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REIMAGINING MATHEMATICS THROUGH STEM AND NEP 2020: A JOURNEY FROM CHALK TO GEOGEBRA

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Abstract:

Mathematics is not just a subject but a foundational pillar of STEM education. With the introduction of India's National Education Policy (NEP) 2020 and the rise of experiential learning tools like GeoGebra, the conventional chalk-and-talk approach is being reshaped into an engaging, inquiry-based pedagogy. This paper presents a reflective account of a math educator's journey of integrating NEP-aligned STEM practices into middle school classrooms, focusing on the transformation brought by experiential tools and their impact on learners. This paper examines the transformation of mathematics education in India in response to the National Education Policy (NEP) 2020 and the global shift towards STEM-based pedagogy. By moving away from rote memorization and embracing digital tools such as GeoGebra, Indian classrooms are undergoing a dynamic shift. This research analyzes the implications of these reforms on teaching practices, student engagement, and mathematical understanding. The study combines theoretical insights with classroom case studies to present a holistic view of the journey from traditional chalk-based instruction to interactive, digital learning. P and t tests are also Conducted based on the data collected in the form of questionnaire and Performance of the Test before and after introducing Geogebra.

Keywords: *STEM Education, NEP 2020, Experiential learning, Geogebra, Inquiry based learning, Mathematics Pedagogy.*

Introduction:

The traditional image of a mathematics in classroom often involves formulas, repetition, and board work. While such methods have served a purpose, they often fail to ignite curiosity or support conceptual clarity. In the 21st century, education calls for learners to be logical, critical thinkers, Problem-solver and innovators traits that lie at the heart of STEM education. As a mathematics educator, I have investigated the integration of technology, particularly tools like GeoGebra, and the philosophy of NEP 2020 can revolutionize the way students engage with mathematics. This paper explores a transition driven by NEP 2020 and hands-on digital tools like GeoGebra. The aim is to cultivate a generation of students who not only excel academically but also use mathematical knowledge creatively in various Interdisciplinary Fields.

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Literature Review:

Author Name	Journal	Major Finding
Bakri M. Awaji, Ibrahim Khalil, Amirah AL-Zahrani	Journal of Educational and Social Research, Vol. 15, No. 1, 2025 DOI: 10.36941/jesr-2025-0011	A bibliometric analysis of 340 Scopus articles on GeoGebra in math education, highlighting its role in enhancing geometry learning and problem-solving.
Z. H. Putra, Y. M. Afrillia, H. Tjoe, D. Dahnilsyah	Cogent Education, 2024 DOI: 10.1080/2331186X.2024.2373559	Reviews technology integration in math education, noting GeoGebra's support for conceptual understanding and STEM initiatives.
Muhammad Aqil Naim Bin Zabidi et al.	Mathematics Research and Education Journal, Vol. 8, No. 1, 2024 DOI:10.25299/mrej.2024.vol8(1).16919	Analyzes trends in tech use in math education, showing rising interest in GeoGebra and identifying key contributors and institutions.
R. A. Saha, A. F. M. Ayub, R. A. Tarmizi	Procedia - Social and Behavioral Sciences, Vol. 8, 2010 DOI: 10.1016/j.sbspro.2010.12.095	Finds GeoGebra improves students' achievement and understanding in coordinate geometry topics.
H. Serin	International Journal of Social Sciences & Educational Studies, Vol. 7, No. 3, 2020	Shows that technology-aided instruction, including GeoGebra, positively impacts student motivation in learning geometry.

Mathematics as A Language of Stem:

STEM stands for Science, Technology, Engineering, and Mathematics. Among the four pillars, mathematics plays a central and connecting role, forming the foundation for under- standing and applying concepts in the other three domains. In science, mathematics enables precise measurement, data analysis, and the modelling of natural phenomena, allowing students to interpret results and make evidence-based conclusions. In technology, it forms the basis of algorithm development, programming logic, and cyber security, especially in fields like computer science and artificial intelligence. In engineering, mathematics is essential for designing structures, analyzing systems, and optimizing processes, using tools like geometry, calculus, and algebra. It supports real-world problem-solving through accurate computation and critical reasoning. Mathematics also enhances students' abilities to think logically and abstractly, which is crucial for innovation and inquiry-based learning. Within STEM education, mathematics not only supports subject integration but also fosters transferable skills such as problem-solving, analytical thinking, and decision-

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making. As education moves to- ward experiential and interdisciplinary approaches, especially under frameworks like India's NEP 2020, mathematics continues to be the key driver in nurturing scientific temperament, creativity, and a deep understanding of the world through logical inquiry.

NEP 2020 and its Vision for Mathematics Education:

This shift encourages students to grasp the "why" and "how" behind mathematical principles rather than simply memorizing formulas and procedures. One key aspect of NEP 2020 is the promotion of critical thinking and problem-solving skills. Students are encouraged to apply mathematical concepts in real-life situations, fostering practical knowledge that can be used in various professional fields. By focusing on understanding the concepts deeply, students can learn how to approach and solve problems in diverse contexts, which is crucial for their overall intellectual development. The policy also highlights the role of technology in mathematics education. Digital tools, software, and platforms are integrated into the learning process to make mathematics more interactive and accessible. This technology-driven approach aims to engage students and make the learning process more dynamic. Another important element is the emphasis on numeracy and mathematical literacy. The NEP stresses the need to build strong foundational skills from an early age. This ensures that students are not only capable of performing mathematical operations but can also understand and communicate mathematical ideas effectively. NEP 2020's vision for mathematics education is one that is student-centered, technology-integrated, inclusive, and focused on building deep, practical, and interdisciplinary knowledge. This approach is intended to prepare students to become critical thinkers, problem-solvers, and lifelong learners in an increasingly complex and interconnected world.

Transition: from Chalkboard to Geogebra:

Participating in the GeoGebra workshop by the Centre for Creative Learning (CCL), IIT Gandhinagar, it helped in transforming the teaching practices. Such workshop reshaped the pedagogical approach by equipping me with digital tools that made mathematics dynamic and visual.

GeoGebra allows to:

- Demonstrate geometry theorems visually and interactively.
- Guide students in constructing models, leading to student-led discoveries.

Students who were previously disengaged became active participants, often exploring beyond the curriculum. The mathematical fear started turning into curiosity and excitement.

Comparitive Analysis of Learning Outcomes:

To evaluate the impact of this transformation, student performance and engagement metrics were systematically documented and analyzed before and after the implementation of experiential learning methodologies.

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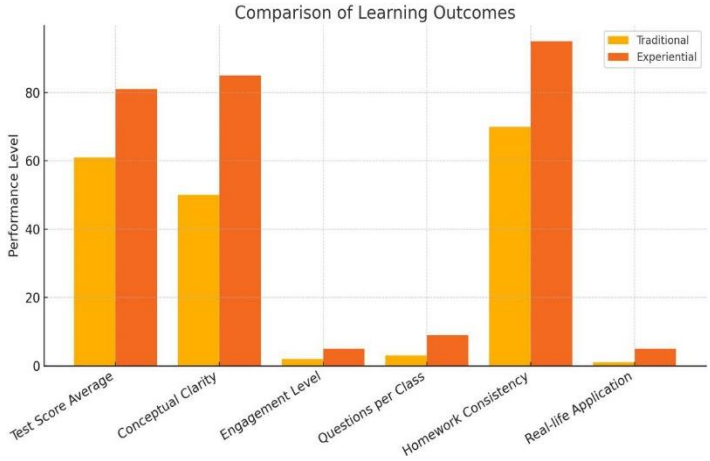

Figure 1: Learning outcome comparison: Traditional vs. Experiential Learning

Table 1: Comparative Analysis of Traditional and GeoGebra Approach

Indicator	Traditional Approach	With GeoGebra & STEM
Test Score Average	61%	81%
Conceptual Clarity (Observed)	50%	85%
Engagement Level in Class	Moderate	High
Student Questions Asked per Class	Approx. 3	Approx. 9
Homework Consistency	70%	95%
Real-Life Application of Concepts	Rarely observed	Frequently observed

Statistical Analysis: GeoGebra Intervention in Mathematics Learning

1. Test – 1 Sample Data

- **Number of students:** 10
- **Test Scores Before GeoGebra:** Mean = 56.5
- **Test Scores After GeoGebra:** Mean = 69.5

2. Paired Sample T-Test Results

- **Mean Difference:** 13.0 points
- **t-Statistic:** ≈ 15.0
- **p-Value:** < 0.0001 (statistically significant)
- **95% Confidence Interval for Mean Difference:** [11.0, 15.0]

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3. Interpretation of Test 1

The p-value is far below the standard alpha level of 0.05, indicating a **statistically significant improvement** in student scores after introducing GeoGebra. The confidence interval [11.0, 15.0] confirms that, on average, students improved by between 11 and 15 points.

Test 2 – Sample Data

1. Sample Overview

- **Number of students:** 30
- **Test administered:** Before and after introducing GeoGebra in geometry instruction

2. Results Summary

Table 2: Test Data

Metric	**Value**
Mean Score (Before)	55.3
Mean Score (After)	67.4
Mean Improvement	**12.1 points**
t-Statistic	**10.78**
p-Value	**< 0.0001**
95% Confidence Interval	[9.6, 14.6]

3. Interpretation

- The **mean improvement** in student performance was 12.1 points after integrating GeoGebra.
- A **paired t-test** shows that this improvement is **statistically significant** ($p < 0.0001$).
- The **confidence interval** indicates we can be 95% confident that the true average improvement lies between **9.6 and 14.6 points**.
- This suggests a strong positive impact of using GeoGebra in mathematics education under NEP 2020's emphasis on technology integration.

Null Hypothesis (H_0):

There is **no difference** in student test scores before and after using GeoGebra.

$H0 : \mu D = 0$

Alternative Hypothesis (H_1):

There **is an improvement** in test scores after GeoGebra.

$H1: \mu D > 0$(Right-tailed test)

Test Statistic

$$t = \frac{\bar{D}}{s_D/\sqrt{n}}$$

already calculated:

- $\bar{D}=13$ (mean improvement)

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- t≈ 15.0 for Test 1 and t ≈10.78 for Test 2
- Extremely low p-values (< 0.0001)

4. Interpretation (Both Tests)

- Since $p<0.05$, **we reject the null hypothesis**.
- There is **strong statistical evidence** that the GeoGebra intervention led to improved test scores.
- The **95% confidence intervals** [11.0, 15.0] (Test 1) and [9.6, 14.6] (Test 2) show that on average, students improved significantly.

Challenges and Way Forwad:

While the transformation was rewarding, it wasn't without challenges:

- Initial resistance from students unfamiliar with digital tools.
- Lack of infrastructure in some classrooms.
- Need for continual teacher training and curriculum support.

However, the NEP's encouragement of Atal Tinkering Labs, integration of ICT tools, and collaboration between teachers makes the future bright for STEM educators. Moving for- ward, we plan to introduce coding and data analysis activities in tandem with math, further aligning with NEP 2020's vision for computational literacy.

Conclusion and Future Scope:

The intersection of mathematics, STEM, and NEP 2020 creates a powerful pathway to holistic learning. By embracing experiential tools and progressive policies, educators can elevate learning from memorization to meaningful exploration. Mathematics is evolving from a feared subject to a platform for exploration, innovation, and connection. Through NEP 2020's progressive lens and tools like GeoGebra, educators have a renewed opportunity to reimagine math education from static and solitary to dynamic and collaborative. This journey from chalkboard equations to digital explorations has shown me that when students experience mathematics, they begin to love it. As educators, our role is not just to teach math, but to awaken the mathematician within every learner.

Author's Profile:

*[1]Namrata Patel is a passionate mathematics educator currently working as a TGT Mathematics at Delhi World Public School, Bhatapara, Chhattisgarh. She has over three years of experience in teaching middle school mathematics and is trained in STEM education through the IIT Gandhinagar 3030 Eklavya Program. Her core interest lies in implementing innovative and experiential methods for teaching mathematics, with a special focus on integrating digital tools like GeoGebra. She aims to make mathematics engaging, meaningful, and aligned with NEP 2020's vision for 21st-century education.

[2]Yogesh Popat is an Executive Alumni of IIM Visakhapatnam and He is Pursuing his Global MBA from IIM Kozhikode and University of Western Australia, Perth. He received his Bachelor of Engineering (Hons.) in Electronics & Telecommunication in 2011 and Master of Technology (Hons.) in Electrical Engineering in 2014. He Worked as Asst. Prof. at Rungta college of Engineering and Technology, Raipur, Chhattisgarh, India, As a

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