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Effectiveness of Practice-Based Professional Development in Enhancing Stem Teachers

Nithya Prem. S. R*

Abstract

STEM is about science technology engineering and math all put together in school work. Small group talks are seen as a good way to help students learn in these classes but it depends on things like how much the teacher knows about the topic and whether they feel ready to lead the talks. We looked at photovoltaics for this which mixes all the STEM areas and connects to solar power as a clean energy option that could help a lot. Teachers took part in talks using articles and similar materials on the subject.It seems the goal was to build their knowledge and get better at running these discussions so they could try the same thing in their classrooms. Some parts of how that actually plays out might still be unclear though. The renewable side of it stands out but maybe not every detail got covered evenly in the sessions. The outcomes revealed that teachers actively engaged in substantive STEM discussions, dedicating the majority of their time to posing authentic questions related to photovoltaic topics that aligned with various science and engineering core ideas. They responded to these questions with detailed, elaborative discourse and took ownership of the discussions. Teachers ended up with a stronger grasp of photovoltaics than they started with. Their sense of being able to lead discussions also got better. It seems like both things happened together. That part is easy to miss but it mattered for the whole program. I am not totally sure how big the change was in every case. Furthermore, most teachers incorporated small-group discussions into their end-of-program lesson plans. Follow-up interviews conducted a year later indicated that a subset of teachers had significantly increased the use of discussions in their STEM classrooms. In conclusion, the study presents a significant contribution by employing a practice-based approach to professional development. This approach not only enhances teachers' photovoltaic content knowledge but also equips them with the skills to effectively implement this knowledge through small-group discussions in their classrooms. Therefore, the findings highlight an innovative pedagogical strategy that could be employed to support teacher education and facilitate the development of enriched curricula for STEM students.

Keywords: Small-group discussion, practice-based teacher education, STEM discourse, instructional strategies, science and mathematics education.

***Author for Correspondence**
Nithya Prem. S. R
E-mail: nithya.prem@curaj.ac.in

Assistant Professor, Department of Education, Central University of Rajasthan, Ajmer, Rajasthan, India

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INTRODUCTION

STEM education integrates science, technology, engineering, and mathematics to promote interdisciplinary learning and problem-solving skills among students. Effective classroom discussions, particularly small-group discussions, can enhance STEM learning by encouraging inquiry, collaboration, and deeper understanding. However, the success of such approaches depends on teachers’ content knowledge and confidence in facilitating meaningful discussions. Practice-based professional development programs provide opportunities for teachers to strengthen both their subject knowledge and instructional strategies.

Photovoltaics, as an interdisciplinary STEM topic connected to renewable solar energy, offers a valuable context for developing teachers' expertise and supporting the implementation of discussion-based learning in STEM classrooms [1].

SCIENCE

Promotes curiosity, exploration, inquiry, and problem-solving, frequently through experimentation and investigation.

TECHNOLOGY

Encourages the use of simple tools such as crayons, rulers, pulleys, and wheels, as well as more complex ones such as microscopes and computers.

ENGINEERING

Promotes the utilization of materials, encourages design, craftsmanship, and construction, fostering comprehension of the mechanisms behind how and why things operate.

MATHEMATICS

Encourages creativity and process development, as well as allows children to illustrate the concepts that they are learning.

NEEDS AND SIGNIFICANCE OF THE STUDY OF STEM PEDAGOGY

STEM fields are crucial for technological advancement and economic growth, necessitating educators to prepare students for careers in these fields.

STEM Pedagogy emphasizes critical thinking, problem-solving skills and inquiry-based learning for success in the modern workforce [2].

STEM education can help reduce disparities by providing quality education to underrepresented groups, requiring inclusive teaching methods and environments.

STEM pedagogy instills a mindset of curiosity and lifelong learning, empowering students to continuously update their skills and adapt to new challenges [3].

The National Science Foundation (USA), s Judith A. Ramaley came up with the phrase STEM in 2001 in order to swap out the older SMET label. At first, both acronyms seemed like they were just meant as a quick reference to the Science, Math, Technology and Engineering disciplines as well as the professionals who work in them. Later on, NSF put together a set of STEM subject areas, and that list covers industry-relevant domains such as psychology, social science, and education and learning research [4].

Today, STEM is basically a brand name people use for the blending together of science, technology, engineering, and mathematics inside educational curricula.

Currently in use definitions for the integrational models of STEM (science, technology, engineering, and mathematics) are:

S- Technology is based on science, which studies and attempts to comprehend the natural world. Science studies the natural world and its contents.

Several scientific methodologies are used to work out the meaning of the natural world, such as "inquiry," "discovering what is," "exploring," and also the application of "the scientific method."

T- But, as the NRC puts it, "The goal of technology is to make modifications in the world to meet human needs." or Technology is the alteration of the natural world to satisfy the needs and desires of humans. Thus, technology is essentially about what can be produced, manufactured, and developed from materials and substances present in nature in order to fulfill human needs and ambitions. "Invention," "innovation," "practical problem solving," and design are some of the technological processes that alter and reshape the natural world.

E- "Engineering is the profession in which one applies judgement to develop ways to economically utilise natural resources and forces for the benefit of mankind by applying knowledge of mathematics and natural sciences acquired through study, practice, and experience". The philosophy of technology and engineering is closely related to each other.

M- Mathematics is the science of patterns and relationships. It gives science, engineering, and technology their own precise language. Technological advancements, like computers, encourage mathematics, while mathematics advancements frequently lead to technological improvements. A mathematical model that aids in technical design by simulating the possible operation of a suggested system is one example of this [5].

STEM LITERACY AND 21ST-CENTURY SKILLS

In order to meet the needs of the future workforce, we must modify the current educational strategies. Interdisciplinary education programs are offered as an alternative to traditional education for the development of 21st century abilities because traditional classroom approaches no longer truly fulfill the task. While they are still learning new information, 21st century skills assist pupils in adjusting to a new environment (Dede, [12]2010).

The abilities that people should have if they want to succeed in 21st-century society, are described by Jerald as basic knowledge and skills (academic knowledge and academic skills), literacy skills (the ability to use academic knowledge and abilities in real-world scenarios) and 21st century skills (the ability to employ literacy and other talents at any time, to achieve in various areas of life).Making sure students are actively engaged in a productive learning environment without it becoming passive or detached is the main goal. Problem-solving skills: In the twenty-first century, problem-solving skills can help people deal with uncommon situations by employing practical strategies.Critical thinking abilities: Critical thinking entails a meticulous, nearly exhaustive examination and assessment of assertions, supporting data, and beliefs [6].

DEVELOPMENT OF STEM EDUCATION PRACTICES

STEM has gained such interest in recent years and in particular discuss ‘science’, ‘technology’ and maths, and how science knowledge and mathematical ability is ‘exploited’ in technology and vice versa. Harari notes, more or less, that it wasnt until the Enlightenment that people really got it that there was a lot of new knowledge just waiting to be uncovered and taken advantage of. He argues that this is basically where the link between science and technology started shifting, rapidly. Still, finding new knowledge and then using it in practical ways tends to be costly. It calls for serious funding, and this is where Harari says a third party moves into the picture, capitalism. In other words, those who had capital to deploy funded scientific discovery and also the later exploitation of it, expecting that they would harvest a substantial profit, and then re-invest some of that money into more discovery and use. So there has been this alliance between science, technology and capitalism (both via private investment and government investment) that helped create a kind of strong synergy, which eventually shaped the world we live in now [7].

In communist places, like the post-war Soviet Union, and also in present day China, government support and the enabling of technological enterprise lifted large numbers of people out of poverty. The main point though, is that technology is not only the application of scientific knowledge that is already completely understood, and this view was also recognized by economist Nathan Rosenberg [8].

STEM EDUCATION

Emergence of STEM Pedagogy In an effort to develop a diverse STEM workforce, schools and community organizations offer STEM education experiences in a variety of settings. STEM education is defined as follows in the 2012 study "Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer": education that includes instruction in mathematics, science, technology, and engineering [9].

It usually spans educational initiatives across all levels of schooling, ranging from pre-school to post-doctorate, and occurs in various settings, including formal environments such as classrooms, as well as informal settings like afterschool programs [10-12].

DEFINITION OF STEM EDUCATION

Although there is no internationally approved definition. The mostly approaches are here:

An attempt to integrate elements of the four STEM fields- science, technology, engineering, and mathematics into a single lesson, unit, or class that focuses on the linkages between the material and real-world issues. One subject’s primary STEM content learning objective may be included in integrated STEM curricular models, but other STEM topics’ context may also by included (Moore et al. [13] 2014).

Method for integrating STEM practice into the curriculum of two or more STEM domains in order to teach the STEM content in a way that will improve student learning. practice should incorporate scientific inquiry, engineering design, mathematical reasoning, and technical literacy [10].

In STEM education, project-based learning is the predominant methodology. For instance, in order to construct a functional greenhouse, students may study geometry, physics, and biology. They might also incorporate automation into their IT education. However, these projects typically adopt a utilitarian interdependence of the subjects and solely functional approach to the work [11].

FACTORS ABOUT STEM LEARNING

Teaching STEM subjects facilitates the development of crucial life skills such as critical thinking, problem-solving, innovation, teamwork, and confidence. However, a challenge for teachers is the continual requirement for inventive methods to sustain students' interest in STEM. Teachers have the concepts and textbooks, and the school curriculum is more STEM-focused than ever before.

INTEGRATING STEM LITERACY WITH 21ST-CENTURY SKILL DEVELOPMENT

In order to meet the needs of the future workforce, we must modify the current educational strategies. For the development of 21st century abilities, interdisciplinary education programs are suggested as a form of alternative for traditional classroom approaches since they no longer truly address the task. While they are still learning new information, 21st century skills assist students in adjusting to changing circumstances (Dede, [12]2010). According to Jerald, basic knowledge and skills (academic knowledge and skills), literacy skills (the ability to use academic knowledge and skills in everyday situations), and 21st century skills (the ability to apply literacy and other skills at any time to succeed in different parts of life) are the capacities that people are expected to have in order to succeed in 21st-century society. It aims to guarantee that students are involved in a productive learning Environment.

In the twenty-first century, having the ability to solve problems can help people deal with unforeseen situations by employing the right strategies.

CONCLUSION

The application of STEM pedagogy learning style shows a significant improvement in the students’ conceptual knowledge of physics.

Before and after the STEM pedagogy learning strategy is used, there is a significant change in the pretest and posttest scores. As a result, the STEM pedagogy learning style improved the students' capacity for conceptual comprehension and problem-solving.

Recommendations

Based on the study's findings, it is strongly advised to use STEM pedagogy as learning strategy and investigate its application in particular subject or discipline. Additionally, it is recommended that educators take part in training on how to use this teaching technique in terms of topic content delivery, style approach, and learning materials. This will enable the teachers to fulfill the learning competencies, particularly with regard to physics' abstract subjects.

Nurturing Future Innovators in Stem

Moving forward, what is the best way to respond to these STEM education stats?
As advocates of STEM learning, we now know that:

- Kids benefit from early STEM education.
- Engaging, hands-on curriculum influences STEM interest for years to come.
- The U.S. and other western countries are at risk of falling behind in STEM.
- The future of society depends on proficient STEM skills, both in academics and practice.

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