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A Theoretical Framework for Building Positive Mathematical Disposition Through Sports-Integrated Mathematics Teaching (SIMT)

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Abstract

Mathematics anxiety, often referred to as math phobia, is a widespread and severe emotional condition that affects many learners across all stages of education. It is usually characterised by fear, avoidance, negative self-belief, and tension whenever mathematical tasks are encountered, and sometimes imposes long-term consequences on students' academic choices and career trajectories. This paper proposes Sports-Integrated Mathematics Teaching (SIMT) as a pedagogically sound and emotionally responsive approach to reducing math phobia by enhancing conceptual clarity, engagement, and emotional safety. This framework analyzes how sports , particularly football, provide familiar and cognitively accessible contexts for mathematical learning, which is supported by constructivism and Experiential learning theory. Authors collected information on existing literature and classroom observations, then synthesized evidence and applied mathematical examples from football to propose a five-stage conceptual framework: Selection of Sport → Engagement in Sport → Mathematical Conceptual Clarity → Confidence Boosting → Reduced Math Phobia. The paper concludes by outlining pedagogical and research implications, and proposes directions for future empirical validation of the SIMT framework.

Keywords: *mathematics education, math phobia, sports-integrated learning, experiential learning, embodied cognition, conceptual framework*

Introduction

Mathematics, despite its universal significance and intellectual beauty, continues to be perceived as one of the most challenging subjects among school learners. Across all grade levels, a substantial proportion of students experience math phobia means an emotional condition marked by fear, tension, helplessness, and avoidance when confronted with mathematical tasks (Ashcraft & Moore, 2009). Students frequently disengage from the subject early in their academic journey, internalizing the belief that they are simply 'not math

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people.' This self-limiting narrative restricts their confidence and performance in mathematics, thus the subject choices in secondary and higher education.

The roots of math phobia are well documented in many educational researches: overly abstract instruction, disproportionate emphasis on speed and rote accuracy, limited use of real-life contexts, prior academic failures, and other negative classroom experiences; all these contribute to its development (Beilock, 2011). In contrast, today's learners are energised by dynamic, interactive, and embodied environments — sports being an example. Sports are not merely recreational; they carry powerful pedagogical potential as they are embedded in children's lived experience, familiar, emotionally stimulating, and rich in mathematical structure.

In the authors' experience while teaching Class VIII students at Sarvodaya Vidyalaya,Delhi they observed that students who were otherwise disengaged during conventional mathematics lessons showed remarkable alertness and enthusiasm when problems were framed around cricket scores, football statistics, or athletics measurements. A student who struggled to compute averages from textbook exercises could fluently calculate a batsman's run rate when the same operation was presented as a match analysis task. These classroom observations strongly suggested that the emotional and contextual framing of a mathematical problem is as important as its mathematical content — a conviction that motivated the present theoretical inquiry.

The present paper argues, on the basis of theoretical reasoning and classroom observation, that integrating sports into mathematics instruction can meaningfully reduce math phobia. This helps a teacher in grounding abstract mathematical ideas in real-world contexts which students already find meaningful, and by leveraging the emotional safety of play-based environments, teachers can create learning experiences that are both intellectually rigorous and affectively supportive. Football is selected as the primary context in this paper because of its global familiarity, structural complexity, and the breadth of mathematical concepts it naturally embodies.

Review of Related Literature

1. Understanding Math Phobia

Math Phobia or math anxiety is described in literature as a trauma or fear for mathematical activities and tasks, which is identified by escaping from the subject , cognitive blankness, and pervasive anxiety.(Richardson & Suinn, 1972). It arises from multiple factors such as : rote-centred pedagogy, fear of making mistakes, negative mindset, disconnect from real life situations, and frequent failures that weaken self-confidence. These causal factors indicate an urgent need to reconceptualise mathematics classrooms as place of joy, exploration, and contextual meaning-making.

2. Constructivism

Piaget's constructivist framework (1973) asserts that learners are not passive recipients of information; rather, they construct knowledge by connecting new experiences to existing cognitive schemas. When mathematics instruction is anchored in contexts that are already

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familiar and meaningful to learners — such as the rules, scores, and spatial relationships of a sport — concept formation occurs more naturally, with reduced cognitive friction and emotional resistance.

3. Experiential Learning Theory

Kolb's Experiential Learning Theory (1984) proposes a four-stage cycle: concrete experience, reflective observation, abstract conceptualisation, and active experimentation. Sports organically integrate all four stages. For example Football, provides the physical experience; post-game reflection ('Why did that strategy succeed?') supports observational thinking; identifying mathematical patterns (angles, distances, probability) constitutes abstract conceptualisation; and modifying game tactics represents active experimentation. This integration makes sports a tool for deep understanding of mathematics.

4. Mathematics Anxiety: Cognitive and Affective Dimensions

Mathematics anxiety has been formally defined as a feeling of tension, apprehension, or fear that interferes with mathematical performance (Ashcraft, 2002). Research indicates that it typically develops early in schooling, often as a direct consequence of negative learning experiences and teacher-centred pedagogies (Carey et al., 2016). These affective responses directly impact working memory, problem-solving efficiency, and long-term academic motivation. Addressing mathematics anxiety requires a fundamental reconceptualisation of classroom environments — one that is emotionally supportive, contextually grounded, and cognitively engaging (Dowker et al., 2019).

5. Sports and Mathematics Integration: Recent Evidence

Recent empirical research lends strong support to the pedagogical value of sports contexts for mathematics instruction. Williams and Wilson-Kennedy (2025) demonstrated that sports-integrated STEM environments help reduce performance anxiety and foster inclusive learning by connecting abstract concepts with students' lived experiences. This finding aligns with Boaler's (2016) argument that mathematics learning is most effective when it is connected to authentic, personally meaningful contexts in which students feel emotionally safe.

6. Interest-Based and Contextual Learning

Research consistently demonstrates that learners engage more deeply and retain more effectively when instructional content aligns with their personal interests (Hidi & Renninger, 2006). Sports, being both emotionally appealing and socially valued across age groups and cultural contexts, create a high-engagement learning atmosphere that can serve as an affective bridge between students' natural enthusiasm and the often-dreaded domain of formal mathematics.

Objective of the Study

The primary objective of the paper is to conceptualise the pedagogical potential of Sports-Integrated Mathematics Teaching (SIMT) as a structured framework for reducing mathematics phobia among school learners.

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- To demonstrate how sports contexts, football in this case, can make abstract mathematical concepts - number sense, statistics, probability, geometry, and mensuration — tangible and concrete for students;
- To establish a theoretically grounded five-stage framework (Selection of Sport → Engagement in Sport → Mathematical Conceptual Clarity → Confidence Boosting → Reduced Math Phobia) ;
- To identify the pedagogical potential of the five-stage framework SIMT in mathematics classrooms.

Methodology

This paper adopts a theoretical and analytical research design. It synthesises insights from existing educational research literature, established learning theories (constructivism, ELT, embodied cognition), and the authors' own pedagogical observations gathered through classroom teaching in Delhi government schools. The football context is used as an illustrative and analytical lens to understand the depth of mathematical connections possible through sports-integrated teaching.

Findings: Mathematical Concepts Through Football

Learners are naturally drawn to sports and demonstrate an inherent aptitude for pattern recognition, spatial reasoning, and logical rule; these cognitive skills are foundational to mathematical thinking. Football, is a globally popular presents an unusually rich pedagogical context for illustrating mathematical concepts across multiple domains.

1. Number Sense and Properties: Jersey Numbers and Team Composition

A football match involves two teams, each with 11 players. The number 11 is the smallest two-digit prime, and its powers reveal an elegant pattern: $11^1 = 11$; $11^2 = 121$; $11^3 = 1331$; $11^4 = 14641$. Each result is a palindromic number with digits corresponding precisely to the rows of Pascal's Triangle (known in India as Pingala's Triangle) — whose entries represent the coefficients of binomial expansions.

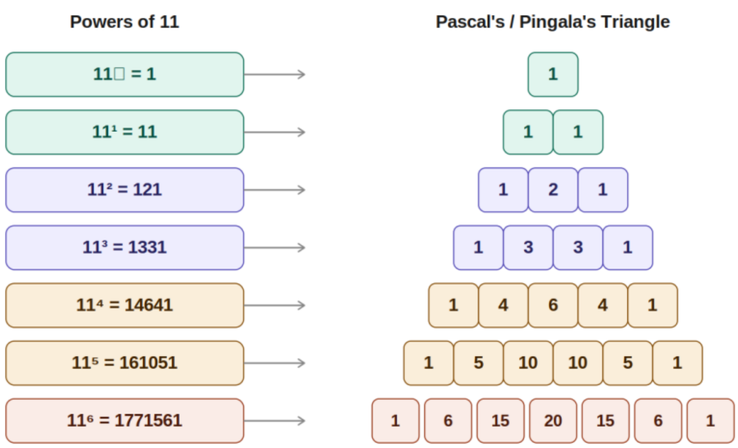

Figure 1: Pascal's / Pingala's Triangle and powers of 11 (Choudhary & Dhingra, 2025)

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The numbers printed on players' jerseys are the identifiers assigned to individual players for recognition, not for counting or ordering provide a concept of nominal numbers. This contrasts with cardinal numbers (used for counting) and ordinal numbers (used for ranking). Students can then be invited to identify nominal numbers in everyday life: Aadhaar numbers, PAN numbers, vehicle registration numbers, and house numbers.

In the authors' experience while teaching Class VIII students at Sarvodaya Vidyalaya, Delhi, they observed that this single distinction — between nominal and cardinal numbers — generated lively classroom discussion. Several students spontaneously cited their school roll numbers, mobile numbers, and pin codes as further examples of nominal numbers, demonstrating genuine conceptual transfer from a sports context to their own lives.

2. Statistics and Data Analysis: Player Performance Metrics

Assessing a football player's performance provides a natural context for arithmetic, averages, and percentages. A striker scoring 2, 1, 0, 3, and 2 goals across five matches has a total of 8 goals and a mean of 1.6 goals per match. Defenders can be evaluated by average saves: 12 saves in 4 matches yields 3 saves per match. These metrics are the real tools of professional football analytics, giving students direct exposure to statistics.

3. Probability: Chance and Uncertainty in Football

Each sport is inherently probabilistic. The pre-match coin toss yields a probability of 1/2 for each outcome. A striker who scores 8 out of 10 penalties has an experimental probability of 0.8. Historical win-loss data of a team can estimate the probability of that team winning a future match.. Selecting a defender randomly from a squad of 11 (of whom 4 are defenders) yields a probability of 4/11. If a team received 20 yellow and 5 red cards in a tournament, the probability of a randomly selected card being red is 5/25 = 0.2

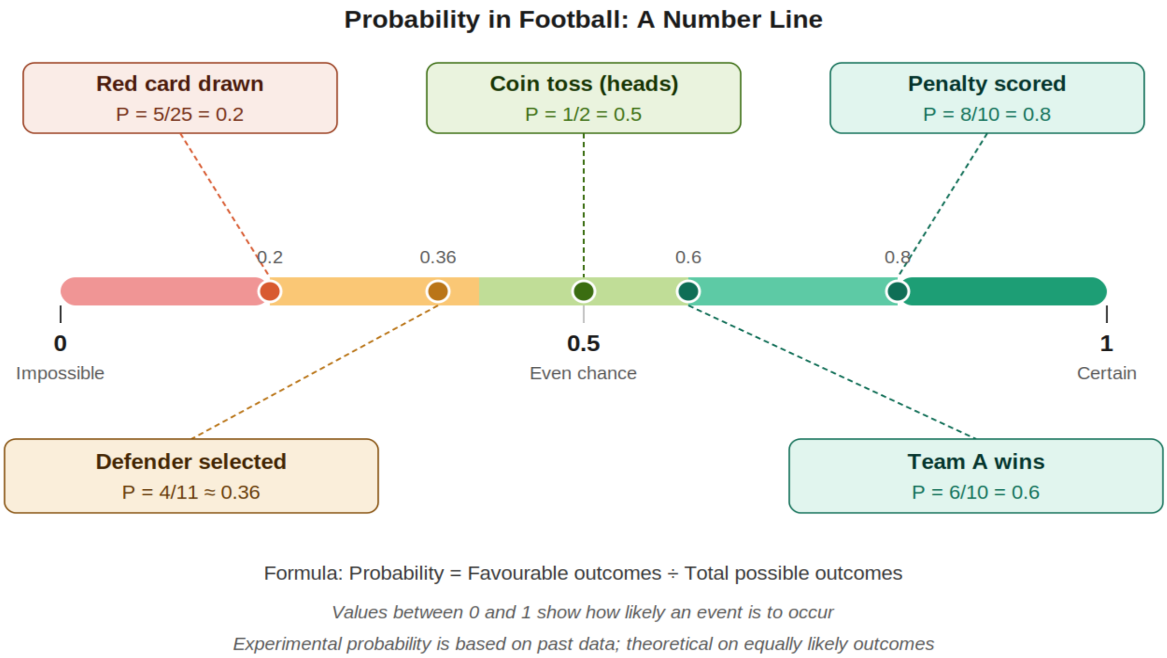

Figure 2: Probability scale with football examples (Choudhary & Dhingra, 2025)

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In the authors' experience while teaching Class VIII students at Sarvodaya Vidyalaya, Delhi, they observed that students who had previously found probability abstract and confusing engaged immediately when the same concepts were presented through penalty kick data and coin tosses at the start of a match.

4. Geometry: 2D and 3D Shapes in Football

A football's surface is composed of 12 regular pentagons and 20 regular hexagons — a truncated icosahedron, one of the thirteen Archimedean solids. This combination of two -polygon gives near-spherical shape and distributes curvature more uniformly than any other two-polygon combination, ensuring consistent bounce and aerodynamic predictability. The football pitch contains a rich collection of shapes: rectangles, circles, semicircles, and arcs which make it a single spatial context that covers an entire geometry unit.

5. Mensuration: Area, Perimeter, and Volume

A standard pitch (100 m × 60 m) yields a perimeter of 320 m and an area of 6,000 m². The centre circle (r = 9.15 m) has a circumference of approximately 57.5 m and an area of approximately 263 m². The goal measures 7.32 m × 2.44 m, giving a perimeter of 19.52 m and an area of 17.86 m². The distinction between the circumference of a semicircle (πr) and its full perimeter ($\pi r + 2r$) is naturally illustrated by the penalty arc. A football itself ($r \approx 11$ cm) has a surface area of approximately 1,520 cm² and a volume of approximately 5,572 cm³.

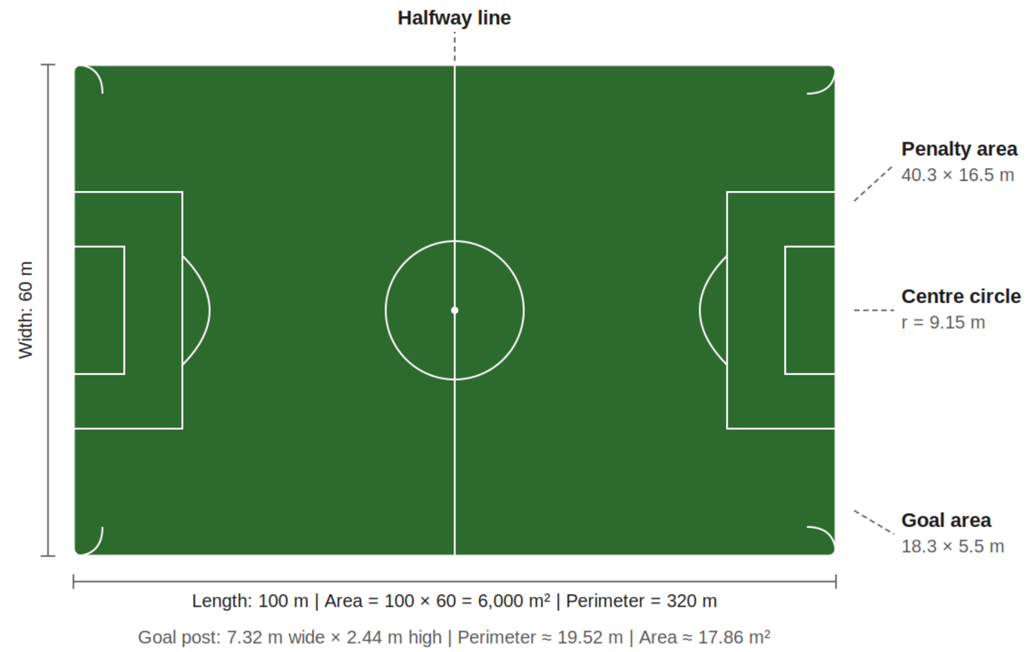

Figure 3: Geometric shapes on a standard football pitch (Choudhary & Dhingra, 2025)

Theoretical Argument: Why Sports Reduce Math Phobia

The pedagogical effectiveness of sports-integrated mathematics teaching can be understood as-

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- **Anchoring Abstraction in Reality:** Mathematical symbols and formulae become meaningful when students encounter them in lived contexts. A formula for pass accuracy is no longer arbitrary — it is a tool with immediate, observable application.
- **Reducing Emotional Pressure:** Sports environments are fundamentally associated with play and enjoyment. When mathematical learning occurs within such a context, the emotional stakes feel lower, creating psychological safety for genuine intellectual exploration.
- **Activating Embodied and Multisensory Processing**: According to the cognition theory, physical experience improves memory retention and cognitive processing. In ways that desk-based training cannot match, movement on a sports field stimulates spatial reasoning and pattern identification.
- **Increasing Confidence Through Mastery Experiences:** When students successfully apply a mathematical concept in a familiar context like correctly predicting a probability outcome or computing a batting average, they experience mastery. These positive experiences build their mathematical self-efficacy progressively.
- **Enhancing Collaborative Learning:** Sports naturally promote teamwork. Group-based mathematical activities help students support one another. They reduce feelings of isolation and discomfort. They also encourage shared problem-solving and learning.

Proposed Conceptual Framework

On the basis of theoretical analysis and classroom observation, the authors propose a five-stage conceptual model for reducing math phobia through sports-integrated teaching:

Selection of Sport → Engagement in Sport → Mathematical Conceptual Clarity → Confidence Boosting → Reduced Math Phobia

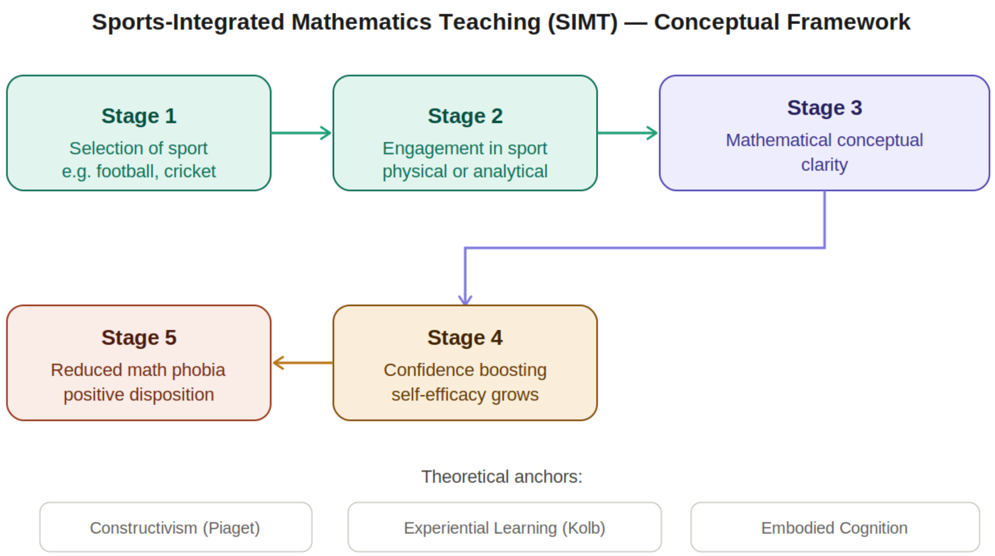

Figure 4: Proposed SIMT conceptual framework (Choudhary & Dhingra, 2025)

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Stage 1 — Selection of Sport: Select a sport that naturally embeds the target mathematical concept. Football is rich in geometry, probability, and statistics. Cricket offers extensive work with averages and data interpretation.

Stage 2 — Engagement in Sport: Make students engage with the sport — either physically through game-play, or analytically through match data. This creates an emotional entry point and intrinsic motivation to understand more deeply.

Stage 3 — Mathematical Conceptual Clarity: Draws out the mathematical principles embedded in the sports context, through structured facilitation. Students recognise abstract mathematics operations in the concrete form in the games they already love.

Stage 4 — Confidence Boosting: Repeated success in applying mathematical concepts within a low-pressure environment and meaningful context builds learners' belief in their own mathematical ability, displacing self-limiting narratives.

Stage 5 — Reduced Math Phobia: As confidence grows and positive associations accumulate, the fear and tension previously linked to mathematics gradually diminish. Students begin to approach mathematical tasks with curiosity rather than with fear.

Curriculum Integration Matrix

Table 1 and Figure 5 illustrate how the SIMT framework maps across key mathematical domains of the school curriculum:

Table 1: SIMT Curriculum Integration Matrix

Mathematical Domain	Key Concept	Football Contextual Element
Number Sense & Arithmetic	Nominal/Cardinal/Ordinal Numbers; Prime and Palindromic Properties	Jersey numbers; 2 teams; 11 players; powers of 11
Statistics & Data Analysis	Averages, Percentages, Data Representation	Goals scored; pass accuracy; saves per match
Probability	Theoretical and Experimental Probability	Coin toss; penalty kicks; card probability; player selection
Geometry (3D)	Truncated Icosahedron; Archimedean Solids; Polyhedra	Structure and geometry of the football
Mensuration	Area, Perimeter, Circumference, Surface Area, Volume	Football pitch; centre circle; goal post; the ball itself

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SIMT Curriculum Integration Matrix

Mathematical Domain	Key Concept	Football Context
Number Sense & Arithmetic	Cardinal, ordinal, nominal; prime numbers	Jersey numbers, 2 teams, 11 players, powers of 11
Statistics & Data Analysis	Mean, percentage, data representation	Goals scored, pass accuracy, saves per match
Probability theoretical & experimental	Likelihood 0 to 1, fractions as probability	Coin toss, penalty kicks, card draws, player selection
Geometry (2D & 3D) polyhedra, shapes	Truncated icosahedron, pentagon, hexagon	Football surface: 12 pentagons + 20 hexagons
Mensuration	Area, perimeter, volume	Pitch, centre circle, ball

Figure 5: Curriculum integration matrix (Choudhary & Dhingra, 2025)

Figure 5: Curriculum integration matrix — visual representation (Choudhary & Dhingra, 2025)

Table 2 : SIMT Curriculum Integration Matrix

Mathematical Domain	Key Concepts	Sports Contextual Elements
Number Sense & Arithmetic	Nominal / Cardinal / Ordinal Numbers Prime & Palindromic Numbers Powers, Factors & Multiples Basic Operations (+, −, ×, ÷)	⚽ **FOOTBALL:** • Jersey numbers 1–99 (nominal) • 2 teams × 11 players = 22 (multiplication) • Powers of 11: $11^1=11$, $11^2=121$, $11^3=1331$ • 90 min + extra time; score arithmetic 🏏 **CRICKET:** • Runs, wickets, overs (6 balls each) • 11 players per side; over count × 6 = balls • Run rate = total runs ÷ overs ♟ **CHESS:** • 64 squares = 8^2 on the board • 32 total pieces; 16 per side • File/rank labels (ordinal: 1st rank … 8th rank) 🏸 **BADMINTON:** • Points per game: 21 • Best of 3 sets; • Court dimensions: 13.4 m × 6.1 m

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Statistics & Data Analysis	Mean, Median, Mode Percentages & Ratios Data Representation (bar, pie, line charts) Range & Variance	**FOOTBALL:** • Goals per match (mean); clean sheets % • Pass accuracy %; shots on target ratio • Seasonal goal tally visualised as bar chart **CRICKET:** • Batting average = runs ÷ innings dismissed • Strike rate = (runs ÷ balls) × 100 • Economy rate for bowlers; • Run comparison across matches (line graph) **CHESS:** • Win/loss/draw percentages across tournaments • Elo rating change displayed as line graph **BADMINTON:** • Rally length data: mean & median • Winners vs. unforced errors ratio per set • Speed of shuttle at smash (range analysis)
Probability	Theoretical Probability Experimental Probability Compound Events Conditional Probability	**FOOTBALL:** • Coin toss: P(heads) = 1/2 • Penalty conversion rates (~75–80%) • Yellow/red card probability per match • Probability of winning given current score **CRICKET:** • Toss outcome; batting first vs. second win % • DRS review success probability • Rain interruption affect on D/L method **CHESS:** • Probability of reaching specific openings • Branching factor ~35 moves per position **BADMINTON:** • Serve direction prediction (left/right/body) • P(winning rally) from net vs. baseline position • Experimental probability from match tallies

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Geometry (2D & 3D)	Shapes, Angles & Symmetry Coordinate Geometry 3D Solids & Polyhedra Transformations (reflection, rotation)	**FOOTBALL:** • Ball = Truncated Icosahedron (32 panels) • Pitch: rectangle; centre circle; penalty arc • Angles for corner kicks and free kicks **CRICKET:** • Pitch = rectangle 20.1 m × 3.05 m • Fielding positions plotted on coordinate grid • Boundary: circle/oval — arc & sector concepts **CHESS:** • 8×8 grid = coordinate plane (algebraic notation) • Bishop diagonal • Board symmetry: reflective & rotational,order 4) **BADMINTON:** • Court lines: parallel & perpendicular • Net height: 1.55 m at post, 1.524 m at centre • Court divided into zones — area & sector work
Mensuration	Area & Perimeter Circumference & Surface Area Volume Speed, Distance & Time	**FOOTBALL:** • Pitch area: 105 m × 68 m = 7,140 m² • Ball circumference: 68–70 cm • Goal area & penalty box perimeter calculations **CRICKET:** • Pitch length: 22 yards = 20.12 m • Ball circumference: 22.4–22.9 cm • Outfield boundary radius (~65–90 m): arc length • Ground area approximation (oval/ellipse) **CHESS:** • Board area: 64 squares; each square = total/64 • 3D chess set volumes (cylinder, cuboid pieces) **BADMINTON:** • Court area: 13.4 × 6.1 = 81.74 m² (doubles) • Singles court: 13.4 × 5.18 = 69.41 m²
Algebra & Pattern Recognition	Sequences & Series Variables & Expressions Linear & Quadratic Equations Ratio & Proportion	**FOOTBALL:** • League points: W=3, D=1, L=0 — linear expr. • Goal difference as signed integers **CRICKET:** • Required run rate equation: RRR = R ÷ O

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	• Fibonacci-like growth in scoring patterns ♝ **CHESS:** • Wheat & chessboard problem: $2^0+2^1+\ldots+2^{63}$ • Exponential sequence: doubling each square 🏸 **BADMINTON:** • Scoring pattern: GP = 21 points, deuce rules • Ranking points system

Implications

Educational Implications

- Teacher professional development programs must focus on a shift from passive, teacher-centered instruction to interactive, collaborative, and problem-solving-oriented pedagogy. Structured exposure to SIMT approaches, including training in how to identify mathematical content embedded within sports contexts, should be given to teachers.
- Sports-integrated and contextual approaches should be formally recognized under Curriculum guidelines at the national and state level as legitimate and valuable instructional models, not as supplementary activities.
- Investment in flexible learning environments like mathematics laboratories, open classrooms, or adapted gymnasium spaces must be made by schools that can accommodate movement-based and experiential learning.
- Development of sports-themed worksheets, data-based tasks using real match statistics, and collaborative problem-solving activities should be emphasized and included in school resource banks.

Research Implications

- More studies are needed to understand how SIMT affects conceptual understanding, confidence in mathematics, and mathematics anxiety. These studies should include students from different types of schools, such as government and rural schools, and from diverse socioeconomic backgrounds.
- Researchers should investigate the factors that support successful SIMT implementation. These include teacher training, availability of resources, and administrative support.
- Long-term studies are needed to examine whether the benefits of sports-integrated learning continue over time. They should also explore whether these benefits influence students' subject choices in secondary and higher secondary education.

Conclusion

Math phobia is not an innate nature of learners; it is a product of the psychological environment and pedagogical practices. This paper has argued, through theoretical analysis and mathematical examples drawn from football, that Sports-Integrated Mathematics Teaching (SIMT) offers a practically accessible method for reducing mathematics anxiety

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among school learners. The SIMT framework, which is grounded in constructivism and experiential learning theory, transforms math classroom from the fearful environment into a dynamic space of exploration and confidence.

The five-stage model proposed here — from sport selection to reduced math phobia — provides educators with a clear and actionable instructional sequence. When students encounter fractions through penalty kick statistics, explore geometry through the truncated icosahedron of a football, or calculate area while imagining themselves on the pitch, mathematics ceases to be abstract and alien. It becomes something they already know, in a language they already speak.

The authors acknowledge that this paper is theoretical in nature and that empirical validation of the SIMT framework across diverse classroom contexts remains an important priority for future research. Nevertheless, the convergence of established learning theory with the rich mathematical potential of sports contexts — reinforced by direct classroom observations at Sarvodaya Vidyalaya — provides strong grounds for encouraging mathematics educators to explore sports-integrated approaches as a transformative tool for building positive mathematical dispositions in every learner.

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