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Effect of Practical Teaching Practices on STEM Syllabus Retention in Preadolescent Students

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***ABSTRACT*:** This study investigated the impact of practical teaching methods on students' retention of STEM topics. The study was conducted with a sample of students in municipal schools in Nashik, Maharashtra. The students were from one of three schools- one with 2 years of experience of practical STEM workshops, one with 1 year and one with no exposure to practical education. The practical teaching methods included hands-on activities and experiments from the syllabi of 7th and 8th grade.

The results of the study showed that the students who received practical teaching methods outperformed the students who did not receive practical teaching methods on a customized test. The students who received two years of practical teaching methods outperformed the students who received one year of practical teaching methods by 5.51%, and the ones who had not received any by 31.48%. Hence, the more consistent their exposure to such methods, the better their performance on tests. Furthermore, a trend showing students scoring higher on topics which were taught with more in depth and interactive methods than those with more demonstrative methods was observed in the students who were exposed to practical learning. For example, the use of extensive circuits to teach electricity yielded a positive outcome of 89.285%, while the demonstration for angle construction stood at only 61.905%. The findings of this study suggest that practical teaching methods can be an effective way to improve student retention of STEM topics. If the study is conducted at a larger scale with greater resources, the results could be generalised towards almost every student in this country. This makes it key to future education policy planning.

1. INTRODUCTION

Education is a driving force for societal progress, with the potential to transform lives and communities. In India, a nation of over a billion people, the educational landscape is undergoing significant changes to adapt to an ever-evolving world. A pivotal aspect of this transformation involves the integration of practical education into middle school curricula. This shift is not just theoretical; it is grounded in real-world data that underscores the profound impact of practical education.

Project STEAM, an innovative initiative, serves as a testament to the potential of practical education. It focuses on students in grades 7 and 8, particularly those attending municipality schools with little to no prior exposure to practical education. Over the course of a month, a series of workshops and activities were meticulously designed to immerse these students in STEM topics such as electricity and algebra. These workshops were interactive, experiment-based, and hands-on, allowing the students to directly engage with and apply theoretical concepts.

The significance of Project STEAM lies in its ability to address the pressing educational challenges in India. Approximately 63% of middle school students in the country struggle with fundamental reading and math skills, according to the Annual Status of Education Report (ASER) 2020. This statistic highlights the urgent need to rejuvenate the educational approach.

Practical education, as exemplified by Project STEAM, offers a promising solution by emphasizing hands-on learning, bridging the gap between theory and application. Through this approach, students can grasp complex concepts more effectively, fostering active engagement and ultimately leading to improved academic performance.

Furthermore, the National Sample Survey Office (NSSO) conducted a study in 2019, revealing that employability remains a significant concern in India, with an estimated 10 million young people entering the job market annually. The data also showed that a substantial portion of these job seekers lacks the practical skills demanded by employers.

Practical education equips middle school students with these essential skills for the 21st-century workforce, such as creativity, problem-solving, and critical thinking. By instilling these skills at an early age, practical education not only empowers students but also enhances India's economic prospects.

Moreover, the COVID-19 pandemic led to a concerning rise in middle school dropout rates, as highlighted in the ASER 2021 report. This crisis underscores the need to reevaluate pedagogical methods.

Practical education, as demonstrated by Project STEAM, can act as a catalyst for increased student retention. Engaging in hands-on activities fosters a sense of ownership over learning, reducing dropout rates. It also makes learning more resilient in the face of disruptions, such as pandemics, by encouraging independent learning and adaptability.

As India strives to improve access to education, it is essential to ensure that the quality of education is not compromised. Practical education, as exemplified by Project STEAM, promotes inclusivity by catering to diverse learning styles and abilities. It accommodates students who may struggle with traditional teaching methods, ensuring that education reaches every corner of the nation, leaving no child behind.

This research paper aims to comprehensively explore the impact of practical education on Indian middle school students. By analyzing real-world statistics and data, including insights from Project STEAM, we aim to elucidate how practical education enhances academic outcomes, empowers youth for the job market, reduces dropout rates, and promotes inclusivity. Through these findings, we contribute to the ongoing discourse on shaping a brighter future for India's youth and the nation as a whole.

2. NEED OF THE STUDY

Approximately 63% of middle school students in India struggle with fundamental reading and math skills, according to the Annual Status of Education Report (ASER) 2020. This statistic highlights the urgent need to rejuvenate the educational approach.

Additionally, the National Sample Survey Office (NSSO) conducted a study in 2019, revealing that employability remains a significant concern in India, with an estimated 10 million young people entering the job market annually. The data also showed that a substantial portion of these job seekers lacks the practical skills demanded by employers.

Education (specifically in India) is highly theoretical and seldom majorly practical. The study's findings can help determine what the effect of the opposite could be. As our country shifts towards a more practical approach towards Education with the National Education Policy-2032 (NEP-2023), the study can predict the change that might be observed in the future. It can also encourage the policymakers around the world to consider a similar approach. Often, teachers skip the practical aspect, thinking it is unnecessary; the results can help convince them otherwise and be more enthusiastic. The study also helps determine what experiments are most effective in helping the students understand STEM topics fully.

3. HYPOTHESIS:

- A student's ability to retain STEM topics increases when the same topic is taught using practical and experimental methods.
  - Students who were a part of Project STEAM score higher on the test given to them than the students who weren't a part of Project STEAM.
- Consistent exposure to experimental teaching methods further improves a student's capabilities in STEM.
  - Students with 2 years of experience score higher than students with 1 year of experience.

4. LITERATURE REVIEW

Science education has shifted from a teacher-centered to a student-centered approach, emphasizing students' responsibility for their own learning. Traditional practices such as direct lecturing and textbook-based learning do not adequately develop critical thinking skills or whole concepts, which are essential for science literacy (Yore, 2001).

Practical work helps students learn scientific concepts, develop problem-solving skills, and understand the nature of science. It also motivates students and provides experience using scientific knowledge (Sotiriou, Bybee, & Bogner, 2017; Hodson, 1990).

Tsakeni (2018) found that the absence of practical examinations can lead to practical work being underestimated in the classroom, which can negatively impact marginalized students. Tsakeni recommended supporting practical work through assessment and instructional leadership.

Practical work is an essential part of science education. It helps students learn and understand science in a more meaningful way. It also helps them develop critical thinking and problem-solving skills (Dillon, 2008; Bryson, Millar, Joseph, & Mobolurin, 2002).

Most of the research on practical teaching methods has been conducted in developed countries, and it is important to investigate the effects of these methods in developing countries like India.

5. RESEARCH METHODOLOGY

This section presents the plan and method on how the study is conducted. This includes population and sample of the study, statistical tools, and data analysis.

5.1 Population and Sample

The study was aimed towards students who have had varying degrees of exposure to practical learning. Using the connections and pre-established samples from Project STEAM, a self-report/test was used to collect data. The test was taken by a total of 232 students with their experience with project STEAM ranging from 0-2 years. 79 students from Manapa School Number 43, Nashik have participated in the project in the years 2022 and 2023; 83 students from N.M.C school Number 76, Nashik have participated in the project only in 2023; 70 students from Nutan Prathamik Vidyamandir, Nashik have never taken part in Project STEAM.

5.2 Statistical and Tools

The study used a questionnaire based on the topics taught during Project STEAM; the students were made to answer the test 12 weeks after the workshops were conducted (late June) in 2023. The test was designed to measure students' knowledge of STEM concepts, their ability to apply those concepts to solve problems, and their understanding of the nature of science. It was curated specifically for this study and draws only from the 7th and 8th grade Maharashtra State Board syllabi for science and math. However, the findings could be extended to other grades and/or education systems with some degree of confidence.

5.3 Analysis of the Data To **assess the impact of practical learning on student learning outcomes in math and science, a test was designed consisting of 10 questions with 2-4 subparts, graded on a scale of 1-10. The test was administered to students with varying levels of exposure to practical teaching. The results of the test were used to: analyse the average scores of students with different levels of exposure to practical teaching; deduce which gender benefits more from practical teaching on average by comparing the difference in average scores of the test with and without practical teaching; identify the topics that are most effectively taught practically by comparing the percentage of students that answered each section of the test correctly**.

6. RESULTS AND DISCUSSION

6.1 Demographic Characteristics of the Participants:

The demographics of the participants are presented through Table 1 and descriptively using the scheme of the students' exposure to Project STEAM and gender.

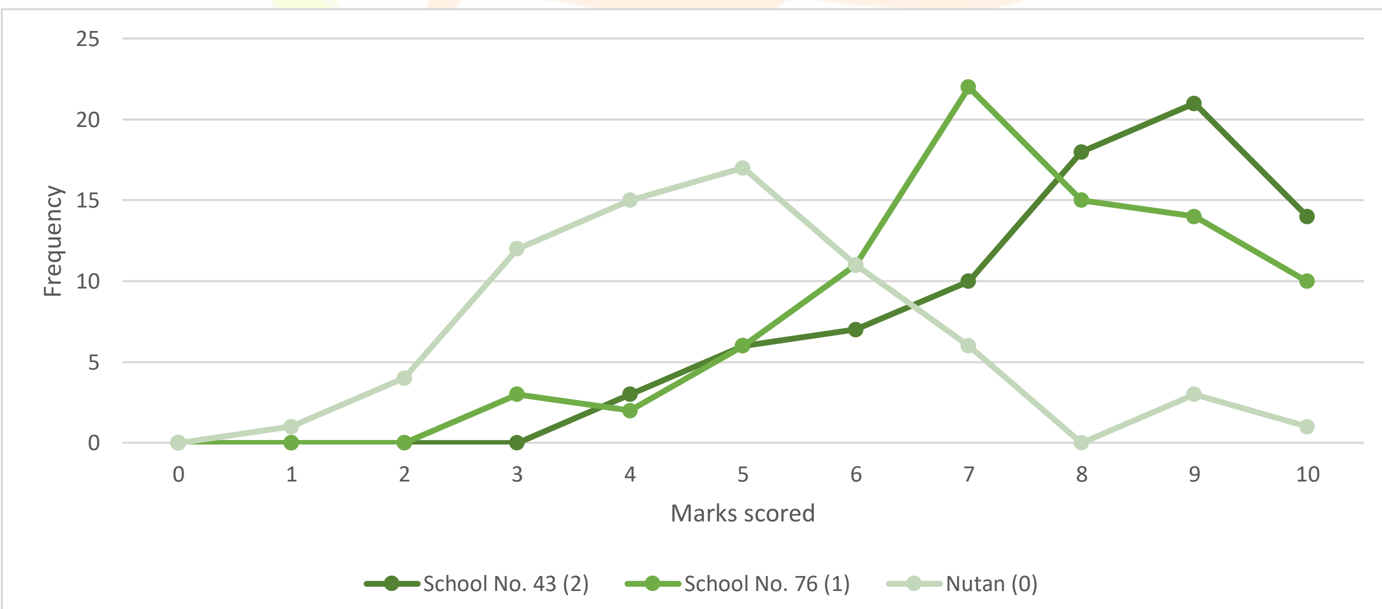
Table 1: Demographic Characteristics of Participants

Variables	Frequency (f)	Percentage (%)
Respondents' Exposure to STEAM		
2 Weeks of Workshops (School A)	79	34.1%
1 Week of Workshops (School B)	83	35.8%
No Exposure (School C)	70	30.2%
Respondents' Gender		
Female	121	52.2%
STEAM	82	
Non-STEAM	39	
Male	111	47.8%
STEAM	80	
Non-STEAM	31	

6.2 Relationship between exposure to practical learning and academic performance.

6.2.1 Comparison between schools with different levels of exposure to practical learning.

Marks Scored	School No. 43 (2)	School No. 76 (1)	Nutan (0)
0	0	0	0
1	0	0	1
2	0	0	4
3	0	3	12
4	3	2	15
5	6	6	17
6	7	11	11
7	10	22	6
8	18	15	0
9	21	14	3
10	14	10	1
Mean	7.937	7.386	4.786



The data shows that there is a clear trend between the number of years of experience with practical learning and the percentage of students who scored more than 80% on the final test. The school with two years of experience had the highest percentage of students scoring above 80%, followed by the school with one year of experience, and then the school with no experience. Specifically, 67.09% of students in the school with two years of experience scored more than 80% on the final test, compared to 46.99% of students in the school with one year of experience, and 5.71% of students in the school with no experience.

The average score of students in the school with two years of experience with practical learning (7.937) is higher than the average score of students in the school with one year of experience with practical learning (7.386), and the average score of students in the school with one year of experience with practical learning is higher than the average score of students in the school with no experience with practical learning (4.786). The average score of students in the school with two years of experience is 3.151 points higher than the average score of students in the school with no experience. This is a statistically significant difference, suggesting that practical learning has a large effect on student learning outcomes.

Mode: The mode of the marks scored by the students of these three school with different levels of exposure to practical learning varies as follow: 2 years of experience- 9 marks;1 year of experience- 7 marks; 0 years of experience- 5 marks.

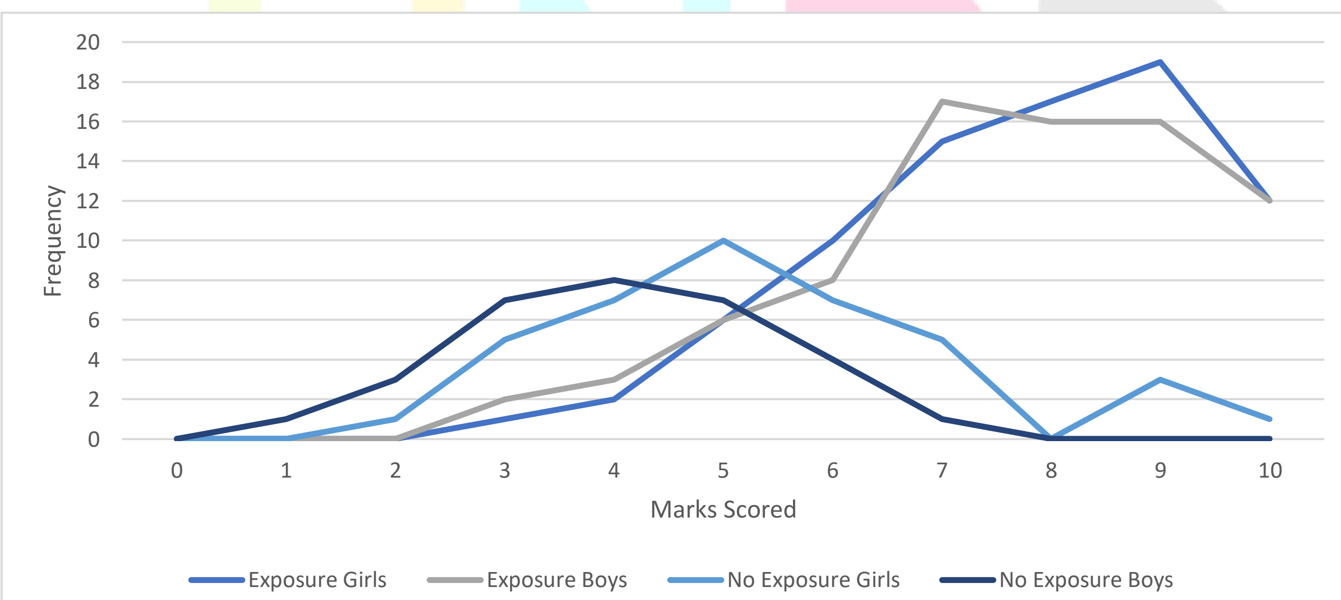
6.2.2 Comparison between the effectiveness of practical learning for different types of topics.

Topics that were taught more practically, such as circuits, yielded better scores than the topics taught more theoretically, such as angles, on the final test. This can be attributed to the difference in the comprehension of those topics.For example, when students learn about circuits by building their own circuits, they are able to see and understand how the different components work together and how to troubleshoot problems. By contrast, topics like angle constructions or angle bisectors have set steps that are to be followed.

Manapa School no.72 students performed significantly better on circuit questions (89.285%) than on angle questions (61.905%) in a recent test, suggesting that practical learning methods may be more effective for certain STEM topics.

6.3 Relationship between gender and effect of practical learning:

	Exposure		No Exposure	
Marks Scored	**Girls**	**Boys**	**Girls**	**Boys**
0	0	0	0	0
1	0	0	0	1
2	0	0	1	3
3	1	2	5	7
4	2	3	7	8
5	6	6	10	7
6	10	8	7	4
7	15	17	5	1
8	17	16	0	0
9	19	16	3	0
10	12	12	1	0
Mean	7.720	7.588	5.359	4.065



While both boys and girls performed better with practical education than without it, boys had a more positive impact on their academic performance due to practical learning. The average score of boys without practical education was 4.065, while the average score of girls without practical education was 5.359. However, with practical education, the average score of boys was 7.588, while the average score of girls was 7.720. This means that the boys' average score increased by 3.523 points when they had practical education, while the girls' average score only increased by 2.361 points.

These findings suggest that practical education may be more beneficial for boys than for girls. However, it is important to note that this is just a small study, and more research is needed to confirm these findings. Additionally, the difference in the impact of practical education on boys and girls may be due to other factors, such as the type of practical education that was provided, or the motivation of the students.

7. CONCLUSION

In conclusion, the findings of this study suggest that practical learning has a positive impact on student learning outcomes in STEM subjects. Students who have more experience with practical learning tend to perform better on tests of their knowledge. This is likely because practical learning helps students to better understand and retain the material. Additionally, practical learning can help students to develop critical thinking skills and problem-solving skills, which are essential for success in STEM subjects. Overall, practical learning is an effective way to improve student achievement in STEM subjects. Schools should consider implementing the recommendations below to ensure that all students have the opportunity to benefit from practical learning.

One possible explanation for why Project Steam had a greater impact on boys than girls is due to the social pressure on girls in India. Girls in India are often socialised to be shy and likeable. This can make them less likely to participate in hands-on activities and experiments, which are essential components of Project STEAM. They may have succumbed to pre-existing stereotypes, hence participating less in experiments that especially require technical abilities (Electricity, for example). It is important to note that these are just possible explanations, and more research is needed to understand why Project Steam had a greater impact on boys than girls. However, it is clear that the social pressure on girls in India is a significant factor that needs to be considered when designing and implementing STEM education programs.

8. RECOMMENDATIONS

This study makes the following recommendations. Policymakers should conduct a large-scale study to investigate the impact of practical learning on student learning outcomes in different STEM subjects, and across different groups of students. This research should be well-designed and rigorous and should use a variety of data collection methods to ensure the validity of the findings. Development and proper implementation of a new science syllabus for preadolescent students that emphasizes practical learning should be done. This syllabus should be designed by experts in science education and should be piloted in a variety of schools before it is widely adopted. Regional supervisor positions should be established to ensure that the new science syllabus is implemented effectively. These supervisors should be responsible for providing training and support to teachers, and for monitoring the implementation of the syllabus in schools. Traditional lab manuals can be replaced with a system that is more focused on student-centered inquiry. This system could be based on the A-level syllabus, or on other successful models from around the world. Furthermore, programs and initiatives to encourage girls to participate in class discussions and build their confidence in STEM subjects should be implemented. This could involve providing girls with role models, creating opportunities for them to collaborate with other girls on STEM projects, and providing them with additional support in STEM classes. A great example of such initiatives is the US National Science Foundation has funded a number of programs to encourage girls to participate in STEM. For example, the NSF-funded Girls Who Code program provides girls with opportunities to learn about computer science and to develop their coding skills.

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