International Journal of Social Science and Economic Research

ISSN: 2455-8834

Volume:11, Issue:08 "August 2026"

A Game-Based Toolkit Intervention for Reducing Mathematics Anxiety Amongst Students with Dyscalculia: A Pilot Study

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DOI: 10.46609/IJSSER.2026.v11i08.017 URL: https://doi.org/10.46609/IJSSER.2026.v11i08.017
Received: 5 August 2026 / Accepted: 18 August 2026 / Published: 22 August 2026

ABSTRACT

Mathematics anxiety, particularly seen in students with Dyscalculia, limits their ability to achieve conceptual clarity and confidence in solving mathematical operations. Understanding of basic concepts is essential to become successful in the subject. This study introduces Tiny Theorems, a mathematics toolkit consisting of four games, built based on visual cues to help reinforce basic topics including number sense, addition, subtraction, multiplication, and division. The toolkit dismissed the traditional classroom approach by changing the way problems are presented to students. A quantitative pilot study involving twenty grade two students was conducted with a record of pre-test and post-test scores to check the effectiveness of the toolkit in improving students' clarity. Students demonstrated improvement, suggesting the potency of the toolkit.

Keywords: Mathematics anxiety, Dyscalculia, Tiny Theorems Toolkit

1. Introduction

Mathematics anxiety is a widespread problem that affects student achievement across all age groups. It is associated with feelings of fear, stress, and eventually losing their confidence in the subject, leaving the student isolated (Naseek, 2021). If left unattended, these challenges can contribute towards long-term academic struggles, ultimately preventing students from demonstrating their full mathematical intellectual capacity. In the cognitive sciences, researchers have termed this anxiety as ‘dyscalculia,’ a cognitive deficiency which limits students' aptitude to acquire arithmetic skills and understand fundamental ideas in numeracy (Michaelson, 2007). Dyscalculia learners face severe difficulties in understanding simple mathematical concepts, including addition, subtraction, multiplication, and division, lack an intuitive grasp of numbers, and face difficulties in learning number facts and procedures (Drew, 2015). There is a critical need for targeted interventions to support students with dyscalculia and improve their performance significantly in the subject. Traditional instructional methods may not be able to

ISSN: 2455-8834

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address the diverse learning needs of such students, highlighting the importance of alternative approaches that incorporate visual learning, activities and conceptual reinforcement. This can help enhance mathematical understanding, thereby drastically reducing math anxiety.

2. Literature Review

According to IJIRSS , Math anxiety is a fear-evoking, unpleasant feeling towards Mathematics. It can be caused by several factors, including low self-confidence, negative experiences in math, and a lack of cognitive abilities. Students thus start to associate negative feelings towards the subject. According to (Salinas et. al., 2019), environmental, cognitive, personality, and gender influences affect math anxiety. The factors are as follows:-

1. Family-related factors - Parents' anxiety about math often results in math anxiety amongst children. Additionally, parents' hesitation about their child's math skills often impacts the child's self-esteem.

2. Teacher-related factors - Teaching with very high requirements and less cognitive and motivational support discourages students. The teaching methodology adopted by the teacher plays a vital role in the child's math learning.

3. School-related factors - The school's environment, which includes the policies and activities organised by the administration, contributes to math anxiety.

Stuart (2000) found that students, during science experiments, who had earlier viewed mathematics negatively began to feel more confident regarding their abilities. On the other hand, children with low self-esteem with regard to the subject continue to associate negative feelings. Mathematics performance is related to mathematics anxiety, in accordance with (Zanabazar et al., 2023). Students with high math anxiety tend to receive lower scores on a test. Whereas students with low math anxiety receive higher scores. Hence, learning methods need to be adopted by teachers to improve students' scores. Targeted interventions are required to help students improve their mathematical anxiety levels.

3. Methodology

This study aims to assess the effectiveness of a toolkit designed to help students facing mathematical anxiety, particularly dyscalculia. Observing students facing difficulties with simple mathematical concepts in a classroom setting highlighted the need for a structured learning approach. The toolkit is created to provide an alternative to traditional teaching methods, which fail to meet the unique needs of each child. The toolkit consists of four games to reinforce simple mathematical concepts, including number sense, addition, subtraction, multiplication, and

ISSN: 2455-8834

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division. The games, unlike conventional educational methods, use visual aids to bring clarity for students.

This study employs a quantitative approach. The quantitative part involves a survey. The study includes twenty students of grade two studying in the same school, located in New Delhi, India, so that there will be no difference with regard to the environment and curriculum of the students. To further reduce variability, students are assigned randomly into two equal groups - the experimental group, i.e., the group exposed to the toolkit, and the control group, i.e., the group which is not exposed to the toolkit.

Over the course of three weeks, six sessions were conducted with both groups. In the first session, both groups were given a pre-test to analyse students' mathematical understanding. Thereafter, the experiment group was introduced to the concepts using the toolkit. On the other hand, the control group was taught the same concepts using standard teaching methods. In the sixth session, a post-test was conducted to evaluate students' scores. The pre- and post-test scores were then compared. If the post-test scores of students in the experimental group showed significant improvement as compared to the pre-test, then the toolkit is effective in overcoming mathematical anxiety.

Ethical considerations were strictly followed throughout the study. Prior permission was obtained from the school administration, and consent was taken from parents or guardians of all students. Participation was voluntary, and students had the right to withdraw from the study at any time without facing any consequences. Additionally, confidentiality was maintained by using numerical codes for each student. Care was taken to ensure no participant experienced psychological distress. Both groups were taught the same academic content to ensure fairness. After completion of the study, the control group was also given access to the toolkit to avoid any educational disadvantage.

4. Data Collection

Table 1: Experimental Group

Pre- Test (30)	Post- Test (30)	Improvement
13	17	+4
11	14	+3
14	21	+7
12	18	+6

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20	26	+6
15	17	+2
23	30	+7
9	11	+2
14	19	+5
23	28	+5

The pre-test and post-test scores (out of thirty marks) of the experimental group are recorded above in Table 1. Each child exposed to the toolkit has shown significant improvement with regard to their scores. The gains range from a minimum improvement of +2 to a maximum improvement of +7 marks. For each student, improvement occurred at different rates. For example, a child who was earlier scoring 14 marks out of thirty is now scoring 21 marks out of thirty. Similarly, students who already had relatively higher baseline scores, such as 23 out of 30, were still able to improve further, ultimately reaching a score of 28 out of 30. This indicates that the toolkit has been effective in not only helping low-performing students but also enhancing the performance of already high-performing students by strengthening conceptual clarity with regard to the topics.

Table 2: Control Group

Pre- Test (30)	**Post- Test (30)**	**Improvement**
13	14	+1
10	8	-2
16	16	0
12	9	-3
20	23	+3
14	15	+1
22	19	-3
25	18	-7

ISSN: 2455-8834

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14	13	-1
18	14	-4

The pre-test and post-test scores (out of thirty marks) of the control group are recorded above in Table 2. The traditional teaching methods have failed to help students understand the concepts. While some students have shown slight improvement, most have performed worse on the post-test. The range of change varies from +3 to -7 marks. For example, a child who was earlier scoring 18 marks out of thirty is now scoring 14 marks out of thirty. Additionally, a student with a relatively high baseline score, i.e., 25 out of 30, has shown a concerning drop in performance by 7 marks to ultimately score an 18 out of 30 despite the student having prior understanding. This suggests that traditional learning approaches often fail to meet the required understanding.
When comparing the experimental group with the control group, there is a clear difference in learning outcomes. The experimental group demonstrates a uniform improvement in scores, while the control group shows variability and even regression in certain cases. This contrast clearly reveals that a game-based toolkit is more effective in supporting mathematical learning.

5. Recommendation

Current educational policies largely favour standardised instructions, leaving students with dyscalculia without adequate support. Therefore, I have developed a toolkit to directly address the gap by offering a structured, visually driven, game-based alternative that can be integrated into classroom settings to create real-world impact.

The toolkit consists of 4 games. The games are as follows -

Game 1 - Number Match Up

This game is to help develop a number sense amongst students. It is for ages three or above. The game consists of 20 number cards and 20 dot cards. Players are required to match each number card to its dot card. Through this game, children practice visualising quantities, counting, matching and improving visual memory, thus building number recognition.

Game 2 - Snakes and Ladders

This game is to help students with addition and subtraction. It is designed for ages 6 and above. The game consists of a Snakes and Ladders board, four playing pieces, three wooden dice with numbers, and plus and minus operation tokens. Players are required to roll any two dice, add/subtract the two numbers and move forward. The first to reach 100 wins. This is great for

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reinforcing basic addition and number tracking, thus helping students build flexibility, conscience and decision making in math.

Game 3 - Multiplication Array Attach

This game helps students master their multiplication skills. The game consists of 2 wipe-erasable game boards, 3 number dice, and 2 dry-erase markers. Players roll all three dice. They are then required to choose any two numbers to multiply. They draw the array on their grid using a marker, making sure it doesn't overlap or go off the grid. The player who makes the maximum number of arrays on the board wins. Through this game, students are able to practice times tables without pressure, gain confidence, and build spatial awareness and planning skills.

Game 4 - Division Bingo

This game helps children master division through active play and self-created problems. The game consists of two wipe-erasable bingo boards and 2 dry-erase markers. Players choose a target to complete - eg, a row or number. They write a division problem in the white space on the board and circle the correct answer. Players are required to keep going until they complete their target. This hands-on approach reinforces division of facts, builds number sense and flexible thinking, and offers a low-pressure practice with visual cues and the freedom to think at one's own pace.

6. Conclusion

This study aims to understand whether a game-based toolkit can meaningfully improve mathematical understanding among students experiencing math anxiety, particularly dyscalculia. The findings from the experimental group and the control group present a significant difference in terms of post-test results. Every student exposed to the toolkit showed great improvement in their post-test scores, while the control group showed no consistent progress.

These results suggest that traditional teaching methods, while being standardised, are insufficiently equipped to meet the learning needs of students with dyscalculia. The toolkit, on the other hand, incorporates visual aids and game-based learning that transform abstract mathematical operations into engaging experiences. This reduces the fear and stress associated with the subject.

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