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From Play to Proficiency: Game-Based Learning for Foundational Literacy and Numeracy

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ABSTRACT

Background: Foundational Literacy and Numeracy (FLN) are critical for academic success and lifelong learning. Yet, a large proportion of early-grade learners in India continue to face difficulties in reading and basic arithmetic, as highlighted by the ASER (2018) survey. The National Education Policy (NEP) 2020 and the NIPUN Bharat Mission emphasize joyful, play-based, and activity-oriented strategies to strengthen FLN. Game-Based Learning (GBL) has emerged as a promising child-centered approach to improve early learning outcomes.

Purpose: This study aimed to assess the effectiveness of Game-Based Learning in enhancing FLN skills among Grade 1 and 2 students in a government primary school.

Methods: A quasi-experimental pre-test–post-test control group design was adopted with 40 students randomly assigned to experimental (GBL) and control (traditional instruction) groups. The ASER tool measured literacy and numeracy skills before and after the intervention. Data were analyzed using t-tests, ANCOVA, and effect size calculations.

Results: The analysis revealed that the experimental and control groups were equivalent at baseline, with no significant difference in pre-test FLN scores ($t(38)=0.87$, $p>0.05$). Following the intervention, the experimental group demonstrated a significant improvement in FLN scores from pre-test to post-test ($t(19)=4.12$, $p<0.05$, Cohen's $d=1.46$). However, after controlling for pre-test scores as a covariate, an ANCOVA indicated no statistically significant difference in post-test scores between the experimental and control groups, $F(1, 37)=0.06$, $p=0.813$. This suggests that while the game-based learning intervention was effective within the experimental group, it did not yield a statistically superior outcome compared to traditional instruction when initial ability levels were accounted for.

Conclusion: The study indicates that Game-Based Learning can enhance foundational skills, engagement, and motivation among early-grade learners. With appropriate teacher training and integration of low-cost, contextually relevant games, GBL can support NEP 2020's vision of strengthening foundational education in resource-constrained schools.

ARTICLE DETAILS

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INTRODUCTION

In recent years, global education systems have increasingly recognised the pressing need to align instructional practices with the evolving demands of the 21st century. Despite advancements in access to education, foundational literacy and numeracy (FLN) remain critical challenges, particularly in developing countries like India. Conventional classroom practices, often centred on rote learning and textbook-based instruction, have failed to ensure that early-grade learners acquire the essential skills needed for lifelong learning (UNESCO, 2023). As a result, many students struggle with reading comprehension, basic arithmetic operations, and problem-solving, which in turn impedes their academic progression and social mobility (ASER Centre, 2018).

India's National Education Policy (NEP) 2020 addresses these challenges by emphasising experiential, play-based, and developmentally appropriate learning approaches during the foundational stage, defined as ages 3–8. The policy strongly advocates for transforming early childhood education through methods that stimulate curiosity, critical thinking, and learner autonomy (Ministry of Education, 2020). In alignment with this, the NIPUN Bharat Mission was launched to ensure that every child attains FLN by the end of Grade 3, recognising foundational learning as the "highest priority" for the country's education system (Ministry of Education, n.d.).

One innovative pedagogical strategy gaining prominence is Game-Based Learning (GBL), which integrates the motivational features of games, such as challenges, rewards, and interactive environments, into instructional design. GBL has been shown to promote learner engagement, enhance cognitive development, and support differentiated instruction for diverse learners (Gee, 2003; Mayer, 2014). It offers immersive experiences that encourage active participation, peer collaboration, and meaningful knowledge construction, making it particularly effective for early learners with short attention spans (Shute, 2016; Alotaibi, 2024).

Given the alarming statistics from ASER (2018), which reveal that nearly half of Grade 5 students in India cannot read a Grade 2-level text, and considering the wide socio-economic and linguistic diversity of Indian classrooms, the integration of low-cost, culturally relevant GBL strategies could serve as a transformative tool for bridging early learning gaps. However, empirical research evaluating the effectiveness of GBL in the Indian foundational education context remains limited. This study aims to address this gap by assessing the impact of GBL on foundational literacy and numeracy skills among early-grade students using a quasi-experimental design. The findings are expected to contribute to both policy and practice by providing evidence for scalable, engaging, and inclusive learning interventions aligned with NEP 2020.

FOUNDATION LITERACY AND NUMERACY

Foundational Literacy and Numeracy (FLN) refers to a child's ability to read basic texts with comprehension and perform simple arithmetic operations such as addition, subtraction, multiplication, and division by the end of Grade 3 (World Bank, 2019). These are not only essential academic skills but also key predictors of lifelong learning, employability, and social participation (Bullard, 2023). FLN is widely recognised as the cornerstone of quality education and is fundamental to achieving the United Nations Sustainable Development Goal 4, which aims to ensure inclusive and equitable quality education for all (UNESCO, 2023).

Foundational literacy includes the development of oral language, phonemic awareness, vocabulary, reading fluency, and reading comprehension (Purpura & Napoli, 2015). These competencies form the basis for children to decode written language, comprehend meaning, and communicate effectively in both academic and real-world contexts (Gupta, S., 2024). Research has shown that children who do not attain basic reading proficiency by the end of early primary grades are more likely to struggle with future learning outcomes and are at a higher risk of dropping out of school (Shvartsman & Shaul, 2024).

Foundational numeracy involves number sense, counting, arithmetic operations, spatial reasoning, measurement, and data handling (Gupta, S., 2024). These skills enable children to understand quantities, perform basic calculations, and solve everyday mathematical problems (Dweck, 2008). Early numeracy is not merely a mechanical process; it is also a cognitive skill deeply linked with reasoning and logical thinking (Isabelle, 2023). Studies suggest that deficiencies in early numeracy can hinder the acquisition of more advanced mathematical concepts in later grades, further widening the learning gap between high-performing and low-performing students (McMullen et al., 2024).

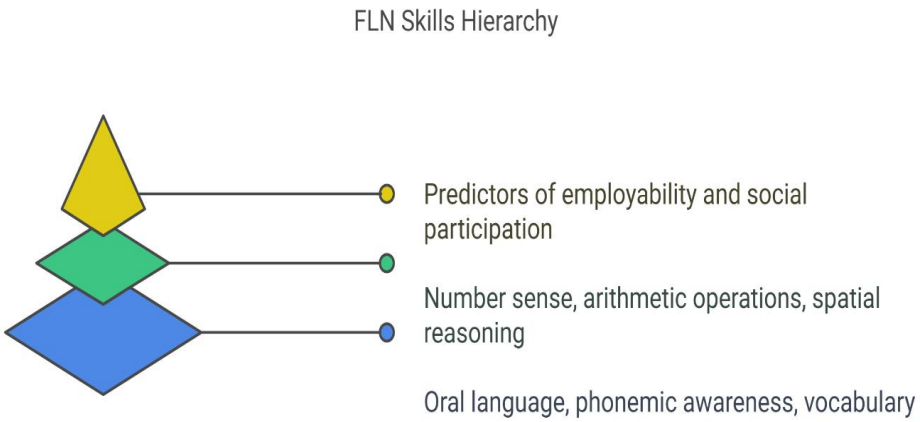

Figure 1. Foundational Literacy and Numeracy (FLN) Skills Hierarchy

Despite increased enrolment in primary education, learning poverty remains a significant challenge. According to Bullard (2023), more than 50% of children in low- and middle-income countries cannot read and understand a simple story by age 10. In India, the ASER (2018) report highlighted that only 44.2% of Grade 5 students could read a Grade 2-level text, and less than 50% could perform basic subtraction. These statistics underscore the urgent need for systemic interventions to strengthen FLN outcomes in the early grades.

Table 1: Key Components and Implementation Strategies of Foundational Literacy and Numeracy (FLN)

Key Areas	S. No.	Foundation Literacy	Foundation Numeracy
Basic Components		Phonemic Awareness	Number Sense
		Phonics	Basic Operations
		Vocabulary Development	Spatial Understanding and Geometry
		Reading Fluency	Measurement
		Reading Comprehension	Patterns and Sequences
		Writing Skills	Data Handling
Skills Related to FLN		Speaking Skills	Logical Reasoning
		Listening Skills	Spatial Awareness
		Cognitive Skills	Problem-Solving Skills
		Fine Motor Skills	Memory and Attention
		Critical Thinking	Fine Motor Skills
Strategies for Implementation	1.	Reading Aloud and Storytelling	Hands-on Manipulatives
	2.	Phonics and Phonemic	Real-Life Math Applications
	3.	Interactive Reading and Shared Reading	Math Games and Puzzles
	4.	*Vocabulary Building*	*Pattern Recognition Activities*

**This table outlines the basic components, associated skills, and recommended strategies for implementing foundational literacy and numeracy (FLN) in primary education.*

Despite NEP 2020's emphasis on FLN, providing high-quality foundational education still presents difficulties. Effective learning is frequently hampered by problems including excessive class sizes, a lack of resources, and insufficient teacher preparation. According to a 2018 ASER (Annual Status of Education Report) report, just 50% of Grade 5 students in India could read a text at the Grade 2 level (The Indian Express). This implies a severe lack of foundational reading abilities. This suggests a serious deficiency in basic reading skills **(ASER, 2018)**. Systemic adjustments are needed to address these issues, such as improved infrastructure, smaller class sizes, and improved teacher preparation. Innovative strategies like game-based learning have emerged as promising alternatives to engage young learners and improve learning results in light of the difficulties encountered in implementing core literacy and numeracy in India.

Game-Based Learning

Game-Based Learning (GBL) refers to an instructional approach that incorporates principles of game design, such as goals, rules, challenges, feedback, and rewards, into educational contexts to enhance student engagement, motivation, and learning outcomes (Mayer, 2014). Unlike gamification, which adds game elements to non-game environments, GBL integrates the entire learning content into game mechanics, allowing students to construct knowledge through interactive and immersive experiences (Shute, 2016). It is rooted in constructivist and experiential learning theories, which emphasize active participation and contextualized understanding (Gee, 2003).

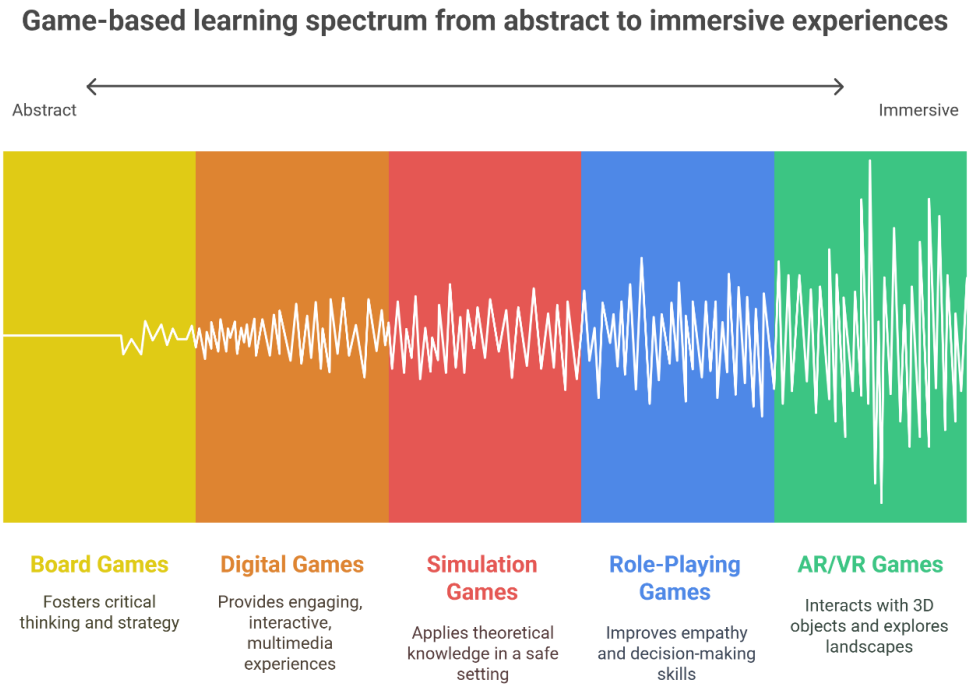

Figure 2. Game-Based Learning Spectrum: From Abstract to Immersive Experiences

The pedagogical importance of GBL lies in its ability to promote active learning, intrinsic motivation, and cognitive engagement. Research indicates that students who participate in game-based instruction demonstrate higher retention, increased problem-solving abilities, and improved conceptual understanding compared to those in traditional settings (Karakoc et al., 2022). GBL also supports the development of 21st-century skills such as collaboration, communication, creativity, and critical thinking (Yeh et al., 2023).

Furthermore, GBL is particularly effective in early childhood and primary education, where attention spans are shorter and play is a natural mode of learning. Studies have shown that integrating games into early literacy and numeracy instruction can improve foundational skills while reducing math anxiety and learning resistance (Riley, 2024; McMullen et al., 2024). Digital games, educational apps, board games, role-playing, and simulations provide multiple modalities for differentiated instruction that can address the diverse learning needs of students, especially in multilingual and low-resource contexts (Alotaibi, 2024; Mohamed et al., 2024).

Importantly, the National Education Policy (NEP) 2020 in India endorses game-based and play-based learning as core strategies for foundational education, reinforcing the relevance of GBL in mainstream pedagogy (Ministry of Education, 2020). As technology becomes more accessible, GBL also offers scalable and low-cost solutions for improving learning outcomes in both formal and informal settings. Its potential to foster inclusive, joyful, and self-directed learning makes GBL an important innovation for bridging early learning gaps and preparing children for lifelong learning.

Table 2: Advantages and Limitations of Game-Based Learning

S. No.	Advantages	Limitations
	Increased Motivation and Engagement	High Development Costs
	Enhanced Cognitive Development	Potential for Distraction
	Active Learning and Knowledge Retention	Limited Scope of Learning Outcomes
	Development of Social and Emotional Skills	Risk of Over-Commercialisation
	Real-World Skill Application	Technical Challenges
	Adaptability and Personalisation	*Dependency on Technology*

**This table presents the pedagogical benefits and constraints of Game-Based Learning (GBL) in educational contexts.*

Synergy Between Game-Based Learning and Foundational Literacy and Numeracy

The intersection of Game-Based Learning (GBL) and Foundational Literacy and Numeracy (FLN) offers a compelling pedagogical framework for early education. While FLN forms the bedrock of lifelong learning, GBL provides a dynamic, engaging, and learner-centred approach to deliver foundational skills in meaningful contexts (Alotaibi, 2024). Their integration is particularly relevant in the foundational years (ages 3–8), when children learn best through exploration, play, and social interaction (Mayer, 2014).

GBL enhances foundational literacy by promoting reading fluency, vocabulary development, phonemic awareness, and comprehension through interactive storytelling, word games, and phonics-based digital tools (Patel et al., 2024). For example, adaptive digital platforms such as GraphoGame have shown positive effects on decoding and phonological skills among early readers, especially in low-literacy environments. Through repetitive but engaging activities, GBL reinforces literacy subskills while maintaining learner interest and motivation (Gee, 2003; McMullen et al., 2024).

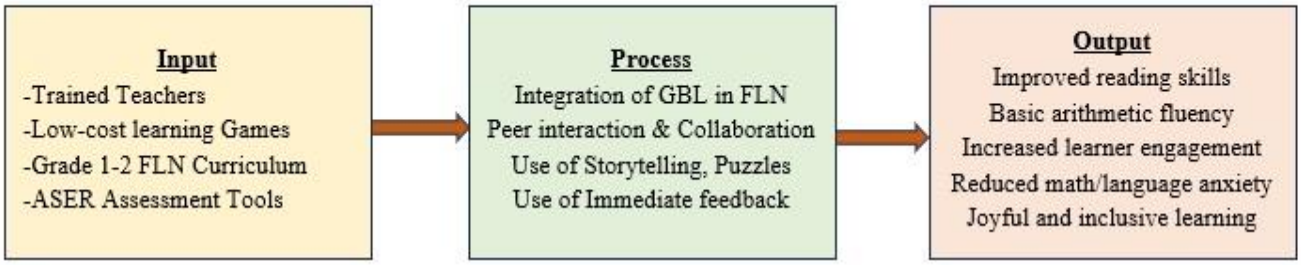

Figure 3. Input–Process–Output Model: Game-Based Learning and FLN Alignment

In the domain of foundational numeracy, GBL supports the development of number sense, pattern recognition, basic arithmetic, and spatial reasoning through math puzzles, number matching, and problem-solving games. These activities encourage children to manipulate numbers and concepts in fun, non-threatening environments, thus reducing math anxiety and improving cognitive flexibility (Riley, 2024; Karakoc et al., 2022). Evidence suggests that GBL not only supports knowledge acquisition but also fosters deeper conceptual understanding and long-term retention of mathematical ideas (Li et al., 2024).

Moreover, GBL facilitates multisensory and differentiated instruction, which is critical in diverse classrooms where children vary in learning pace, language ability, and cognitive readiness (Gupta, S., & Singh, V., 2024). By allowing students to learn by doing, through visuals, sound, movement, and immediate feedback, GBL creates inclusive learning experiences aligned with the constructivist and socio-cultural learning paradigms (Vygotsky, 1978; Shute, 2016).

The National Education Policy (NEP), 2020 of India strongly advocates play-based, experiential, and activity-based learning for the foundational stage, recognising that joyful and meaningful instruction enhances learner engagement and foundational outcomes (Ministry of Education, 2020). In this context, GBL acts as a catalyst, aligning with policy goals while offering practical, scalable tools to bridge FLN gaps, particularly in resource-constrained settings. In summary, the synergy between GBL and FLN lies in GBL's capacity to make learning visible, joyful, and contextually relevant, thereby ensuring that foundational skills are not just taught but truly understood and retained (Gupta, S., Sharma, M., & Shukla, P., 2025). As the global focus shifts toward equity and quality in early education, this integrated approach emerges as both timely and transformative.

REVIEW OF RELATED LITERATURE

Foundational Literacy and Numeracy (FLN) are globally acknowledged as critical for lifelong learning and socio-economic advancement. Numerous international studies emphasize that children who do not acquire reading and arithmetic proficiency by the end of Grade 3 are more likely to face learning difficulties in higher grades and are at greater risk of dropping out (Bullard, 2023; Shvartsman & Shaul, 2024). According to the World Bank (2019), over 50% of children in low- and middle-income countries suffer from "learning poverty," defined as the inability to read and comprehend a simple text by age 10.

In the Indian context, the Annual Status of Education Report (ASER, 2018) revealed that only 44.2% of Grade 5 students in government schools could read at a Grade 2 level, and less than half could perform basic subtraction. These statistics underscore the systemic challenges in foundational education and point to the need for innovative pedagogical interventions.

Game-Based Learning (GBL) has gained momentum as a learner-centred instructional approach that leverages the engaging, immersive, and interactive features of games to support learning. Gee (2003) argued that well-designed games mirror effective learning principles such as active engagement, feedback, and situated cognition. Mayer (2014) emphasized that game-based instruction promotes deep learning when it aligns educational content with well-structured challenges and rewards.

Empirical studies have validated the effectiveness of GBL in improving both literacy and numeracy outcomes. Alotaibi (2024), in a meta-analysis of early childhood education studies, found that GBL significantly enhanced reading fluency, vocabulary development, and comprehension. Similarly, Patel et al. (2024) reported that the use of GraphoGame, a phonics-based game,

improved foundational literacy among Indian primary school children in low-resource settings. For numeracy, Karakoc et al. (2022) concluded through meta-analysis that GBL significantly increased mathematical achievement across multiple educational levels. Li et al. (2024) found that digital games positively influenced learning motivation and engagement, which mediated improved academic outcomes. In another study, McMullen et al. (2024) demonstrated that game-based instruction in rational number concepts led to improved cognitive flexibility and problem-solving among elementary students. Moreover, Riley (2024) noted a reduction in math anxiety among adult learners when GBL methods were integrated into STEM instruction.

While most studies validate the effectiveness of GBL in developed contexts, emerging research from low- and middle-income countries supports its scalability and contextual relevance. Hou and Li (2024) showed that blended, game-based learning approaches in remote environments improved both conceptual understanding and learner participation.

Despite these promising findings, the application of GBL to address foundational learning deficits in rural or public Indian schools remains underexplored. Most existing studies either focus on developed educational systems or involve digital games requiring substantial infrastructure. There is limited evidence on the effectiveness of low-cost, context-specific GBL strategies tailored for early-grade students in resource-constrained environments.

Although previous studies have demonstrated the positive impact of GBL on student engagement and academic performance, there exists a significant gap in empirical research focusing on:

1. The impact of GBL specifically on FLN outcomes in Indian government primary schools.
2. The effectiveness of non-digital or hybrid (digital + physical) game-based interventions where digital infrastructure is limited.
3. The use of quasi-experimental designs with standardised assessment tools (e.g., ASER) to objectively evaluate the learning gains from GBL in the foundational stage.

This study attempts to bridge these gaps by examining the effect of game-based learning interventions on FLN development among Grade 1 and 2 students in a government school in India using a quasi-experimental pre-test–post-test control group design.

RESEARCH OBJECTIVES

1. To study the foundational literacy and numeracy of the foundational stage students before the treatment of game-based learning
2. To study the foundational literacy and numeracy of foundational stage students after treatment with game-based learning.
3. To examine whether there is a significant difference in post-test scores of foundational literacy and numeracy between the experimental group and the control group.

RESEARCH HYPOTHESIS

H_{01}: There is no significant difference in FLN scores of students before the GBL intervention.
H_{02}: There is no significant difference in FLN scores of students after the GBL intervention.
H_{03}: There is no significant difference between experimental and control groups in post-test FLN scores.

METHODS

The present study employs a quantitative approach, incorporating elements of experimental design, to evaluate the impact of game-based learning. A quasi-experimental, pre-test, and post-test design is used to measure the difference in literacy and numeracy skills before and after the intervention. Researchers have taken up an experimental study to describe, explain and interpret the present existing phenomenon. In this present study, a pre-test post-test control group design was used to find out the effect of Game-Based Learning (GBL) on the foundational literacy and numeracy of foundational stage students. The figure given below in Table 3 shows the design of the study.

Table 3: **Research Design: Pre-Test and Post-Test Control Group Structure**

Group	Pre Test (O1)	Intervention	Post-Test (O2)	Comparison
Control Group	$M_{CG}O_1$	No Intervention	$M_{CG}O_2$	$M_{CG}O_1$~$M_{CG}O_2$
Experimental Group	$M_{EG}O_1$	Game-Based Learning	$M_{EG}O_2$	$M_{EG}O_1$~$M_{EG}O_2$

Where [1]$M_{CG}O$: Mean scores of observations of the control group
[3]$M_{EG}O$: Mean scores of observations of the experimental group

Sample & Sampling Procedure-

Keeping in mind the size of the population researcher has decided to select a true representation of the population. Therefore, the researcher has selected one institute purposely and 40 students of the foundational stage from the selected institute randomly. The sampling procedure regarding this study may be categorized in two categories.

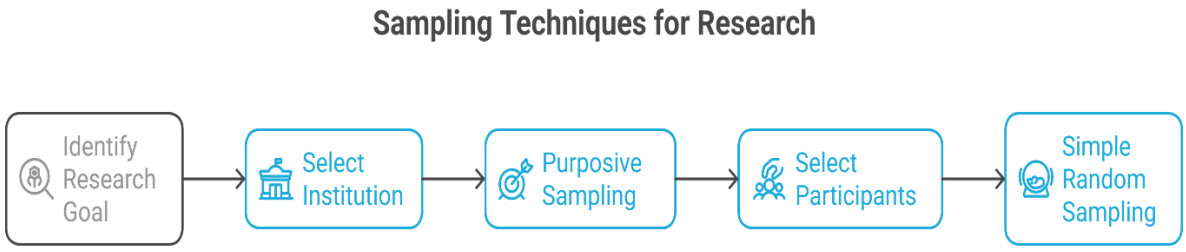

Figure 4. Sampling Procedure and Group Assignment

Tool and Statistical Technique

To assess the foundational literacy and numeracy skills of students, the ASER (Annual Status of Education Report) tool was used in this study. The ASER tool is a widely recognised and validated assessment tool that measures basic reading and arithmetic levels among children aged 5 to 16 years.

The reliability of the test is given in Table No. 4:

Table 4: Reliability of the ASER Tool for FLN Assessment

Sr. No.	Type of Reliability	Task Assessment	Reliability coefficient
1.	Test- Retest Reliability	ASER reading test ASER math test	0.95 0.90
2.	*Inter-rater Reliability*	*ASER reading test* *ASER math test*	*0.64* *0.65*

**This table displays test-retest and inter-rater reliability coefficients for the ASER reading and math assessment tools.*

This study assessed two distinct foundational skills, literacy and numeracy, using separate ASER instruments. For the primary analysis, these scores were combined into a single composite FLN score to provide an overall measure of foundational learning. This decision was grounded in the integrative nature of the intervention and to enhance statistical power for detecting an overall effect.

Consequently, an Analysis of Covariance (ANCOVA) was conducted to examine post-intervention differences, treating the *composite post-test FLN score* as the dependent variable, *Group* (Experimental vs. Control) as the independent factor, and the *composite pre-test FLN score* as the covariate. This approach is statistically more powerful and appropriate for pre-test-post-test control group designs than simple ANOVA, as it adjusts for initial group differences**."**

For data analysis, appropriate statistical techniques were applied at different stages of the study. The details are presented in Table 5:

Table 5: **Stages of Data Analysis, Statistical Techniques, and Their Purpose**

S. No.	*Stage of Analysis*	*Statistical Technique Used*	*Purpose*
1.	Pre-test comparison (Experimental vs. Control)	Independent Samples t-test	To examine the baseline equivalence of the groups before intervention
2.	Within-group comparison (Pre-test vs. Post-test of Experimental Group)	Paired Samples t-test	To assess improvement in foundational literacy and numeracy within the experimental group
3.	Between-group comparison (Post-test scores of Experimental vs. Control)	Analysis of covariance (ANCOVA)	To examine whether there is a significant difference in post-test performance between the groups after adjusting for pre-test scores.

This approach ensured that both within-group progress and between-group differences were analysed rigorously, while controlling for possible initial differences at the pre-test stage.

Note: To ensure clarity, coherence, and academic tone, AI-based language enhancement tools such as Grammarly and ChatGPT were used for language correction and refinement in the preparation of this section.

RESULTS

H_{01}: There is no significant difference in FLN scores of students before the GBL intervention.

Table No. 6: **Pre-Test Scores: Experimental vs. Control Group**

Group	N	Mean	SD	Df	*t*cal	Effect Size (Cohen's *d*)	Remark
Experimental	20	5.30	1.742	38	0.87	0.22	Not significant at the 0.05 level
Control	20	4.95	1.370				

**This table shows the mean scores, standard deviations, t-value, and effect size for the comparison of the experimental and control groups before the intervention.*

The analysis of pre-test scores for foundational literacy and numeracy skills (FLNS) using the ASER tool revealed no statistically significant difference between the experimental and control groups before the intervention. As shown in Table 1, the experimental group had a mean score of 5.30 (SD = 1.742), while the control group scored a mean of 4.95 (SD = 1.370). The calculated *t*-value was 0.87 with 38 degrees of freedom, which is less than the critical *t*-value at the 0.05 level of significance ($p > 0.05$), indicating that the difference is not statistically significant.

Additionally, the effect size as measured by Cohen's *d* was 0.22, which is considered small (Cohen, 1988). This further supports the conclusion that the two groups were statistically equivalent at baseline in terms of their foundational literacy and numeracy abilities.

These findings are important as they confirm the comparability of the two groups before the application of the game-based learning (GBL) intervention. Such equivalence is critical in quasi-experimental research to ensure that any post-intervention differences can be attributed to the treatment rather than pre-existing disparities (Shadish et al., 2002).

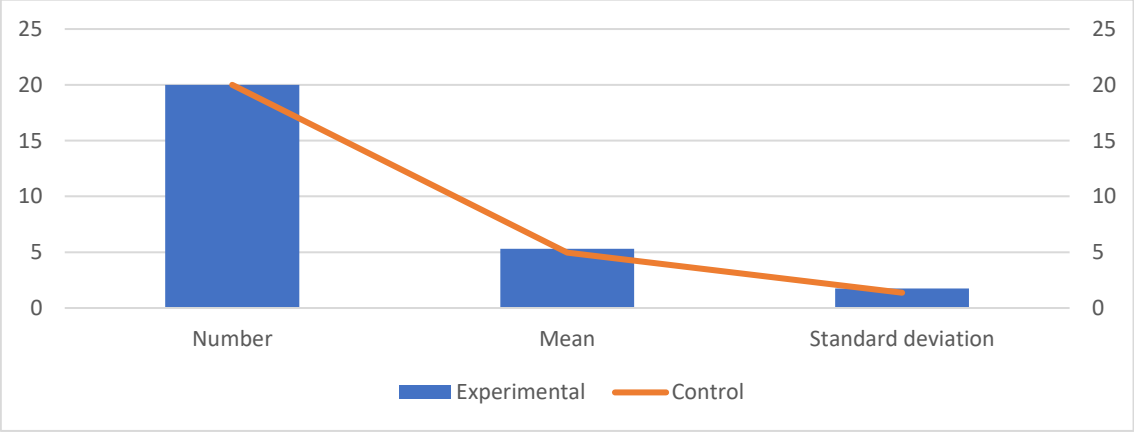

Figure 5. Mean Scores of the Control and Experimental Groups at Pre-Test

The result aligns with previous studies where researchers established similar baseline equivalence in pre-test conditions before applying innovative pedagogical treatments. For example, Patel et al. (2024) conducted a randomised controlled trial on Grapho Game-based phonics intervention in Indian schools and found no significant difference between the control and experimental groups at the pre-test stage. Likewise, Karakoc et al. (2022), in their meta-analysis of game-based learning interventions, emphasised the necessity of baseline equivalence to ensure valid inferences about treatment effectiveness.

H_{02}: There is no significant difference in FLN scores of students after the GBL intervention.

Post Testing Stage-

This section deals with the analysis and interpretation of the performance of experimental and control groups in the ASER Test for foundational literacy and numeracy (FLN) skills. After the implementation of Game-Based Learning (GBL). In this section, the comparison between the scores in pretest and post-test of experimental groups in literacy and numeracy was considered for assessment. The performance of students of experimental and control groups was also compared after the implementation of Game-Based Learning.

Sub-Section I- Comparison between mean scores of experimental groups concerning the Pretest and post-test of the ASER Test of foundational literacy and numeracy

Sub-Section II- Comparison between the mean scores of the experimental group and the control group concerning the post-test of foundational literacy and numeracy skills (FLNS)

Sub Section III- Measure the effectiveness of Game-Based Learning on overall foundational literacy and numeracy skills of foundational stage students, Class (1st and 2nd)

Table-7: Pre-Test vs. Post-Test Scores of Experimental Group (Paired-Samples t-test)

Group	Scores	N	Mean	SD	df	*t*- value	Effect Size (Cohen's *d*)	Remark
Experimental Group	Pre-Test	20	5.30	1.940	19	4.12	1.46	significant at the 0.05 level
	Post-Test	20	7.10	0.726				

**This table compares mean scores before and after the GBL intervention within the experimental group and indicates statistical significance.*

The comparison of pre-test and post-test scores within the experimental group shows a statistically significant improvement in foundational literacy and numeracy (FLNS) skills after the implementation of Game-Based Learning (GBL). As detailed in Table 2, the mean score increased from 5.30 (SD = 1.940) in the pre-test to 7.10 (SD = 0.726) in the post-test. The computed *t*-value was 4.12 with 19 degrees of freedom, exceeding the critical value at the 0.05 level of significance, indicating that the improvement is statistically significant ($p < 0.05$).

Furthermore, the calculated Cohen's *d* effect size was 1.46, which represents a very large effect according to conventional benchmarks (Cohen, 1988). This large effect suggests that the GBL intervention had a substantial impact on improving the literacy and numeracy outcomes of students in the experimental group.

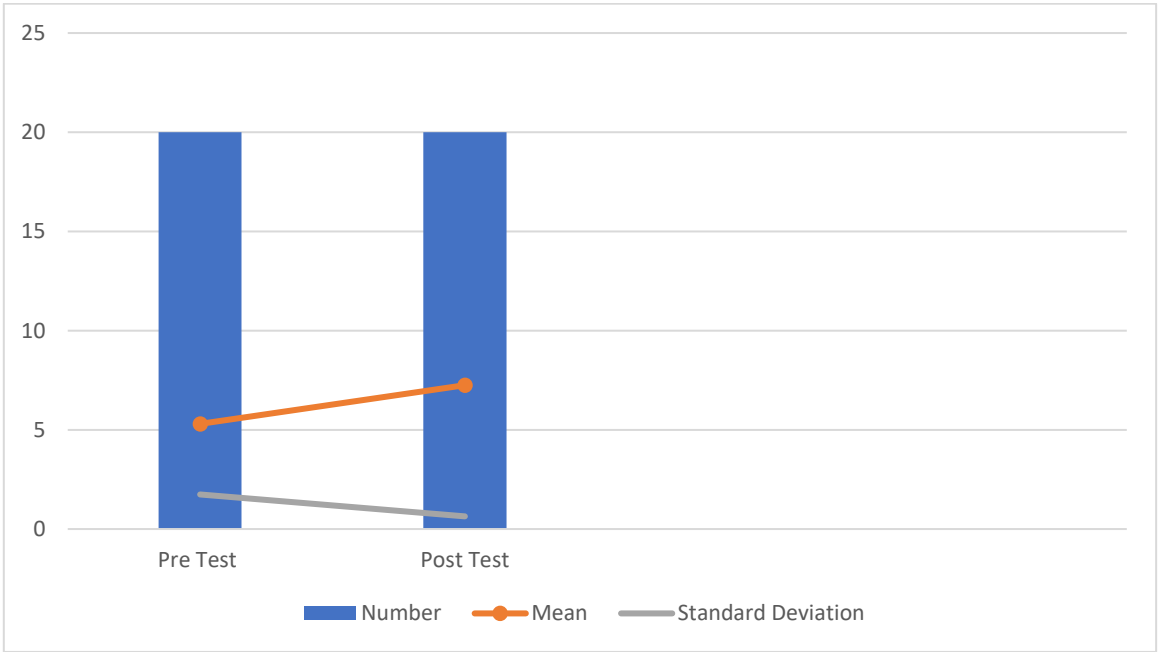

Figure 6. Mean Scores of Experimental Group: Pre-Test vs. Post-Test

These findings are consistent with a growing body of literature highlighting the positive influence of game-based learning on academic outcomes in early education. For instance, Alotaibi (2024), in a meta-analysis of GBL studies in early childhood education, found significant improvements in students' reading fluency and math accuracy following digital and physical game-based interventions. Similarly, McMullen et al. (2024) reported that students who engaged in GBL activities developed stronger number sense and cognitive flexibility compared to those taught via traditional methods.

The success of GBL in this context can be attributed to its interactive, play-based format, which aligns with the cognitive and emotional needs of young learners. By integrating literacy and numeracy content into game mechanics, students remained more engaged, received instant feedback, and participated actively in their learning process (Gee, 2003; Mayer, 2014).

These results reinforce the call from the National Education Policy (NEP), 2020, which advocates for play-based, experiential learning approaches at the foundational level to foster joyful and effective learning experiences (Ministry of Education, 2020). The strong effect observed in this study suggests that GBL can serve as a powerful pedagogical strategy to accelerate foundational learning in early primary education, particularly in environments where conventional instruction may fail to engage diverse learners.

H_{03}: There is no significant difference between experimental and control groups in post-test FLN scores.

Table 8: Descriptive Statistics for Post-Test Composite FLN Scores by Group

Descriptives - post score					
Group	N	Mean	SD	SE	Coefficient of variation
Experimental	20	7.100	0.788	0.176	0.111
Control	20	7.150	0.933	0.209	0.131

The descriptive statistics for the post-test composite FLN scores are presented in Table 8. The control group (N = 20) achieved a mean score of 7.15 (SD = 0.93), while the experimental group (N = 20) obtained a mean score of 7.10 (SD = 0.79). The negligible mean difference of 0.05 points and the overlapping standard deviations indicate that the post-test performance of both groups was very similar before accounting for pre-test differences.
Sss

Table 9: **Analysis of Covariance (ANCOVA) for Post-Test Composite FLN Scores with Pre-Test as Covariate**

ANCOVA - post score							
Cases	**Sum of Squares**	**df**	**Mean Square**	**F**	**p**	**η^2**	**ω^2**
Group	0.025	1	0.025	0.057	.813	8.928×10^{-4}	0.000
pre-test **score**	11.864	1	11.864	26.628	< .001	0.418	0.396
Residuals	16.486	37	0.446				

Note. **Type III Sum of Squares**

An Analysis of Covariance (ANCOVA) was conducted to compare the post-test composite FLN scores between the experimental and control groups, while controlling for the pre-test composite scores as a covariate. The pre-test score was a significant covariate, $F(1, 37) = 26.63$, $p < .001$, partial $\eta^2 = .418$, indicating that pre-intervention FLN levels were a strong predictor of post-intervention scores.

After adjusting for pre-test differences, the ANCOVA revealed no statistically significant main effect of Group on the post-test scores, $F(1, 37) = 0.06$, $p = .813$, partial $\eta^2 < .001$. The effect size (partial eta squared) is minimal, suggesting that the game-based learning intervention did not lead to a statistically significant difference in FLN outcomes compared to traditional instruction when baseline scores were controlled.

This finding, while indicating that GBL was not superior to traditional methods in this specific instance, is consistent with several prior studies that highlight the contextual factors influencing GBL's effectiveness. For example, Karakoc et al. (2022), in their meta-analysis, noted that while GBL generally has a positive effect, the magnitude of this effect can be moderated by variables such as intervention duration and sample characteristics. Similarly, Aldo et al. (2022) found that the comparative advantage of game-based learning over video-based learning was not always statistically significant, especially in short-term interventions where both instructional methods were effective. Furthermore, Mohammed et al. (2024) reported that in their study using a repeated measures design, while within-group improvements were notable, the gains from GBL were not always distinct enough from those achieved through conventional methods to produce significant between-group differences, particularly when the control group also received structured, quality instruction. These studies collectively suggest that the non-significant between-group result in the current study may be attributed to factors such as the short intervention period, the small sample size, or the possibility that the traditional instruction received by the control group was itself sufficiently effective, thereby limiting the observable differential impact of the GBL intervention.

DISCUSSION

The present study examined the impact of Game-Based Learning (GBL) on the development of Foundational Literacy and Numeracy (FLN) among early-grade students. Findings revealed significant within-group improvements in the experimental group, demonstrating that GBL enhanced students' reading and arithmetic skills, confidence, and engagement. These results are consistent

with prior research that highlighted the effectiveness of GBL in improving literacy and numeracy outcomes through interactive, child-centred approaches (Alotaibi, 2024; McMullen, McDonagh, & Mulligan, 2024).

The strong within-group effect (Cohen's d = 1.46) suggests that GBL interventions are particularly effective in short-term, intensive implementations. Similar conclusions were reported by Patel et al. (2024), who found substantial literacy gains among Indian primary students through phonics-based games, and by Karakoc, Erdem, and Adıgüzel (2022), who emphasised that well-designed educational games significantly enhance achievement across disciplines. Furthermore, GBL's ability to reduce math anxiety and foster positive attitudes toward learning has been highlighted in earlier studies (Riley, 2024), which supports the observation that students in the experimental group displayed greater confidence and active participation.

However, contrary to the study's hypothesis, the ANCOVA results indicated no statistically significant difference in post-test FLN scores between the experimental and control groups after controlling for pre-test abilities. This non-significant finding ($p = .813$), coupled with a negligible effect size (partial $\eta^2 < .001$), suggests that the game-based learning intervention, as implemented in this study, was not sufficient to produce a differential impact on overall foundational learning compared to conventional methods. This outcome may be attributed to contextual factors such as the short duration of the intervention, the small sample size, or the possibility that both groups received instruction that was effective in promoting learning gains. These factors are known moderators of intervention effectiveness (Shadish, Cook, & Campbell, 2002; Mishra, 2021). Future studies with longer intervention periods and larger samples are needed to further investigate the comparative effectiveness of GBL.

Despite this limitation, the study supports India's NEP 2020 vision, which emphasizes activity-based and play-based strategies at the foundational level to foster joyful learning (Ministry of Education, 2020). The findings align with Gee's (2003) and Shute's (2016) assertions that game-based environments facilitate active knowledge construction and provide continuous feedback, thereby creating inclusive and motivating learning spaces. Moreover, the effectiveness of low-cost, culturally relevant GBL materials demonstrates its potential scalability in government schools, addressing the challenges of resource constraints highlighted by ASER (2018).

In summary, while the intervention showed significant within-group gains but not between-group differences, the study contributes valuable evidence for integrating GBL into foundational classrooms. Future research should employ larger, multi-site samples and longer intervention periods to better capture the comparative benefits of GBL. Longitudinal studies may also explore how sustained exposure to GBL influences long-term learning trajectories and student motivation.

Table 10: Reflections and Educational Implementation of Game-Based Learning (GBL) in Educational Settings

S. No.	Key Reflection	Educational Implementation
1	GBL is effective in enhancing foundational literacy and numeracy skills among young learners, as evident from the significant improvement in post-test scores of the experimental group.	Teachers should be oriented and trained in the design and use of age-appropriate educational games to enhance classroom interaction and promote better learning outcomes.
2	The experimental group significantly outperformed the control group in the post-test, confirming the superiority of the game-based instructional approach over traditional methods.	The effectiveness of GBL aligns with the National Education Policy (NEP) 2020's vision of promoting experiential, play-based, and child-centred pedagogy, especially at the foundational level.
3	Game-based learning not only supports academic achievement but also encourages greater student engagement and active participation in the learning process.	The significant improvement in literacy and numeracy among the experimental group suggests that GBL should be actively incorporated into foundational stage curricula to support joyful and engaging learning.
4	GBL promotes critical Thinking, active participation, peer learning, and interest in learning.	Schools should be encouraged to create classroom environments that foster such interactive learning experiences.
5	Game-based activities do not necessarily require expensive resources.	With creative and contextual materials, even low-cost or no-cost games can be used to effectively improve foundational skills.

**This table highlights reflections from the study and their corresponding implications for classroom-level implementation of GBL practices.*

Despite its promising results, the study is limited by its small sample size and single-school setting. Future research should include larger, multi-site studies and explore the long-term effects of GBL on student achievement. Overall, the results affirm that GBL is not only theoretically sound but also a practical, scalable, and inclusive strategy to strengthen foundational skills in early education.

CONCLUSION

This study evaluated the effectiveness of Game-Based Learning (GBL) in enhancing Foundational Literacy and Numeracy (FLN) among Grade 1 and 2 students through a quasi-experimental design. The results demonstrated significant within-group

improvements in the experimental group, with a large effect size, indicating that GBL can effectively promote early reading and numeracy skills. These findings are consistent with prior research demonstrating the benefits of structured game-based interventions for literacy and numeracy development (Alotaibi, 2024; McMullen, McDonagh, & Mulligan, 2024; Karakoc, Erdem, & Adıgüzel, 2022).

Although between-group post-test differences were not statistically significant, the observed within-group gains underscore GBL's potential as a child-centered pedagogical strategy. Similar challenges regarding sample size, intervention duration, and implementation fidelity have been noted as moderating factors in earlier studies (Shadish, Cook, & Campbell, 2002; Mishra, 2021). This suggests that longer-term and large-scale interventions may yield clearer comparative advantages of GBL over traditional instruction.

Importantly, the study aligns with the recommendations of India's National Education Policy (Ministry of Education, 2020), which advocates experiential, play-based, and joyful learning approaches to strengthen FLN. GBL fosters engagement, motivation, and confidence among young learners (Gee, 2003; Shute, 2016), while also offering scalable solutions in low-resource contexts, as highlighted by the ASER (2018) findings on learning poverty in India.

In conclusion, GBL emerges as a promising and policy-aligned approach to support early-grade education. Its integration into mainstream pedagogy, supported by teacher training and low-cost, contextually relevant resources, has the potential to bridge FLN gaps and contribute to achieving universal foundational learning by Grade 3 in India. Future studies should expand on these findings through multi-site, longitudinal designs to explore the sustained impact of GBL on learning outcomes.

DECLARATIONS

Ethical Approval and Consent to Participate

This study received approval from the Institutional Ethics Committee of the Department Quality Assurance Cell (DQAC), Chhatrapati Shahu Ji Maharaj University, Kanpur, Uttar Pradesh, India. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent

Informed consent was obtained from the parents/legal guardians of all participating students before the commencement of the study. The purpose, procedures, potential risks, and benefits of the research were explained in detail in the local language. Guardians were assured of the voluntary nature of participation and their right to withdraw their child from the study at any time without consequence. Written consent forms were collected and securely stored.

Data Availability Statement

The datasets generated and analysed during the current study are not publicly available to protect participant confidentiality, but are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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