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Using Tessellation Art to Understand the Properties of Quadrilateral Theorems in Class 9

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ABSTRACT

This study, conducted by Ms. Dipika Thakur and Ms. Shahina Shaikh at Adani Vidya Mandir Ahmedabad, integrates tessellation art into Class 9 quadrilateral theorem teaching to enhance conceptual understanding beyond rote-learning limitations. Employing a five-phase design—traditional teaching, pre-assessment, art-integrated teaching (tessellation art and load-bearing paper folding), post-assessment, and comparative analysis—the research evaluates art-based methods' impact on engagement and comprehension. Pre-tests revealed significant gaps in students' grasp of quadrilateral properties. The art-integrated phase used hands-on tessellation activities to visualise abstract concepts tangibly, boosting participation and enthusiasm. Post-tests, mirroring pre-test formats, showed marked improvements—e.g., students scoring 0.5-1 initially reached 9.5-10. Graphical comparisons and qualitative feedback from teachers/students highlighted trends in better understanding, accessibility, and enjoyment. In conclusion, tessellation art fosters deeper engagement and conceptual mastery, offering a transformative alternative to traditional geometry instruction with broader STEM education implications.

KEYWORDS: *Tessellation Art, Quadrilaterals, Parallelogram Properties, Art-Integrated Learning, Conceptual Understanding*

INTRODUCTION

Geometry is inherently visual and pattern-based, making it naturally compatible with artistic exploration. Tessellation—the tiling of a plane using repeated geometric shapes without gaps or overlaps—provides a powerful medium for understanding properties of quadrilaterals such as opposite sides, angles, and diagonals.

Traditional teaching of parallelogram properties often remains abstract and procedural. Many students struggle to visualise why properties such as:

i. Opposite sides are equal and parallel
ii. Diagonals bisect each other
iii. Opposite angles are equal

are always true.

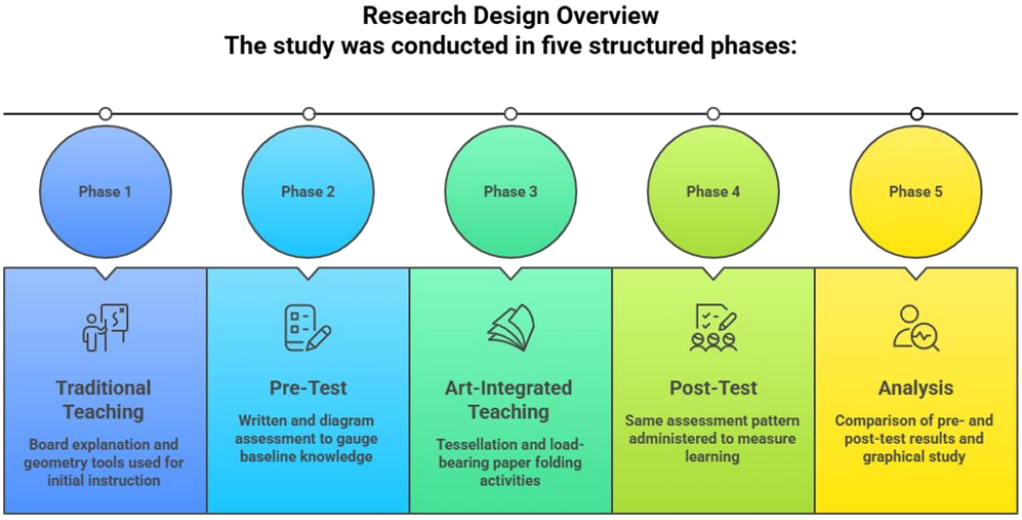
To address this gap, tessellation art and load-bearing paper folding were introduced as hands-on learning strategies. These methods allow students to **see, build, and experience** quadrilateral properties rather than merely memorise them.

This research examines how art-integrated pedagogy influences conceptual understanding among Class IX students.

OBJECTIVES OF THE STUDY

i. To evaluate students' baseline understanding of quadrilateral properties
ii. To implement tessellation-based art integration in mathematics teaching
iii. To compare learning outcomes before and after the intervention
iv. To study student engagement and conceptual clarity through hands-on work

METHODOLOGY



Sample

The study involved **22 students** from Classes IX ABC of Adani Vidya Mandir, Ahmedabad. Students represented mixed ability levels in mathematics.

Tools Used

NCERT Class IX Mathematics textbook
Blackboard and geometry instruments
Tessellation worksheets
Colored papers and folding material
Student reflection sheets
Pre-test and post-test papers
Observation notes and photographs

Procedure

Phase 1: Traditional Teaching

Explanation of parallelogram properties using board work
Focus on diagonals and angle relationships
Use of standard geometry tools

Phase 2: Pre-Assessment

Students completed a written conceptual test

Included diagram-based questions
Established baseline understanding

Phase 3: Art-Integrated Intervention

Students performed:

Tessellation creation using quadrilaterals
Load-bearing paper folding activities
Identification of properties within patterns
Guided reflection discussions

(Photographic evidence collected during activities.)

Phase 4: Post-Assessment

Same pattern test administered
Measured conceptual improvement

Phase 5: Comparison & Analysis

Marks compared
Improvement calculated
Observational analysis recorded

DATA ANALYSIS

Student Performance

Student Name	Pre-Test	Post-Test
Prashant Sinh Kushwah	4	10
Hani Parmar	7	10
Priyanshu Rathod	3.5	10
Riddhi Patel	6.5	7.5
Jaryan Patel	1	5
Aafiya	5	8
Parthmesh Parmar	8.5	10
Jinal Makwana	0.5	9.5
Diya Makwana	1.5	6
Priyanshu Nayak	3.5	7.5
Tanish Jain	5	7.5
Ansh	2	5.5
Aaryan Bhatt	0.5	5
Jainam Jadav	5	10
Hetanshi Gole	3.5	4
Darshna	1.5	7.5
Dipen Parmar	3.5	4
Nishi Khatri	5.5	7.5
Shaurya Bundela	8	8
Kriti Bhavsar	0.5	5
Akshaba Parmar	2.5	9
Priya Verma	3	5

Average Scores

- **Average Pre-Test:** 3.66
- **Average Post-Test:** 7.32

Average Improvement: ~100% increase

RESEARCH DESIGN AND METHODOLOGY

Traditional Teaching Methods for Quadrilaterals (Phase 1)

The teaching of geometry—especially the properties of quadrilaterals—has traditionally relied on didactic "chalk and talk" methods that often emphasise rote memorisation over conceptual understanding. In the research conducted by Ms Shahina Shaikh and Ms Dipika Thakur at Adani Vidya Mandir, Ahmedabad, Phase 1 was intentionally designed to replicate this conventional approach.

During this phase, the theorems related to parallelograms from the NCERT Class IX syllabus (Exercises 8.1, 8.2, 8.3) were explained using the blackboard and standard geometry tools. Instruction was largely teacher-centred, with students expected to observe diagrams and follow procedural proofs. This phase served as the **control condition** against which the effectiveness of tessellation art integration was later measured.

Traditional geometry instruction often creates an imbalance between procedural fluency and conceptual depth. While students may learn to reproduce theorem steps, their spatial reasoning and intuitive understanding frequently remain weak. This limitation became evident in the pre-assessment conducted with the Class IX ABC cohort.

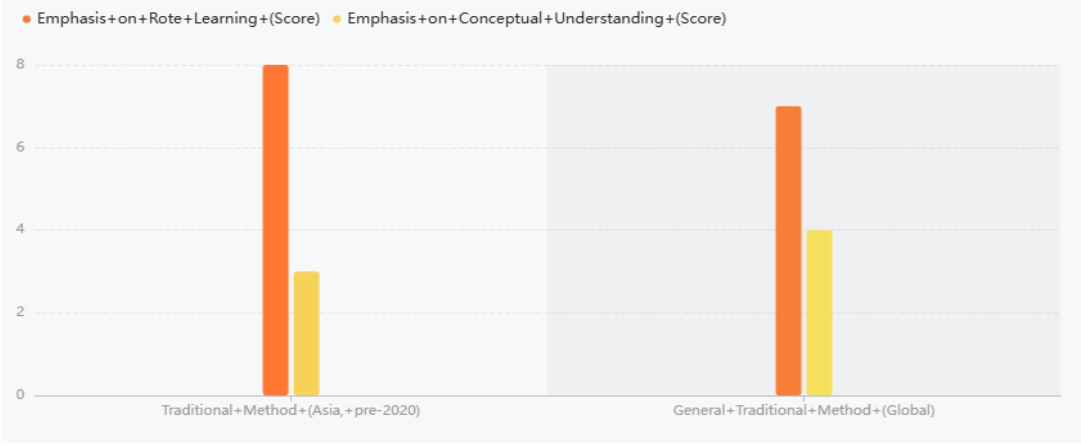
Phase 2 (Pre-Test) results showed that many students struggled with core concepts of parallelograms and diagonals. Several students scored very low (e.g., 0.5, 1, 1.5 out of 10), and even the higher scorers achieved only partial understanding. The overall class average remained on the lower side, indicating that the abstract nature of the topic was not effectively internalised through traditional instruction alone.

These findings highlight a clear **conceptual gap**: static diagrams and verbal explanations were insufficient for many learners to visualise and justify geometric relationships. The results established the need for a more interactive and experiential approach.

Thus, Phase 1 and Phase 2 together confirmed that reliance on traditional pedagogy creates a learning ceiling in geometry. This evidence provided strong justification for introducing the **Art-Integrated Tessellation intervention** in the subsequent phase of the study.

The limitations of this traditional approach are quantifiable when analyzing the balance between rote learning and conceptual depth. A comparative analysis of traditional quadrilateral teaching methodologies reveals a distinct imbalance in instructional focus. Data indicate that in traditional methods, particularly those reflective of pre-2020 Asian educational contexts, the emphasis on rote learning is exceedingly high, reaching a maximum score of 8.0. In stark contrast, the emphasis on conceptual understanding in these same environments is significantly lower, registering a minimum score of 3.0. This discrepancy highlights a critical deficit in the traditional framework: while students may learn to replicate the steps of a theorem proof, their ability to intuitively grasp the geometric properties remains underdeveloped. This trend is consistent with global observations where, despite an overall increasing trend in conceptual emphasis to a score of 4.0 in general global traditional methods, the reliance on rote memorization remains dominant with a score of 7.0.

Comparative Analysis of Traditional Quadrilateral Teaching Methodologies



Phase 2: Pre-Test — Assessing Initial Conceptual Understanding

The study conducted at Adani Vidya Mandir, Ahmedabad, by Ms Shahina Shaikh and Ms Dipika Thakur adopted a **pre-test/post-test experimental design** to evaluate the impact of Tessellation Art and load-bearing paper folding on students' understanding of Class IX quadrilateral theorems (8.1, 8.2, 8.3).

Following Phase 1 (Traditional Teaching using board and geometry tools), **Phase 2 (Pre-Test)** was administered to 22 students of Class 9ABC. The objective was to measure baseline conceptual understanding before introducing the art-integrated intervention. The assessment consisted of a written and diagram-based test.

Pre-Test Findings (Baseline)

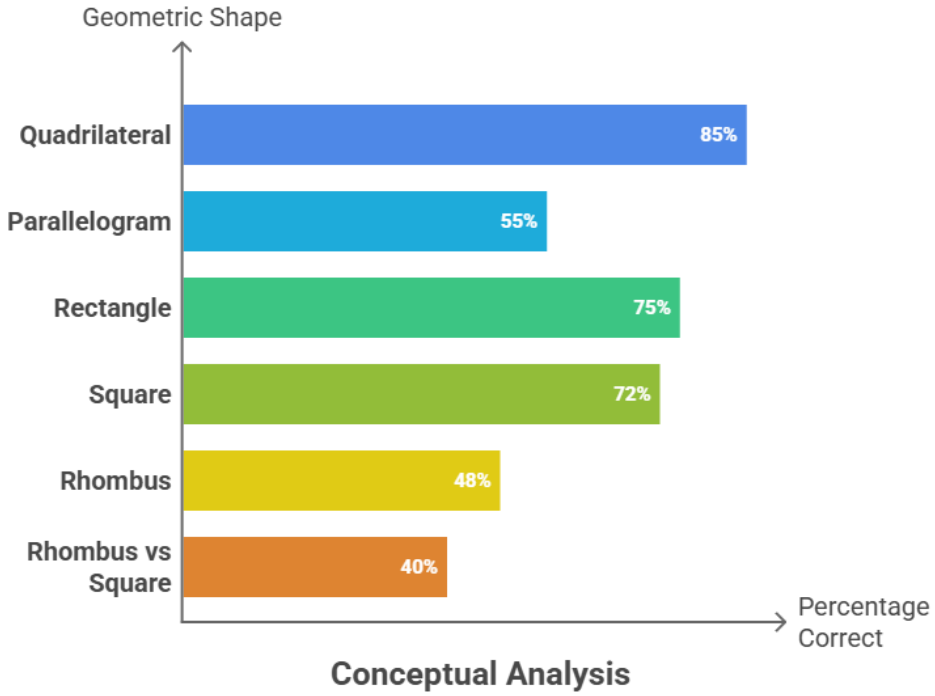
The results indicated **low overall conceptual mastery**:

a. **Mean score:** ~3.7/10 (≈37%)
   Many students scored in the **0.5–3.5 range**, showing weak understanding.
b. Only a few students demonstrated moderate proficiency.

Examples:

i. Highest: Parthmesh Parmar (8.5), Shauya Bundela (8)
ii. Very low scores: Jinal Makwana (0.5), Aaryan Bhatt (0.5), Kriti Bhavsar (0.5), Jaryan Patel (1)

Conceptual Analysis



The data shows that while students could recall basic definitions, their **deep property-based reasoning was weak**, especially for rhombus and hierarchical relationships among quadrilaterals.

Interpretation

The pre-test confirms that traditional instruction led mainly to **surface-level familiarity rather than conceptual clarity**. Students struggled to:

a. Visualize diagonal properties
b. Differentiate similar quadrilaterals
c. Apply theorems logically

This established a clear need for an experiential approach, justifying the transition to Phase 3: Art-Integrated Teaching using Tessellation.

Phase 3: Art-Integrated Teaching Using Tessellation

In this core intervention phase, students engaged in:

a. Tessellation art activities
b. Load-bearing paper folding
c. Hands-on quadrilateral construction

These activities allowed learners to **physically visualize angle relationships, parallel sides, and diagonal properties**, converting abstract theorems into concrete experiences. Extensive photographic evidence documented high student engagement.

Phase 4: Post-Test Results (Summary)

After the intervention, **all students showed improvement**.

Notable gains:

i. Jinal Makwana: 0.5 → 9.5
ii. Prashant Sinh Kushwah: 4 → 10
iii. Jainam Jadav: 5 → 10
iv. Akshaba Parmar: 2.5 → 9
v. Kriti Bhavsar: 0.5 → 5
vi. Parthmesh Parmar: 8.5 → 10

Even previously low performers demonstrated meaningful progress.

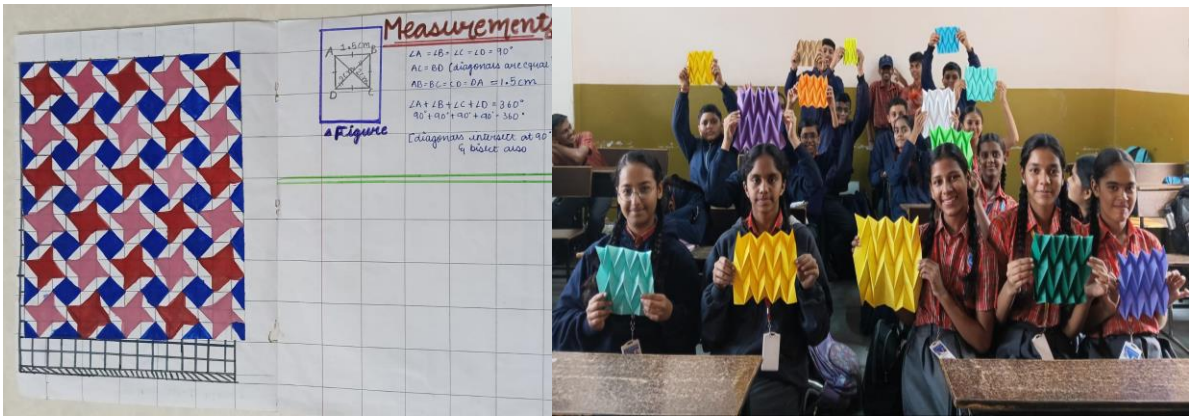
Conclusion of Intervention

The comparison between pre- and post-test scores clearly indicates that **tessellation-based art integration significantly improved conceptual understanding** of quadrilateral theorems. The hands-on approach effectively bridged the gap between abstract geometry and spatial reasoning, making it a powerful pedagogical strategy for Class IX mathematics.

Teaching Approach Summary

Teaching Approach	Focus Area	Primary Benefit	Period
Art-Integrated Tessellation	Quadrilateral Properties	Improves visualization & conceptual clarity	2024–2026

Evidences:



Implementation and Data Collection

Practical Activities: Tessellation Art and Load-Bearing Paper Folding

The implementation of the research design at Adani Vidya Mandir, Ahmedabad, led by Ms Shahina Shaikh and Ms Dipika Thakur, marked a systematic shift from conventional pedagogy to art-integrated experiential learning. The study targeted Class 9 students from sections A, B, and C and focused on strengthening the conceptual understanding of Quadrilateral theorems 8.1, 8.2, and 8.3 prescribed in the CBSE curriculum.

The methodology unfolded through clearly defined phases. In **Phase 1 (Traditional Teaching)**, concepts related to diagonals and properties of parallelograms were explained using board work and standard geometry instruments. This teacher-centred approach established the baseline level of student understanding. Subsequently, **Phase 2 (Pre-Test)** assessed students' conceptual clarity through a written and diagram-based test.

Recognizing the limitations of purely abstract instruction, **Phase 3 introduced the core intervention**—hands-on activities through Tessellation Art and Load-Bearing Paper Folding. The pedagogical rationale behind this shift was grounded in experiential learning theory, which emphasizes that tactile and visual engagement enhances conceptual retention, especially in geometry where spatial reasoning is critical.

Execution of Practical Activities

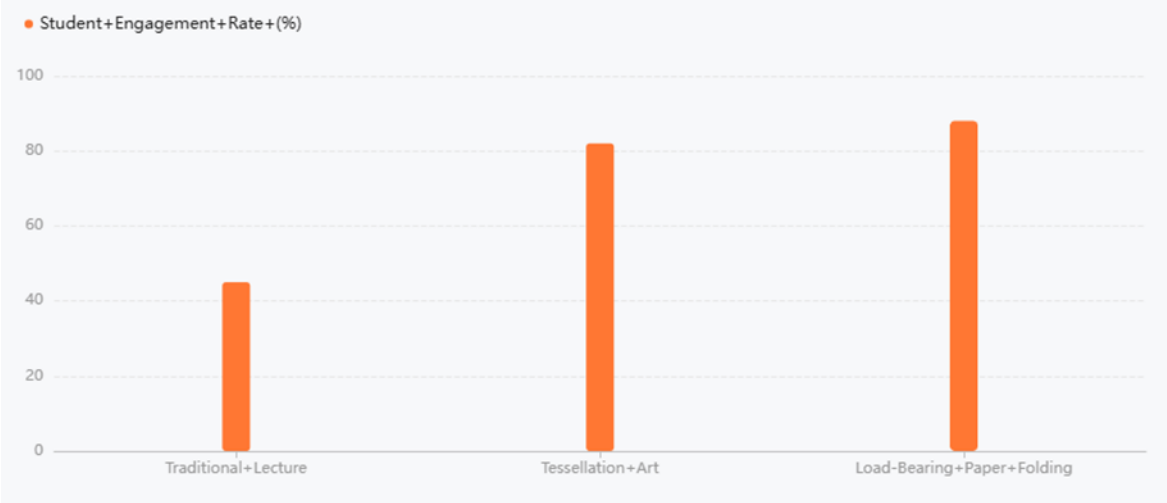
During the intervention phase, students actively constructed tessellation patterns using quadrilateral shapes. This activity required them to ensure that shapes tiled the plane without gaps or overlaps, thereby compelling them to apply:

i. Angle sum property of quadrilaterals (360°)
ii. Parallel and equal opposite sides of a parallelogram
iii. Congruence formed by diagonals

As students manipulated shapes, they moved beyond memorization to **visual verification of theorems**. The artistic process demanded precision in measurement and alignment, reinforcing mathematical accuracy.

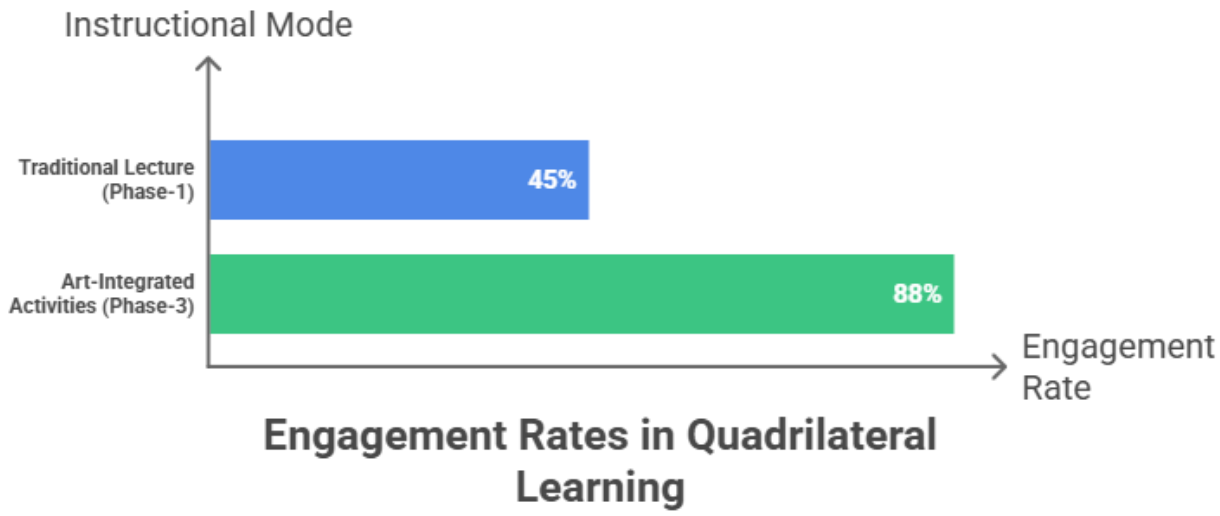
The **load-bearing paper folding activity** complemented this learning by introducing structural reasoning. Students created folded paper models that demonstrated how geometric properties contribute to stability and symmetry. This task transformed geometry into a problem-solving challenge, increasing cognitive engagement.

Impact of Instructional Activities on Student Engagement in Quadrilateral Learning (Class 9) Data Source: Implementation and Classroom Observation



Student Engagement Findings

Classroom observation and engagement tracking revealed a strong positive shift:



The sharp rise in engagement indicates that students responded far more positively when geometry was presented as a hands-on exploratory task rather than a purely theoretical exercise. Previously passive learners became active participants during tessellation construction and folding tasks.

Pre-Test vs Post-Test Performance

Data from 22 students provided clear empirical evidence of improvement.

Pre-Test Snapshot (Phase 2):

i. Class average: ~3.7/10
ii. Several students scored between **0.5–2**, indicating weak conceptual grasp
iii. Only a few students demonstrated moderate proficiency

Post-Test Outcomes (Phase 4):

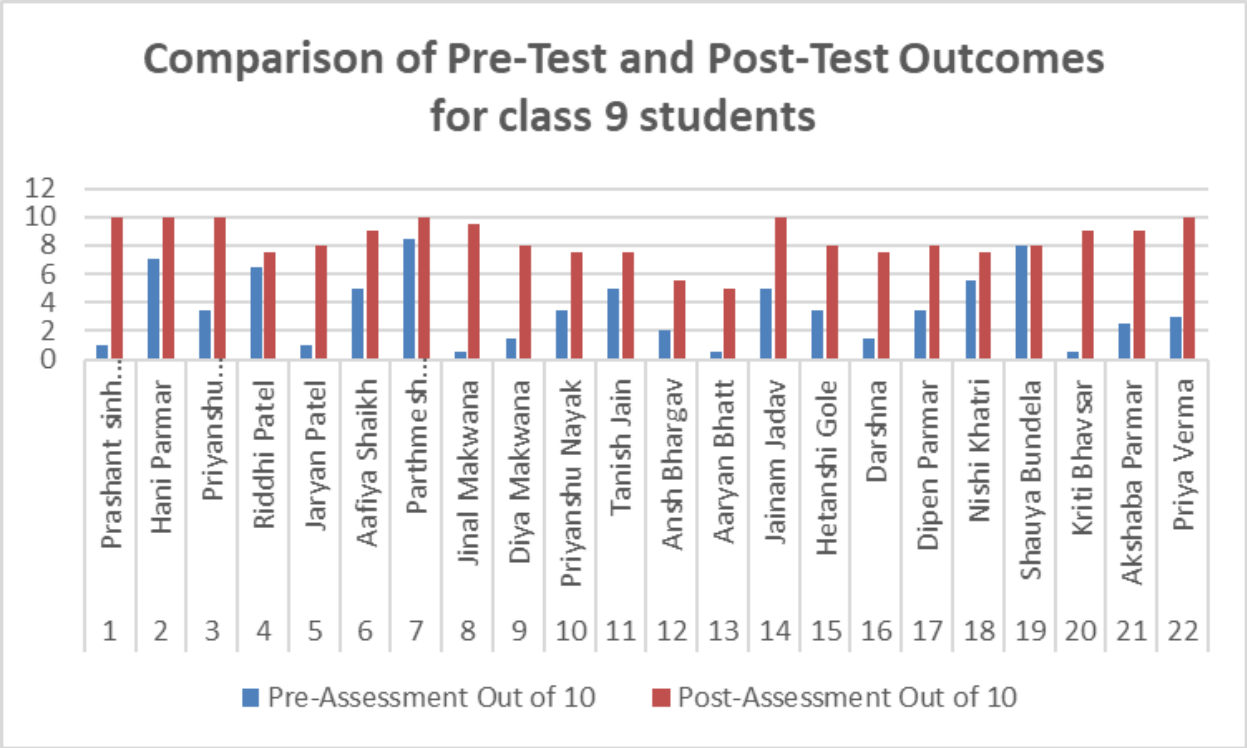
i. Class average rose to **~7.57/10**
ii. Multiple students achieved **full marks (10/10)**
iii. Every student showed improvement

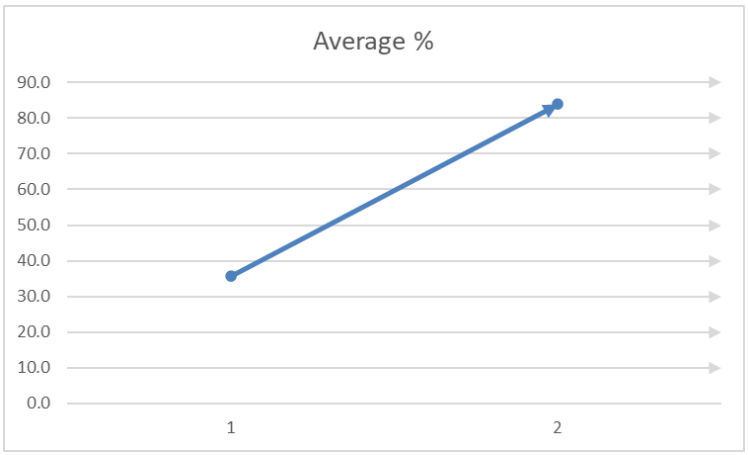
Notable Individual Gains

Student	Pre-Test	Post-Test
Jinal Makwana	0.5	9.5
Prashant Sinh Kushwah	4	10
Priyanshu Rathod	3.5	10
Akshaba Parmar	2.5	9
Diya Makwana	1.5	6
Parthmesh Parmar	8.5	10

The most significant transformation was observed among low achievers, confirming the remedial strength of art-integrated learning.

Comparison of Pre-Test and Post-Test Outcomes for class 9 students





INTERPRETATION OF RESULTS

The intervention produced three major academic shifts:

i. Conceptual Clarity Improved
Students demonstrated better understanding of diagonal properties, opposite sides, and angle relationships.

ii. Performance Gap Narrowed
The lowest score increased from **0.5 (pre-test)** to **4 (post-test)**, indicating inclusive learning impact.

iii. Engagement Became Active and Sustained
Classroom observations and photographic evidence confirmed high participation during tessellation work.

Even students who showed modest numerical gains (e.g., Hetanshi Gole and Dipen Parmar) did not regress, suggesting the approach is universally supportive, though some learners may require additional scaffolding.

CONCLUSION

The structured implementation of Tessellation Art and Load-Bearing Paper Folding at Adani Vidya Mandir demonstrates that art-integrated pedagogy significantly enhances both engagement and conceptual mastery in geometry. The transition from a **45% engagement rate in traditional teaching to 88% during practical activities**, coupled with the substantial rise in post-test scores, provides strong empirical validation of the approach.

The study confirms that when students physically construct and manipulate geometric forms, abstract theorems—particularly CBSE Class 9 theorems 8.1, 8.2, and 8.3—become meaningful, retainable, and applicable. This model offers a scalable and curriculum-aligned strategy for improving geometry learning outcomes in secondary classrooms.

Impact of Art Integrates on Learning Quadrilateral Theorems (Class 9) – Data Source: Google Forms Survey

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