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IMPACT OF STEM-BASED PEDAGOGY ON SCIENCE ACHIEVEMENT AND CRITICAL THINKING AMONG GRADE VIII STUDENTS - AN ACTION RESEARCH STUDY

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Abstract: This research study examines the transformative impact of STEM-based pedagogy on academic achievement, critical thinking, and innovative capabilities among Grade VIII students at Adani Vidya Mandir, Ahmedabad. Recognizing the growing need for 21st-century competencies, the study systematically integrates STEM strategies into classroom instruction and evaluates their effectiveness through both quantitative and qualitative measures. A total of 111 students participated in the intervention during the academic year 2025–26.

The comparative analysis of science average scores indicates a substantial rise from 49.37 (2024–25) to 59.92 (2025–26), reflecting a measurable academic improvement of 10.55 marks. Beyond numerical gains, classroom observations reveal heightened engagement, deeper conceptual understanding, improved collaboration, and stronger analytical reasoning. The findings suggest that STEM-based pedagogy not only strengthens subject knowledge but also cultivates problem-solving skills, creativity, and independent thinking. The study reinforces the value of interdisciplinary, experiential learning as a powerful instructional approach in middle school science education.

Key words: STEM Education, Science Achievement, Action Research, Critical Thinking, Innovation, Grade VIII

I. INTRODUCTION

Science education at the middle school level plays a pivotal role in shaping students' logical reasoning, inquiry skills, and conceptual clarity. However, traditional lecture-based instruction often restricts students to passive learning, limiting opportunities for exploration, experimentation, and real-world application. As education systems increasingly emphasize competency-based learning, there is a pressing need to shift from rote memorization to inquiry-driven, skill-oriented pedagogy.

STEM education—integrating Science, Technology, Engineering, and Mathematics—offers a dynamic instructional framework that promotes experiential learning, interdisciplinary connections, and authentic problem-solving. Rather than teaching concepts in isolation, STEM pedagogy encourages students to apply theoretical knowledge to practical challenges. It transforms classrooms into collaborative learning spaces where students investigate problems, design solutions, test hypotheses, and reflect on outcomes. This action research was undertaken to examine whether structured integration of STEM strategies could positively influence science achievement and higher-order thinking skills among Grade VIII students. The study aims to bridge the gap between theoretical knowledge and practical application, thereby enhancing both academic performance and cognitive engagement.

II. Objectives of the Study

To examine the impact of STEM-based instruction on science academic achievement
To analyze changes in students' critical thinking and innovative abilities
To compare pre- and post-intervention science averages
To reflect on the effectiveness of STEM pedagogy in classroom practice

2. Research Methodology

Research Design

The study employed an Action Research design, combining quantitative and qualitative approaches. Action research was chosen because it allows the educator to systematically implement instructional innovations while continuously observing, analyzing, and refining classroom practices.

Sample Size:

The sample consisted of 111 Grade VIII students from Adani Vidya Mandir, Ahmedabad, representing diverse learning abilities and academic backgrounds**.**

Duration

The intervention was conducted throughout the Academic Year 2025–26.

Intervention Strategy

STEM-based pedagogy was integrated into regular science lessons through:

- Hands-on laboratory experiments
- Model construction and engineering-based challenges
- Problem-based learning tasks
- Real-life application projects
- Collaborative group discussions
- Inquiry-driven questioning techniques
- Integration of digital tools and simulations

Students were encouraged to design experiments, predict outcomes, analyze data, and present findings. Lessons were structured to promote exploration rather than direct instruction.

Tools for Data Collection

1. Unit tests and periodic assessments
2. Pre- and post-average score comparison
3. Classroom observation records
4. Student reflections and feedback
5. Performance-based evaluation tasks

Both academic data and behavioral observations were analyzed to assess impact comprehensively.

3. Data Analysis and Graphical Presentation

The comparative data reveals a significant improvement in science achievement after STEM implementation.

- **Average Science Score (2024–25):** 49.37
- **Average Science Score (2025–26):** 59.92
- **Total Improvement:** 10.55 marks

This improvement represents more than just numerical growth; it indicates stronger conceptual understanding and application-based learning. The upward trend suggests that students responded positively to experiential and interdisciplinary instruction.

The increase in average scores demonstrates that STEM pedagogy not only supports high achievers but also benefits moderate and struggling learners by making concepts tangible and relatable.

Figure 1: Bar Graph Showing Comparison of Science Averages Before and After STEM Implementation

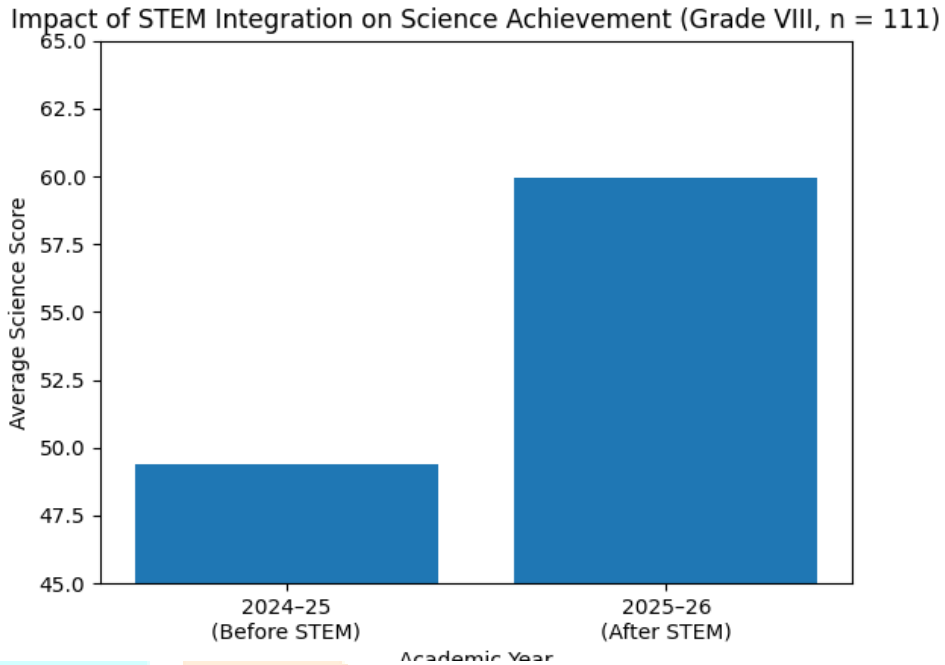
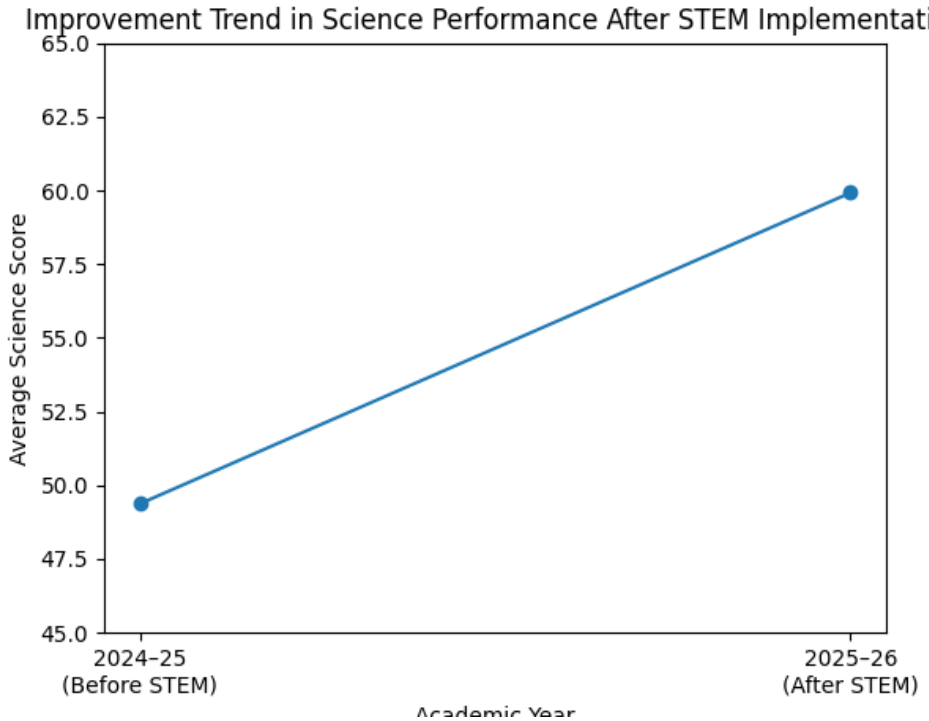


Figure 2: Line Graph Showing Upward Trend in Science Achievement After STEM Integration



3.1 Findings and Interpretation

The findings of the study highlight multiple dimensions of improvement:

Academic Achievement

There was a marked increase in overalll science performance. Students showed better retention of concepts and improved accuracy in application-based questions.

Conceptual Clarity

Learners demonstrated deeper understanding of scientific principles rather than memorized definitions. They could explain phenomena with logical reasoning.

Student Engagement

Classroom participation increased significantly. Students actively asked questions, shared ideas, and volunteered for demonstrations.

Collaboration and Communication

Group-based STEM activities enhanced teamwork, leadership, and communication skills. Students learned to respect diverse viewpoints and collectively solve problems.

3.2Impact on Critical Thinking and Innovation

STEM pedagogy directly contributed to the development of higher-order thinking skills. Students were encouraged to:

- Formulate hypotheses
- Analyze experimental data
- Evaluate results
- Identify errors and redesign solutions
- Connect theoretical knowledge to practical scenarios

Engineering-based challenges fostered innovation as students constructed working models and prototypes. They explored multiple solutions to a single problem, strengthening analytical flexibility.

Students began viewing problems not as obstacles but as opportunities to design and innovate. This shift in mindset reflects the development of critical thinking, creativity, and resilience.

4.RESULTS AND DISCUSSION:

The research conclusively demonstrates that STEM-based pedagogy significantly enhances science achievement and promotes cognitive growth among Grade VIII students. The 10.55-point increase in average scores, coupled with qualitative improvements in critical thinking, collaboration, and innovation, validates the effectiveness of experiential and interdisciplinary instruction.

STEM education transforms the classroom from a teacher-centered environment into a dynamic learning ecosystem. It empowers students to think critically, apply knowledge meaningfully, and develop competencies essential for future academic and professional success. The study strongly recommends sustained and structured integration of STEM strategies across science curricula to nurture holistic learner development.

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I extend my heartfelt appreciation to the Grade VIII students who actively participated in the STEM-based activities with enthusiasm, curiosity, and commitment. Their willingness to explore, experiment, and innovate contributed significantly to the success of this study.

I am also thankful to my colleagues for their constructive feedback, collaborative discussions, and professional support throughout the implementation of the intervention. Their insights helped refine the instructional strategies and assessment methods. Finally, I acknowledge the broader educational community and researchers in the field of STEM education whose scholarly contributions have inspired and guided this study.

Appendix.1

Evidence Summary

Academic Year	Number of Students Participated	Projects Completed	Level of Participation
2024–2025	10	03	ATL Marathon
2025–2026	20 Students actively participated, and rest are ongoing projects	06	Viksit Bharat Buildathon 2025, School innovation Marathon, Inspire, Manak , CBSE Science Exhibition, Kidovation 2.0 and Junior Science Laureates

Sr.no	Name of the students	Name of the Project	Level of Participation	Video Links and Project Pics
1.	1.Ms Saanvi Nair	Solar Refrigerator	First Round cleared and selected for Evaluation Round in WAAH Junior Laurates, Viksit Bharat Buildathon 2025, School innovation Marathon, Inspire Manak , CBSE Science Exhibition Secured 2nd position on Kidovation 2.0	https://www.facebook.com/share/v/17ma5Dy1eo/  
2.	1.Zainab Bhadki 2.Triyasha Ghosh 3.Vritika Shiroya	Meal Bridge App	Viksit Bharat Buildathon 2025, School innovation Marathon	https://youtu.be/na-kzr6CWjU?si=nDn3ZRqE-KQC-gYB
3.	1.Vedika Soni 2. Aliya Pipadwala	Oculus Veritas	Viksit Bharat Buildathon 2025, School innovation Marathon	https://www.facebook.com/share/v/14MhPVG4fER/
4.	1.Maahi Jain 2.Fatma Shaikh 3.Reni Bhavsar 4.Navya Rathod 5.Zara Patel	Smart Drainage System	First Round of WAAH Junior Laurets	Video not access
5	1.Kaushal Kanani 2.Shlok Veer 3Jaryan Patel 4. Prashant Singh Kushwaha 5.Anas Shaikh	Obstacles Detective Glasses	Viksit Bharat Buildathon 2025, First Round of WAAH Junior Laurets, School innovation Marathon	https://youtu.be/ffIl-difdXI?si=CcEOVZoCeI2pguuJ ``

Academic Year	Number of Students Participated	Projects Completed	Level of Participation
6.	1.Muskan Shaikh 2.Mitali Metkel 3.Niyati Galoriya 4.Binjal Dhobi	Disaster Management	First Round of WAAH Junior Laurets, Viksit Bharat Buildathon 2025	https://youtu.be/1IywixSlgz0?si=ovMBRfu7279wrr25

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