borrowing.

Materials:

Base-ten blocks, whiteboard.

Time	Activity	Details
5 min	Warm-up	Oral subtraction facts.
10 min	Concept Input	Demonstrate borrowing in 3-digit subtraction.
15 min	Guided Practice	Solve problems with borrowing together.
7 min	Independent Practice	Students solve 5 problems with borrowing.
3 min	Closure & Assessment	Summarize regrouping steps; clear doubts.

Lesson Plan 10

Day 10: Introduction to Fractions – Understanding Halves and Quarters

Understand halves and quarters using shapes and objects.

Materials:

Paper shapes (circles, squares), scissors, fraction charts.

Time	Activity	Details
5 min	Warm-up	Discuss everyday examples of halves and quarters.
10 min	Concept Input	Show how to fold shapes into halves and quarters.
15 min	Guided Practice	Students fold and color halves/quarters on paper.
7 min	Independent Practice	Draw and label halves and quarters on worksheet.
3 min	Closure & Assessment	Ask students to explain halves and quarters orally

Lesson Plan 11

Day 11: Fractions as Parts of a Whole

Identify fractions as parts of a whole.

Materials:

Pie charts, fraction cards, flashcards.

Time	Activity	Details
5 min	Warm-up	Recap halves and quarters orally.
10 min	Concept Input	Show different fractions using pie charts.
15 min	Guided Practice	Match fraction cards to visual representations.
7 min	Independent Practice	Complete fraction matching worksheet.
3 min	Closure & Assessment	Quiz: Name the fraction shown in a picture.

Lesson Plan 12

Day 12: Equivalent Fractions

Objective:

Understand and identify equivalent fractions.

Materials:

Fraction strips, charts, worksheets.

Time	Activity	Details
5 min	Warm-up	Review fractions learned so far.
10 min	Concept Input	Demonstrate equivalent fractions using fraction strips.
15 min	Guided Practice	Identify and color equivalent fractions on strips.
7 min	Independent Practice	Worksheet on equivalent fractions.
3 min	Closure & Assessment	Oral Q&A on equivalent fractions.

Lesson Plan 13

Day 13: Comparing Fractions

Objective: Compare simple fractions and identify which is greater.

Materials:

Fraction strips, number lines, flashcards.

Time	Activity	Details
5 min	Warm-up	Review equivalent fractions.
10 min	Concept Input	Model comparing fractions using fraction strips.
15 min	Guided Practice	Compare fraction pairs together.
7 min	Independent Practice	Solve comparison worksheet.
3 min	Closure & Assessment	Ask 3 students to explain comparisons orally.

Lesson Plan 14

Day 14: Addition of Fractions with Same Denominator

Objective

Students will be able to add fractions with the same denominator.

Materials

Fraction charts, paper strips, flashcards.

Time	**Activity**	**Details**
5 min	Warm-Up	Recap comparing fractions.
10 min	Concept Input	Demonstrate adding fractions with the same denominator using visual aids.
15 min	Guided Practice	Add fractions together using paper strips.
7 min	Independent Practice	Students complete a worksheet on adding fractions with the same denominator.
3 min	Closure Assessment	Review answers and clarify misconceptions.

Lesson Plan 15

Day 15: Subtraction of Fractions with Same Denominator

Objective:

Subtract fractions with the same denominator.

Materials:

Fraction strips, whiteboard.

Time	**Activity**	**Details**
5 min	Warm-up	Quick review of adding fractions.
10min	Concept Input	Demonstrate subtraction of fractions with same denominator..
15min	Guided Practice	Solve subtraction problems as a class
7 min	Independent Practice	Worksheet on subtraction of fractions.
3 min	Closure & Assessment	Ask 2 students to explain steps or

Lesson Plan 16

Day 16: Introduction to Mixed Numbers

Objective:

Understand mixed numbers and convert improper fractions.

Materials:

Fraction charts, flashcards, paper strips.

Time	**Activity**	**Details**
5 min	Warm-up	Review fraction addition/subtraction.
10 min	Concept Input	Explain mixed numbers and improper fractions.
15 min	Guided Practice	Convert improper fractions to mixed numbers.
7 min	Independent Practice	Worksheet practice on mixed numbers.
3 min	Closure & Assessment	Review key concepts orally.

Lesson Plan 17

Day 17: Multiplication and Division Review

Review multiplication and division facts.

Materials:

Flashcards, whiteboard.

Time	**Activity**	**Details**
5 min	Warm-up	Oral multiplication tables (2, 5, 10).
10 min	Concept Input	Quick review of division as sharing.
15 min	Guided Practice	Solve multiplication and division problems together.
7 min	Independent Practice	Worksheet on multiplication and division.
3 min	Closure & Assessment	Quick quiz on multiplication/division facts.

Lesson Plan 18

Day 18: Multiplying Fractions by Whole Numbers

Objective:

Multiply fractions by whole numbers.

Materials:

Fraction strips, whiteboard, flashcards.

Time	**Activity**	**Details**
5 min	Warm-up	Review multiplication facts.
10 min	Concept Input	Model multiplication of fractions by whole numbers.
15 min	Guided Practice	Practice multiplying fractions by whole numbers.
7 min	Independent Practice	Worksheet on multiplying fractions.
3 min	Closure & Assessment	Oral Q&A to check understanding.

Lesson Plan 19

Day 19: Division of Fractions by Whole Numbers (Conceptual)

Objective:

Understand dividing fractions by whole numbers conceptually.

Materials:

Visual fraction models, flashcards.

Time	**Activity**	**Details**
5 min	Warm-up	Review multiplication of fractions.
10 min	Concept Input	Explain dividing fractions by whole numbers visually.
15 min	Guided Practice	Solve conceptual problems together.
7 min	Independent Practice	Worksheet on fraction division concepts.
3 min	Closure & Assessment	Discuss common errors

Lesson Plan 20

Day 20: Real-Life Applications of Fractions

Objective:

Apply fractions to solve real-world problems.

Materials:

Word problem cards, fraction charts.

Time	Activity	Details
5 min	Warm-up	Discuss everyday examples involving fractions.
10 min	Concept Input	Model word problems using fractions.
15 min	Guided Practice	Solve word problems as a class.
7 min	Independent Practice	Worksheet on fraction word problems.
3 min	Closure & Assessment	Ask students to explain their problem-solving process.

Lesson Plan 21

Day 21: Review of Number Operations

Objective

Students will review all number operations (addition, subtraction, multiplication, division) taught so far.

Materials

Flashcards, worksheets.

Lesson Plan

Time	Activity	Details
5 min	Warm-Up	Quick oral quiz on addition, subtraction, multiplication, and division.
10 min	Concept Input	Teacher revisits key strategies for solving number operation problems.
15 min	Guided Practice	Solve mixed operation problems together as a class.

Time	Activity	Details
7 min	Independent Practice	Students complete a worksheet with mixed number operations.
3 min	Closure Assessment	Discuss difficult problems and solutions.

Lesson Plan 22

Day 22: Review of Fractions

Objective:

Review all fraction concepts taught so far.

Materials:

Fraction charts, flashcards.

Time	Activity	Details
5min	Warm-up	Quick oral quiz on fraction facts.
10 min	Concept Input	Recap fraction concepts.
15 min	Guided Practice	Solve fraction problems together.
6min	Independent Practice	Worksheet practice.
3 min	Closure & Assessment	Answer students' questions and clarify doubts.

Lesson Plan 23

Day 23: Problem Solving with Number Operations

Objective

Students will be able to apply number operations to solve word problems.

Materials

Word problem cards, whiteboard.

Time	**Activity**	**Details**
5 min	Warm-Up	Discuss the steps of problem-solving (understand, plan, solve, check).
10 min	Concept Input	Teacher models solving word problems using number operations.
15 min	Guided Practice	Solve word problems together as a class.
7 min	Independent Practice	Students complete a worksheet with word problems.
3 min	Closure Assessment	Review strategies and ask students to share their solutions.

Lesson Plan 24

Day 24: Problem Solving with Fractions

Objective:

Apply fraction knowledge to solve word problems.

Materials:

Word problem cards, fraction charts.

Time	**Activity**	**Details**
5 min	Warm-up	Discuss fraction problem-solving strategies.
10 min	Concept Input	Model fraction word problems.
15 min	Guided Practice	Solve problems as a class.
7 min	Independent Practice	Worksheet on fraction word problems.
3 min	Closure & Assessment	Clarify misunderstandings; summarize.

Lesson Plan 25

Day 25: Practice Test – Number Operations

Objective:

Assess understanding of number operations.

Materials:

Test papers, pencils.

Time	**Activity**	**Details**
5 min	Warm-up	Relaxation and test instructions.
30 min	Test	Students complete test independently.
5 min	Closure	Collect papers and brief feedback session

Lesson Plan 26

Day 26: Practice Test – Fractions

Objective:

Assess understanding of fractions.

Materials:

Test papers, pencils.

Time	**Activity**	**Details**
5 min	Warm-up	Relaxation and test instructions.
30 min	Test	Students complete test independently.
5 min	Closure	Collect papers and brief feedback session.

Lesson Plan 27

Day 27 Review Test Results and Error Correction

Objective:

Review tests and correct common errors.

Materials:

Test papers, whiteboard.

Time	**Activity**	**Details**
5 min	Warm-up	Discuss importance of learning from mistakes.
15 min	Review	Go over common errors in test papers.
15 min	Correction Practice	Solve problems students struggled with.
5 min	Closure & Assessment	Summarize key corrections and improvements.

Lesson Plan 28

Day 28: Extended Practice on Weak Areas

Objective:

Provide additional practice on topics needing improvement.

Materials:

Worksheets, flashcards.

Time	**Activity**	**Details**
5 min	Warm-up	Quick review of weak topics.
30 min	Practice	Focused practice on identified weak areas.
5 min	Closure & Assessment	Check understanding and answer questions.

Lesson Plan 29

Day 29 Enrichment Activities for Number Operations

Objective:

Challenge students with higher-order thinking problems.

Materials:

Challenge worksheets, puzzles.

Time	**Activity**	**Details**
5 min	Warm-up	Brain teasers related to number operations.
30 min	Enrichment	Solve challenging problems individually or in groups.
5 min	Closure & Assessment	Discuss solutions and strategies.

Lesson Plan 30

Day 30: Enrichment Activities for Fractions

Objective:

Challenge students with advanced fraction problems.

Materials:

Worksheets, fraction puzzles.

Time	**Activity**	**Details**
5 min	Warm-up	Fraction puzzles warm-up.
30 min	Enrichment	Solve challenging fraction problems.
5 min	Closure & Assessment	Review answers and strategies.

Lesson Plan 31

Day 31: Comprehensive Review

Objective:

Review all topics before final tests.

Materials:

Whiteboard, flashcards, worksheets.

Time	Activity	Details
10 min	Warm-up & Review	Oral quick-fire questions on all topics.
20 min	Group Practice	Solve mixed problems as a class.
10 min	Closure	Summarize key points and address doubts.

Lesson Plan 32

Day 32: Final Assessment

Objective:

Final test covering all content taught.

Materials:

Test papers, pencils.

Time	Activity	Details
5 min	Warm-up	Relaxation and instructions for the test.
30 min	Test	Students complete the final assessment independently.
5 min	Closure	Collect papers and give motivational closing remarks.

7.2 Appendix-B Lesson Plans for Experimental Group (Non-Digital Adaptive Math Games)

Lesson Plan 1 (Week 1, Session 1)

Component	**Details**
Lesson No.	1
Grade Level	Grade 3
Subject	Mathematics
Topic(s)	Roman Numbers
Learning Objectives	- Recognize and match Roman numerals I to L. - Build familiarity with Roman numeral values.
Materials	Roman numeral flashcards, number cards, counters
Games & Descriptions	1. **Roman Race** (All Levels): Students pick a Roman numeral card and race to match it with the correct number card on the board. 2. **Roman Puzzle Challenge** (High): Arrange Roman numeral cards to form larger numbers or sequences. 3. **Match the Value Cards** (Low): Pair Roman numeral cards with number cards at desks to build recognition skills.
Teacher Facilitation	Introduce Roman numerals and model the matching. Group students by ability. Walk around to support, ask guiding questions, and encourage teamwork. Summarize learning after games.
Activities	1. Introduction & modeling (10 min) 2. Game play by groups (20 min) 3. Group discussion & quiz (10 min)
Component	**Details**
Assessment	Observe participation, oral questioning, quick matching worksheet
Time	40 minutes
Remarks	First session of intervention; adjust groups as needed

Lesson Plan 2 (Week 1, Session 2)

Component	**Details**
Lesson No.	2
Grade Level	Grade 3
Subject	Mathematics
Topic(s)	Roman Numbers
Learning Objectives	- Reinforce recognition and conversion of Roman numerals. - Enhance speed and accuracy through game play.
Materials	Flashcards, number cards, counters
Games & Descriptions	1. **Roman Race** (All Levels): Team relay matching Roman numerals to values. 2. **Roman Puzzle Challenge** (High): Complex numeral puzzles for sequencing. 3. **Match the Value Cards** (Low): Matching pairs game at desk.
Teacher Facilitation	Review previous lesson briefly. Explain game rules clearly. Encourage competition and collaboration. Monitor and provide hints as needed. Reflect on strategies used.
Activities	1. Quick review (5 min) 2. Game rounds (25 min) 3. Reflection & Q&A (10 min)
Assessment	Formative observation, oral questioning
Time	40 minutes
Remarks	Reinforcement session for Roman numerals

Lesson Plan 3 (Week 1, Session 3)

Details

Lesson No. 3

Grade Level 3

Subject Mathematics

Topic(s)	Even and Odd Numbers
Learning Objectives	- Identify even and odd numbers. - Sort numbers correctly using cards.
Materials	Number cards, counters
Games & Descriptions	1. **Odd One Out** (Average): Group sorting game to separate even and odd numbers. 2. **Number Sprint** (High): Timed competition to classify numbers quickly. 3. **Even-Odd Hunt** (Low): Guided activity searching for even/odd cards in a set.
Teacher Facilitation	Introduce the concept with examples. Demonstrate sorting. Guide students in groups, providing support and asking probing questions. Encourage discussion about number properties.
Activities	1. Introduction and demo (10 min) 2. Game play by ability groups (20 min) 3. Review & feedback (10 min)
Assessment	Observation of sorting accuracy, verbal questioning
Time	40 minutes
Remarks	Focus on number property understanding

Lesson Plan 4 (Week 1, Session 4)

Details

Lesson No.	4
Grade Level:	3
Subject	Mathematics
Topic(s)	Even and Odd Numbers
Learning Objectives	- Strengthen ability to classify numbers as even or odd. - Increase fluency through game participation.
Materials	Number cards, counters
Games & Descriptions	1. **Odd One Out** (Average): Sort and explain why a number is odd or even. 2. **Number Sprint** (High): Fast-paced identification and classification game. 3. **Even-Odd Hunt** (Low): Supportive guided sorting game with visuals.
Teacher Facilitation	Recap previous session learning. Encourage students to explain reasoning. Support students with difficulties. Use questioning to deepen thinking.
Activities	1. Recap & explanation (10 min) 2. Game sessions (20 min) 3. Group sharing & quiz (10 min)
Assessment	Verbal explanations, observation
Time	40 minutes
Remarks	Continue building concept mastery

Lesson Plan 5 (Week 2, Session 1)

Details

Lesson No. 5

Grade Level 3

Subject Mathematics

Topic(s)	Place Value
Learning Objectives	- Understand place value of digits in numbers up to 100,000. - Apply knowledge in interactive games.
Materials	Place value charts, number wheels, dice
Games & Descriptions	1. **Place Value Bingo** (Average): Bingo cards with place value clues; students mark numbers accordingly. 2. **Number Pyramid Challenge** (High): Build pyramids by adding digits with correct place values. 3. **Roll & Build** (Low): Roll dice and build numbers focusing on correct digit placement.
Teacher Facilitation	Explain place value concept and game rules. Model examples. Facilitate games by guiding and questioning groups based on their level. Discuss strategies and common errors.
Activities	1. Concept intro (10 min) 2. Game play (20 min) 3. Review & Q&A (10 min)
Assessment	Observation, oral questioning
Time	40 minutes
Remarks	Introduce and practice place value concept

Lesson Plan 6 (Week 2, Session 2)

Details

Lesson No.	6
Grade Level:	3
Subject	Mathematics
Topic(s)	Place Value
Learning Objectives	- Reinforce place value understanding. - Develop problem solving using number building.
Materials	Place value charts, number wheels, dice
Games & Descriptions	1. **Place Value Bingo** (Average): Students identify place values in a bingo format. 2. **Number Pyramid Challenge** (High): Solve more complex pyramids with multi-digit numbers. 3. **Roll & Build** (Low): Focus on placing digits in correct places after dice rolls.
Teacher Facilitation	Review previous game outcomes. Guide groups through increased challenge. Use questioning to deepen understanding and explain mistakes.
Activities	1. Quick review (5 min) 2. Game rounds (25 min) 3. Reflection & summary (10 min)
Assessment	Formative observation, oral questions
Time	40 minutes
Remarks	Reinforce and extend place value skills

Lesson Plan 7 (Week 2, Session 3)

Details

Lesson No. 7

Grade Level 3

Subject Mathematics

Topic(s)	Numbers up to 100,000
Learning Objectives	- Read and write 5-digit numbers. - Understand place value in larger numbers.
Materials	5-digit number cards, place value charts, pyramid templates
Games & Descriptions	1. **Place Value Bingo (Average):** Students are given clues related to digits in specific places (e.g., "circle the number where 3 is in the thousands place"). 2. **Number Pyramid Challenge (High):** Students build number pyramids by arranging digit cards to meet specific place value rules. 3. **Roll & Build (Low):** Using dice, students roll numbers and build 5-digit numbers on their charts.
Teacher Facilitation	Review how to form and read 5-digit numbers using flashcards. Demonstrate each game briefly. Group students and circulate, providing support and asking reflective questions. Emphasize number reading accuracy.
Activities	1. Introduction and demonstration (10 min) 2. Game play in groups (20 min) 3. Quick review and quiz (10 min)
Assessment	Spot-check answers during games, short oral quiz

Component	**Details**
Time	40 minutes
Remarks	First exposure to 5-digit numbers; monitor progress closely

Lesson Plan 8 (Week 2, Session 4)

Details	
Lesson No	8
Grade	3
Subject	Mathematics
Topic(s)	Numbers up to 100,000
Learning Objectives	- Compare and order 5-digit numbers. - Reinforce number building using place value.
Materials	Dice, number strips, scoring sheets
Games Descriptions	1. **Number Pyramid Challenge (High):** A race format where teams build the tallest correct pyramid with given constraints. 2. **Roll & Build (Low):** Students roll to generate numbers and place them on their chart by place value. 3. **Place Value Bingo (Average):** Focus on identifying digits in various place values.
Teacher Facilitation	Begin with a quick recap. Set up stations. Rotate groups and support with hints and place value tips. Use mini whiteboards for feedback during review.
Activities	1. Review (5 min) 2. Station rotation (25 min) 3. Feedback and wrap-up (10 min)
Assessment	Informal checks, teacher questioning
Time	40 minutes
Remarks	Reinforcement session; prepare for comparing numbers next week

Lesson Plan 9 (Week 3, Session 1)

Details	
Lesson No.	9
Grade	3
Subject	Mathematics
Topic(s)	Comparing & Ordering Numbers
Learning Objectives	- Compare numbers using symbols (>,<,=). - Order numbers from smallest to largest.
Materials	Number cards, symbol flashcards, chalk/tape for number line
Games Descriptions	1. **Number Mountain Race (High):** Students race to arrange number cards from smallest to largest. 2. **Number Line Hopscotch (Average):** Students jump on a floor number line to place numbers in order. 3. **Greater Gator Cards (Low):** Use cards showing >, <, = to compare pairs of numbers.
Teacher Facilitation	Introduce comparison symbols. Demonstrate a simple number comparison. Facilitate group activities and monitor accuracy. Encourage students to explain reasoning.
Activities	1. Introduction & demo (10 min) 2. Group game sessions (20 min) 3. Group discussion and reflection (10 min)
Assessment	Observation of correct symbol use, oral questioning
Time	40 minutes
Remarks	Focus on conceptual understanding of comparison

.

Lesson Plan 10 (Week 3, Session 2)

Details

Lesson No	10
Grade	3
Subject	Mathematics

Topic(s)	Comparing & Ordering Numbers
Learning Objectives	- Apply comparison skills to order numbers accurately. - Develop speed and accuracy through timed activities.
Materials	Number strips, flashcards, stopwatch
Games & Descriptions	1. **Number Mountain Race (High):** Challenge with decimal numbers or close values. 2. **Number Line Hopscotch (Average):** Timed hopping game placing numbers. 3. **Greater Gator Cards (Low):** Game with scoring for correct comparisons.
Teacher Facilitation	Review previous session's concepts. Set clear time limits and scoring. Monitor for understanding and provide feedback. Highlight common errors.
Activities	1. Recap (5 min) 2. Timed game rounds (25 min) 3. Feedback and reflection (10 min)
Assessment	Timed accuracy checks, verbal questioning

Time	40 minutes
Remark	Emphasis on fluency and confidence

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Lesson Plan 11 (Week 4, Session 1)

Lesson N0.11	
Grade	3
Topic(s)	Addition (with/without carrying)
Learning Objectives	- Add numbers with and without carrying. - Build mental addition skills.
Materials	Dice, addition puzzles, beads
Games & Descriptions	1. **Addition Relay (High):** Teams solve addition problems quickly in relay style. 2. **Fast Fingers (Average):** Students answer flashcard addition problems rapidly. 3. **Dice Sum Race (Low):** Roll dice and add numbers, moving forward on a track.
Teacher Facilitation	Model addition with and without carrying. Explain game rules and monitor teamwork. Provide support and hints during play. Encourage mental calculation strategies.
Activities	1. Introduction and modeling (10 min) 2. Game rounds (20 min) 3. Wrap-up and quiz (10 min)
Assessment	Observation of strategy use, quick written quiz
Time	40 minutes
Remarks	Focus on fluency in addition

Lesson Plan 12 (Week 4, Session 2)

Details	
Lesson No	12
Grade	3
Subject	Mathematics
Topic(s)	Addition (with/without carrying)
Learning Objectives	- Improve speed and accuracy in addition. - Apply addition in practical contexts.
Materials	Dice, addition puzzles, beads
Games & Descriptions	1. **Addition Relay (High):** Increased difficulty with multi-digit addition. 2. **Fast Fingers (Average):** Timed rounds of flashcard addition. 3. **Dice Sum Race (Low):** Focus on adding smaller numbers quickly.
Teacher Facilitation	Review previous session outcomes. Facilitate competitive rounds. Provide encouragement and correct errors tactfully.
Activities	1. Warm-up review (5 min) 2. Game play (25 min) 3. Group feedback (10 min)
Assessment	Monitoring accuracy and speed
Time	40 minutes
Remarks	Build confidence and accuracy

Lesson Plan 13 (Week 5, Session 1)

Lesson No.	13
Grade	3
Subject	Mathematics
Topic(s)	Addition (Real-Life Problems), Subtraction (with/without carrying)
Learning Objectives	- Solve real-life addition and subtraction problems. - Understand subtraction with and without borrowing.
Materials	Real-life worksheets, tokens, game boards
Games & Descriptions	1. **Math Market Role Play (All Levels):** Students role-play as buyers/sellers to solve addition/subtraction problems. 2. **Subtraction Spin & Solve (Average):** Spin spinner to generate subtraction problems. 3. **Missing Amount Match (Low):** Match cards showing missing addend/subtrahend.
Teacher Facilitation	Set context for real-life math use. Guide role-play. Support problem-solving and check reasoning. Encourage discussion on strategies.
Activities	1. Introduction and scenario setting (10 min) 2. Role-play and games (20 min) 3. Group reflection (10 min)
Assessment	Observation, worksheet completion
Time	40 minutes
Remarks	Practical application focus

Lesson Plan 14 (Week 5, Session 2)

Details	
Lesson No.	14
Grade	3
Subject	Mathematics
Topic(s)	Addition (Real-Life Problems), Subtraction (with/without carrying)
Learning Objectives	- Develop problem-solving skills using addition and subtraction. - Strengthen understanding through games.
Materials	Game boards, tokens, worksheets
Games & Descriptions	1. **Challenge Cart (High):** Complex problem cards for quick solving. 2. **Subtraction Spin & Solve (Average):** Continued practice with spin-generated problems. 3. **Missing Amount Match (Low):** Reinforcement matching game.
Teacher Facilitation	Recap previous session's learning. Set challenges. Monitor and scaffold where needed. Facilitate peer support.
Activities	1. Review (5 min) 2. Game play (25 min) 3. Wrap-up discussion (10 min)
Assessment	Peer and teacher feedback
Time	40 minutes
Remarks	Challenge and consolidate

Lesson Plan 15 (Week 6, Session 1)

Lesson No. 15	
Grade	3
Subject	Mathematics
Topic(s)	Mental Subtraction, Subtraction (Real-Life Problems)
Learning Objectives	-Develop mental subtraction skills. - Apply subtraction in real-life scenarios.
Materials	Flashcards, spinners, pictorial story cards
Games & Descriptions	1. **Quick Think Subtract (High):** Rapid subtraction questions in teams. 2. **Subtraction Card Challenge (Average):** Matching subtraction problems with answers. 3. **Money Match Game (Low):** Use fake money to solve subtraction problems.
Teacher Facilitation	Model mental subtraction strategies. Guide games with timing and encouragement. Support problem solving with real-life context.
Activities	1. Introduction and demonstration (10 min) 2. Games in groups (20 min) 3. Reflection and recap (10 min)
Assessment	Observation and oral questions
Time	40 minutes
Remarks	Emphasis on mental calculation

Lesson Plan 16 (Week 6, Session 2)

Details

Lesson No. 16	
Grade 3	
Subject	Mathematics
Topic(s)	Mental Subtraction, Subtraction (Real-Life Problems)
Learning Objectives	-Reinforce mental subtraction skills. - Increase fluency and confidence.
Materials	Flashcards, spinners, story cards
Games Descriptions	1. **Quick Think Subtract (High):** Timed rounds with increasing difficulty. 2. **Subtraction Card Challenge (Average):** Team competitions. 3. **Money Match Game (Low):** Practice with money and subtraction.
Teacher Facilitation	Review strategies. Facilitate timed games. Provide immediate feedback and encouragement.
Activities	1. Quick review (5 min) 2. Timed games (25 min) 3. Discussion and feedback (10 min)
Assessment	Formative observation
Time	40 minutes
Remarks	Build speed and accuracy

Lesson Plan 17 (Week 7, Session 1)

Details

Lesson No. 17	
Grade 3	
Subject	Mathematics
Topic(s)	Division (2-digit ÷ 1-digit), Mental Division Strategies
Learning Objectives	- Understand division concepts and strategies. - Solve division problems using games.
Materials	Division wheels, number grids, token boards
Games Descriptions	1. **Division Dash Challenge (High):** Timed division problem solving relay. 2. **Divide & Conquer Board Game (Average):** Move across board by solving division problems. 3. **Token Share Out (Low):** Distribute tokens evenly to practice division basics.
Teacher Facilitation	Explain division concepts and steps. Demonstrate games. Circulate to support and clarify doubts. Encourage mental calculation where possible.
Activities	1. Introduction and explanation (10 min) 2. Game play (20 min) 3. Review and quiz (10 min)
Assessment	Observation, oral questioning
Time	40 minutes
Remarks	Begin division concept introduction

Lesson Plan 18 (Week 7, Session 2)

Details

Lesson No. 18	
Grade 3	
Subject	Mathematics
Topic(s)	Division (2-digit ÷ 1-digit), Mental Division Strategies
Learning Objectives	- Apply division in practical contexts. - Improve speed and accuracy in division.
Materials	Division wheels, number grids, token boards
Games Descriptions	1. **Divide & Conquer Board Game (Average):** Extended play with problem-solving. 2. **Division Dash Challenge (High):** Timed competitions. 3. **Token Share Out (Low):** Hands-on sharing exercises.
Teacher Facilitation	Monitor game play. Offer strategy hints. Conduct short quizzes during breaks. Encourage mental math.
Activities	1. Review and strategy talk (10 min) 2. Games and quizzes (25 min) 3. Wrap-up discussion (5 min)
Assessment	Observation and short oral quiz
Time	40 minutes
Remarks	Reinforcement session

Lesson Plan 19 (Week 7, Session 4)

Details

Lesson No. 20

Grade 3

Subject	Mathematics
Topic(s)	Division (2-digit ÷ 1-digit), Mental Division Strategies
Learning Objectives	- Consolidate division knowledge. - Prepare for assessment.
Materials	Division wheels, number grids, token boards
Games Descriptions	1. **Divide & Conquer Board Game (Average):** Review play. 2. **Division Dash Challenge (High):** Final timed challenge. 3. **Token Share Out (Low):** Group sharing practice.
Teacher Facilitation	Lead review session. Encourage students to share strategies. Provide positive reinforcement.
Activities	1. Review and Q&A (10 min) 2. Game sessions (20 min) 3. Final reflection (10 min)
Assessment	Formative feedback, oral questions
Time	40 minutes
Remarks	Prepare students for upcoming post-test

Lesson Plan 20 (Week 8, Session 1)

Details

Lesson No.	20
Grade	3
Subject	Mathematics
Topic(s)	Post-Test Preparation (Review)
Learning Objectives	- Review all topics covered. - Build confidence for post-test.
Materials	Mixed materials from previous lessons
Games Descriptions	1. **Mixed Review Relay (All Levels):** Teams answer questions from various topics in relay format. 2. **Quick Quiz Cards:** Flashcards with mixed questions. 3. **Number Challenge Board:** Students solve problems moving across a game board.
Teacher Facilitation	Guide review sessions, clarify doubts, provide encouragement, and keep timing.
Activities	1. Review through relay game (15 min) 2. Quick quiz cards (15 min) 3. Number Challenge Board (10 min)
Assessment	Informal assessment via quiz and observations
Time	40 minutes
Remarks	Preparation for post-test next sessions

Lesson Plan 21 (Week 8, Session 2)

Details

Lesson No. 21	
Grade 3	
Subject	Mathematics
Topic(s)	Post-Test Preparation (Focus on Weak Areas)
Learning Objectives	- Strengthen understanding of challenging topics. - Practice with peer support.
Materials	Flashcards, worksheets, tokens
Games Descriptions	1. **Error Correction Challenge:** Identify and fix mistakes on cards. 2. **Peer Teaching Game:** Students explain concepts to each other. 3. . **Token Reward Game:** Earn tokens for correct answers on focused topics.
Teacher Facilitation	Facilitate peer support groups. Monitor corrections and explanations. Guide students on effective communication.
Activities	1. Error correction (15 min) 2. Peer teaching (15 min) 3. Token game (10 min)
Assessment	Observation and oral questioning
Time	40 minutes
Remarks	Targeted review session

Lesson Plan 22 (Week 8, Session 3)

Details

Lesson No.	22
Grade	3
Subject	Mathematics
Topic(s)	Post-Test (Assessment)
Learning Objectives	- Assess students' knowledge and skills on all topics.
Materials	Printed test papers, pencils
Games Descriptions	(Assessment Session)
Teacher Facilitation	Administer test according to guidelines. Maintain quiet environment. Provide support for test procedures only.
Activities	Post-test administration (40 min)
Assessment	Formal post-test results
Time	40 minutes
Remarks	Formal assessment session

Lesson Plan 23 (Week 9, Session 1)

Details

Lesson No. 23	
Grade 3	
Subject	Mathematics
Topic(s)	Fractions: Introduction to Fractions
Learning Objectives	- Understand the concept of fractions as parts of a whole. - Identify numerator and denominator.
Materials	Fraction circles, fraction cards, counters
Games Descriptions	1. **Fraction Pizza (All Levels):** Use fraction circles to create pizza slices representing fractions. 2. **Fraction Match-Up (High):** Match written fractions with visual models. 3. **Fraction Sorting (Low):** Sort cards by numerator or denominator.
Teacher Facilitation	Introduce fraction concepts with visual aids. Guide games emphasizing correct terminology and understanding.
Activities	1. Introduction & demonstration (10 min) 2. Game play by groups (20 min) 3. Group reflection and Q&A (10 min)
Assessment	Observation and questioning
Time	40 minutes
Remarks	Beginning fractions unit

Lesson Plan 24 (Week 9, Session 2)

Details

Lesson No. 24	
Grade 3	
Subject	Mathematics
Topic(s)	Fractions: Identifying Fractions on Number Lines
Learning Objectives	- Locate and identify fractions on number lines. - Understand fraction size relative to whole numbers.
Materials	Number line charts, fraction cards
Games Descriptions	1. **Fraction Line Hop (Average):** Students jump to correct fraction points on a floor number line. 2. **Fraction Finders (High):** Place fraction cards on a number line accurately. 3. **Fraction Walk (Low):** Guided walk on number line with teacher prompts.
Teacher Facilitation	Demonstrate fraction placement on number line. Facilitate games with group support. Provide corrective feedback.
Activities	1. Demo & explanation (10 min) 2. Group game play (20 min) 3. Review and discussion (10 min)
Assessment	Observation and oral feedback
Time	40 minutes
Remarks	Focus on visual understanding

Lesson Plan 25 (Week 9, Session 3)

Details

Lesson No. 25	
Grade 3	
Subject	Mathematics
Topic(s)	Fractions: Comparing Fractions
Learning Objectives	- Compare fractions using visual models. - Use terms 'greater than', 'less than', and 'equal to'.
Materials	Fraction strips, comparison cards
Games Descriptions	1. **Fraction War (High):** Card game comparing fraction sizes. 2. **Strip Match (Average):** Match fraction strips and explain comparisons. 3. **Fraction Sort (Low):** Sort fractions by size using cards.
Teacher Facilitation	Explain comparison rules and model examples. Support groups and prompt explanations.
Activities	1. Explanation and demo (10 min) 2. Game play in groups (20 min) 3. Group sharing (10 min)
Assessment	Observation of comparison explanations
Time	40 minutes
Remarks	Conceptual comparison focus

Lesson Pl an 26 (Week 10, Session 1)

Details

Lesson No. 26	
Grade 3	
Subject	Mathematics
Topic(s)	Fractions: Adding Like Fractions
Learning Objectives	- Add fractions with the same denominator. - Represent sums using models.
Materials	Fraction circles, addition cards
Games Descriptions	1. **Fraction Addition Race (High):** Solve addition problems quickly. 2. **Model Build (Average):** Use fraction circles to build sums. 3. **Add & Match (Low):** Match addition problems with correct sums.
Teacher Facilitation	Model addition steps. Monitor groups, prompt problem-solving. Check understanding with questions.
Activities	1. Modeling and explanation (10 min) 2. Group games (20 min) 3. Review and quiz (10 min)
Assessment	Formative questioning and observation
Time	40 minutes
Remarks	Practice adding fractions

Lesson Plan 27 (Week 10, Session 2)

Details

Lesson No. 27	
Grade 3	
Subject	Mathematics
Topic(s)	Fractions: Subtracting Like Fractions
Learning Objectives	- Subtract fractions with the same denominator. - Use visual models to explain subtraction.
Materials	Fraction strips, subtraction cards
Games Descriptions	1. **Fraction Subtract Sprint (High):** Timed subtraction problem solving. 2. **Strip Subtract (Average):** Use strips to visually subtract. 3. **Subtract & Match (Low):** Matching subtraction problems with answers.
Teacher Facilitation	Demonstrate subtraction with models. Support groups during games. Encourage explanation of process.
Activities	1. Demonstration (10 min) 2. Group games (20 min) 3. Wrap-up discussion (10 min)
Assessment	Observation and questioning
Time	40 minutes
Remarks	Reinforce subtraction concepts

Lesson Plan 28 (Week 10, Session 3)

Details	
Lesson No. 28	
Grade 3	
Subject	Mathematics
Topic(s)	Fractions: Real-Life Application Problems
Learning Objectives	- Apply fraction skills to solve real-life problems. - Explain reasoning clearly.
Materials	Story problem cards, tokens
Games Descriptions	1. **Fraction Story Role-Play (All Levels):** Act out fraction word problems. 2. **Problem Solve Relay (High):** Teams solve story problems quickly. 3. **Token Share Game (Low):** Use tokens to demonstrate fractions in sharing.
Teacher Facilitation	Set context for real-life problems. Facilitate role-plays. Support problem-solving strategies.
Activities	1. Scenario introduction (10 min) 2. Games and role-play (20 min) 3. Reflection and sharing (10 min)
Assessment	Observation and verbal responses
Time	40 minutes
Remarks	Practical fraction use

.

Lesson Plan 29 (Week 10, Session 4)

Details

Lesson No. 29	
Grade Level	Grade 3
Subject	Mathematics
Topic(s)	Fractions: Review and Reinforcement
Learning Objectives	- Consolidate all fraction concepts. - Prepare for retention test.
Materials	Mixed fraction materials, flashcards
Games Descriptions	1. **Fraction Challenge Quiz (All Levels):** Team quiz game. 2. **Matching and Sorting Games:** Review key fraction ideas. 3. **Fraction Bingo:** Mixed fraction problems in bingo format.
Teacher Facilitation	Lead review activities. Provide feedback and encouragement. Prepare students for test.
Activities	1. Quiz and games (30 min) 2. Wrap-up discussion (10 min)
Assessment	Formative feedback and observation
Time	40 minutes
Remarks	Final review before retention test

.

Lesson Plan 30 (Week 11, Session 1)

Details

Lesson No. 30	
Grade Level	Grade 3
Subject	Mathematics
Topic(s)	Retention Test (Assessment)
Learning Objectives	Assess long-term retention of mathematical concepts covered.
Materials	Printed test paper, pencils
Games Descriptions	(Assessment only)
Teacher Facilitation	Administer retention test. Ensure quiet environment. Support test procedures only.
Activities	Test administration (40 min)
Assessment	Formal retention test results
Time	40 minutes
Remarks	Formal assessment session

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Lesson Plan 31 (Week 11, Session 2)

Details

Lesson No. 31	
Grade Level	Grade 3
Subject	Mathematics
Topic(s)	Reflection and Feedback
Learning Objectives	- Reflect on learning journey. - Identify strengths and areas for improvement.
Materials	Reflection sheets, discussion prompts
Games Descriptions	1. **Group Reflection Discussion:** Share experiences and thoughts. 2. **Self-Assessment Activity:** Complete reflection sheets. 3. **Teacher Feedback:** Individual feedback sessions.
Teacher Facilitation	Guide reflection discussion. Support honest self-assessment. Provide constructive feedback.
Activities	1. Group discussion (15 min) 2.Self-assessment (15 min) 3. Teacher feedback (10 min)
Assessment	Self and teacher assessment
Time	40 minutes
Remarks	Closure of intervention phase

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Lesson Plan 32

Component	Details
Lesson No.	32
Grade Level	Grade 3
Subject	Mathematics
Topic(s)	Introduction to Fractions – Understanding ½, ⅓, and ¼
Learning Objectives	- Identify fractions as equal parts of a whole.- Represent ½, ⅓, and ¼ using shapes and objects.- Compare simple fractions visually.- Participate in adaptive fraction-based games to enhance conceptual understanding.
Materials	Fraction circles, colored paper, scissors, fraction flashcards, cardboard fraction strips, markers, dice, game board.
Games & Descriptions	**Game 1: “Fraction Pizza Challenge”** – Students are given circular paper “pizzas” divided into equal slices. They roll a dice to determine a fraction (½, ⅓, or ¼) and color that portion. The goal is to visualize fractions as equal parts of a whole. **Game 2: “Fraction Match-Up”** – Students draw fraction cards (e.g., ½, ⅓, ¼) and match them with corresponding visual fraction pieces. Adaptive element: Students who master simple fractions move to mixed fractions (e.g., ¾).
Teacher Facilitation	Introduces the concept of fractions using real-life examples (e.g., sharing a pizza or chocolate bar). - Demonstrates how to divide shapes into equal parts. - Guides students during the Fraction Pizza Challenge, prompting questions like “How many equal parts do we have?” and “What fraction is colored?” - Encourages peer explanation and supports struggling learners with physical manipulatives. - Monitors and adapts difficulty level according to student responses.

7.3 Appendix-C Self-Developed Achievement Test

The study title Effect of Non-Digital Adaptive Math Games on Students Mathematics Achievement at Primary Level. This research aims to assess the effect of non-digital adaptive math games on the mathematics achievement of Grade 3 students. Participation involves completing a pre-test and post-test on mathematical skills over an 8-week period. All information collected will remain confidential and be used only for research purposes. Participants' identities will be kept private in order to protect privacy.

Table of Specification

Table 7.3
Table of Specification

Topic	Objectives	Cognitive Domain	Types of Items	No of Questions	Marks %
Addition	Access understanding of basic addition concepts	Remembering and Understanding	MCQs 4	4	20%
Subtraction	Evaluate ability to solve subtraction problems	Remembering and Understanding	MCQs 5	5	25%
Multiplication	Test knowledge of multiplication and facts	Remembering and Understanding	MCQs 4	4	20%
Fractions	Test the basic concepts of	Remembering and Understanding	MCQs 3 fractions	3	15%

Division	Evaluate knowledge related to concept of division	Remembering and Understanding	MCQs	4	4	20%
Total	—	—	—	**20**	**20**	**100%**

Self –Developed Achievement Test

(Pre-Test, Post-Test Grade 3)

Total Marks =20

Time Duration= 40 minutes

Topics Covered:

- Addition
- Subtraction
- Multiplication
- Division
- Fraction

Section A: Multiple Choice Questions (MCQs)

Circle the correct answer.

1. **What is 35 + 47?**
   a) 72
   b) 82
   c) 84
   d) 92
2. **What is 95 - 36?**
   a) 59
   b) 61
   c) 63
   d) 69
3. **What is 9 × 4?**
   a) 32
   b) 36
   c) 40
   d) 44

4. **What is 64 ÷ 8?**
   a) 6
   b) 7
   c) 8
   d) 9
5. **What fraction represents one-half?**
   a) 1/3
   b) 1/2
   c) 2/4
   d) 1/4
6. **What is 123 + 86?**
   a) 199
   b) 209
   c) 213
   d) 218
7. **If you subtract 72 from 150, what do you get?**
   a) 78
   b) 82
   c) 88
   d) 90
8. **What is 7 × 8?**
   a) 49
   b) 54
   c) 56
   d) 63
9. **If you divide 54 by 6, what is the result?**
   a) 7
   b) 8
   c) 9
   d) 10

10. Which of the following fractions is equivalent to 3/6?

a) 1/2

b) 1/3

c) 2/3

d) 3/4

11. What is 245 + 378?

a) 613

b) 623

c) 633

d) 643

12. What is 120 - 57?

a) 62

b) 63

c) 64

d) 65

13. What is 6 × 12?

a) 66

b) 70

c) 72

d) 76

14. What is 144 ÷ 12?

a) 11

b) 12

c) 13

d) 14

15. If a pizza is divided into 8 slices, and 3 are eaten, what fraction of the pizza is left?

a) 3/8

b) 5/8

c) 1/2

d) 7/8

16. What is 389 + 156?

a) 533

b) 543

c) 549

d) 545

17. What is 500 - 345?

a) 145

b) 155

c) 165

d) 75

18. What is 11 × 11?

a) 111

b) 121

c) 131

d) 141

19. What is 90 ÷ 10?

a) 9

b) 10

c) 11

d) 12

20. Which of the following represents a fraction greater than 1/2?

a) 2/5

b) 1/4

c) c)3/4

d) d) 1/3

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
b	a	b	c	b	b	a	c	c	a
Q11	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**Q18**	**Q19**	**Q20**
b	b	c	b	b	d	b	b	a	c

7.4 Appendix-D Academic Calendar for the Session 2025-2026

ISLAMABAD GRAMMAR SCHOOL

G-11 CAMPUS

Email: info@igs.edu.pk

Address: G-11 Markaz, Islamabad

Academic Calendar 2025-26

Months	Key Activities/Events
March 2025	Academic session starts on 12nd March
April 2025	Regular classes, academic projects, assessments
May 2025	Mid-term exams, PTM (Parent-Teacher Meeting)
June 2025	Classwork continues, pre-summer wrap-up
July 2025	Summer Vacation (5 June to 4 August 2025)
August 2025	Classes resume, Independence Day activities
September 2025	Class tests, group activities, revision weeks
October 2025	First Term Exams
November 2025	Remedial sessions, co-curricular programs
December 2025	Winter Break (20th Dec – 31st Dec)
January 2026	Revision Sessions/Test
February 2026	Final Term Exams

7.5 Appendix-E Instruments Validation Certificates

Certificate of Validation

Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level

By

Afsheen Moazzam

MS Scholar, Department of Teacher Education, Faculty of Education, International Islamic University Islamabad (IIUI), Pakistan

This is to certify that the researcher-developed instruments have been assessed by me, and I found that these have been designed adequately to address the title **"Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level"**

Name: Erum Raza Ahmed

Designation: Branch Head

Institute: Islamabad Grammar School (G-11)

Signature: Erum

Stamp: ISLAMABAD GRAMMAR SCHOOL Branch Head G-11 CAMPUS

Certificate of Validation

Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level

By

Afsheen Moazzam

MS Scholar, Department of Teacher Education, Faculty of Education, International Islamic University Islamabad (IIUI), Pakistan

This is to certify that the researcher-developed instruments have been assessed by me, and I found that these have been designed adequately to address the title **"Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level"**

Name: Maryam

Designation: Math Teacher

Institute: Islamabad Grammar School

Signature: [signature]

Stamp: ____________________

Certificate of Validation

Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level

By

Afsheen Moazzam

MS Scholar, Department of Teacher Education, Faculty of Education, International Islamic University Islamabad (IIUI), Pakistan

This is to certify that the researcher-developed instruments have been assessed by me, and I found that these have been designed adequately to address the **title "Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level"**

Name: Dr. Fatima Batool

Designation: AP

Institute: IIUI

Signature: [signature]

Stamp:

Dr Fatima Batool
Assistant Professor
Department of Teacher Education
Faculty of Education
nternational Islamic University
Islamabad Pakistan

Certificate of Validation

Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level

By

Afsheen Moazzam

MS Scholar, Department of Teacher Education, Faculty of Education, International Islamic University Islamabad (IIUI), Pakistan

This is to certify that the researcher-developed instruments have been assessed by me, and I found that these have been designed adequately to address the **title "Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level"**

Name: Sakina Ahmed

Designation: Maths Teacher

Institute: Islamabad Grammar School

Signature: ____________

Stamp: ____________

Certificate of Validation

Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level

By

Afsheen Moazzam

MS Scholar, Department of Teacher Education, Faculty of Education, International Islamic University Islamabad (IIUI), Pakistan

This is to certify that the researcher-developed instruments have been assessed by me, and I found that these have been designed adequately to address the title **"Effect of Non-Digital Adaptive Math Games on Students' Achievement in Mathematics at Primary Level"**

Name: Dr. Alina Raza

Designation: TRA DOTE

Institute: IIU

Signature: [signature]

Stamp: INCHARGE, ACADEMIC AFFAIRS
DEPARTMENT OF TEACHER EDUCATION
FACULTY OF EDUCATION
INTERNATIONAL ISLAMIC UNIVERSITY
ISLAMABAD PAKISTAN