



Reimagining Stem Teacher Education in Under-Resourced Indian Context- A Thematic Framework

¹Dr. T. Premalatha & ²Shalini A/P Jayaprakash

¹Assistant Professor and Head i/c, Department of Education (CDOE), Bharathiar University, Coimbatore

²PhD Research Scholar, Department of Education, Bharathiar University, Coimbatore



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Abstract

The paper is a thematic review of STEM (Science, Technology, Engineering, and Mathematics) teacher education in the context of under-resourced regions, specifically in the Indian context. The education based on STEM is very important in equipping students to become a force in the 21st century. Nevertheless, there are major challenges in teacher training of STEM in under-resource regions such as poor infrastructure, accessibility to technology, and professional development opportunities to the teachers. It is a literature review that summarizes information on the pedagogical practices, professional development requirements, and technological integration of STEM learning in low-resource environments. It emphasizes the significance of interdisciplinary training of teachers, the incorporation of modern educational technologies, and the necessity of the specifics of professional development programs to increase teacher efficiency. The paper further discusses the changing nature of STEM teacher education in India with focus on policy, rural issues and the current reforms in teacher training programs. The results indicate that despite the slow change in favor of educating teachers in STEM subjects in under-funded districts, there remains a significant gap in teaching preparation and needs more intensive, localized interventions. The review will make future research and policy formulation in STEM education in low-resource and rural settings, especially in India, a valuable source of information.

Keywords: STEM education, teacher education, Under-resourced areas, India, professional development, Pedagogical Content Knowledge (PCK), inquiry-based learning, Project-Based Learning (PBL), technology integration, interdisciplinary teaching, rural education, educational inequalities.

Introduction

STEM (Science, Technology, Engineering, and Mathematics) education is vital in providing the skill needed by students to solve complex real-life challenges and to match the requirements of the 21st century. Nevertheless, in poorly resourced regions, specifically in India, there are considerable obstacles to effective STEM education, such as low quality of teaching materials, poorly trained teachers, and lack

of facilities (Kumar & Azad, 2016) The inclusion of STEM subjects is essential, argues (Kukulkska-Hulme et al., 2024), yet in such subjects, teachers do not have the required pedagogical content knowledge (PCK) to deliver an interdisciplinary approach to STEM education.

In other developing nations, such as India, the issue is even more complicated by the inequalities in access to and quality of education throughout the



regions, rural areas in particular, which cannot offer sufficient education in STEM because of the lack of educational facilities (Sujeewa Vijayanthi Polgampala, 2017). The National Education Policy (NEP) 2020 aims at dealing with these issues and it is aimed at enhancing the teacher education and making teachers have the competencies necessary to implement integrated STEM education. Nonetheless, research has revealed that despite the presence of reforms, the disparity in teacher preparation and professional growth is currently a major challenge, especially in the rural and disadvantaged areas (Suryadi et al., 2023)

This study is aimed at investigating the thematic issues of the teacher education in STEM in under-resourced regions, particularly in India. It seeks to show the professional development gaps of teachers, the role played by teacher training programs and how innovative pedagogical practices can help to overcome such barriers. Through the literature review, this research will lead to the realization of the current condition of STEM education in India and the ways to improve the performance of teachers working in under-resourced schools.

Conceptual Framework Teacher Education to Stem in Under-Resourced Areas

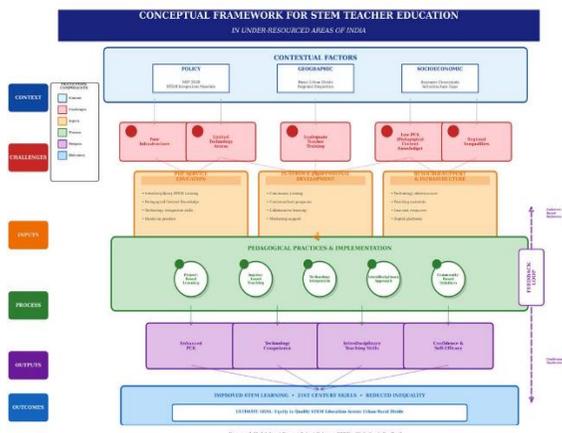


Figure 1 STEM Teacher Education Conceptual Framework of Under-Resourced Areas, India

Teacher Education for Stem

The effective teacher preparation is the basis of pedagogical content knowledge (PCK) and

integration of STEM disciplines. It is important that teachers are in a good position to make interdisciplinary concepts of STEM to be taught holistically. They should also be trained about the social and emotional learning (SEL) of students to ensure they have supportive learning conditions, which help them develop cognitively in addition to the emotional level. (*Integrated SEL into Modern Pedagogy in Teacher Education*, n.d.)

Difficulties with the Under-Resourced Areas

Limited resources such as infrastructure, teaching materials, and access to technology are some of the barriers to STEM education in under-resourced regions. As (*Integrated SEL into Modern Pedagogy in Teacher Education*, n.d.) point out, these regions have a major problem with introducing new methods of teaching, which can negatively affect the involvement and performance of students in STEM disciplines.

Pedagogical Practices

Project-based learning (PBL), as well as inquiry-based learning (IBL), are not only effective methods of engaging students, but they also can be used in low-resource settings. (Suriya E & Premalatha T, 2024) says that these active learning approaches promote critical thinking and problem-solving abilities, which are crucial in STEM education.

Technology Integration

The adoption of technologies can also offer efficient solutions at low costs to resource-depleted environments. (Suriya E & Premalatha T, 2024) state that teacher training in technology can improve the participation and engagement of the students to overcome some of the challenges related to the lack of physical resources.

Professional Development (PD) Needs

Professional development should be focused to enhance the preparedness of teachers. To support the idea that PD programs must be aimed at interdisciplinary teacher training, teamwork in solving problems, and integrating technology,



(Premalatha, 2015) believe that teachers should adapt to the local issues.

Thematic Literature Review

STEM education has emerged as a very important component in equipping students with the demands of the 21st century. Nonetheless, there are serious challenges to the implementation of efficient STEM education in the regions of limited resources, including inadequate infrastructure, limited resources, and teacher training (Kumar & Azad, 2016). Teacher education is very significant in addressing these challenges by providing the educators with skills and knowledge to teach STEM subjects effectively and in an integrated way. Both pre-service and in-service programs should be aimed at promoting cross-disciplinary teaching practices and increasing the knowledge of pedagogical content (PCK) in the STEM areas (Kukulka-Hulme et al., 2024; Shahzad et al., 2024). Although teacher education has proven to be of utmost importance, most teachers in rural and less developed areas, particularly in such countries as India, have the problem of unfavorable professional development opportunities (Sujeewa Vijayanthi Polgampala, 2017). Moreover, research highlights the importance of the technology integration in STEM classrooms, as this technology can facilitate the process of overcoming the problem of resource limitations due to the possibility of creating interactive and digital educational experiences (Rehman et al., 2025).

Hardships in Low-Income Neighborhoods

There are many obstacles to teaching STEM in under-resourced schools, including, but not limited to, the absence of infrastructure, inadequacy of teaching resources, and the shortage of teacher education. As it is stressed in (Ahmad & Sikandar, 2022), in the rural schools of India, the typical facilities to support STEM learning, such as computers, laboratory facilities, or even a stable internet connection may be scarce. As indicated (Suryadi et al., 2023) the lack of access to professional development programs leads to the poor preparation of teachers in low-income areas to teach

STEM subjects. The lack of interdisciplinary teaching possibilities also contributes to the aggravation of the problem since teachers tend to teach only one subject field (Desai, 2012)

Good Pedagogical Practices on Stem in Low-Resource Schools

Pedagogical practices in low-resource settings are critical as they allow the students to learn about STEM despite the lack of resources. One of them is project-based learning (PBL), which has been especially effective in under-resourced schools. As (Tene et al., 2024) PBL is an activity that helps to encourage students to solve real-world problems, which leads to the development of critical thinking and collaboration (Kukulka-Hulme et al., 2024) also point out that inquiry-based learning allows students to actively learn about the science, even in the context where there is not much access to laboratory equipment by the teacher. They contend that practical learning experiences, (Suriya E & Premalatha T, 2024) would be advantageous.

Professional Development Requirements of a Teacher

The concept of Professional Development (PD) is essential in enhancing education in STEM in the under-resourced regions, since it directly correlates with the ability of teachers to adopt effective instructional models (Bhattacharjee, n.d.) emphasize that continuous PD programs should equip teachers with the means of teaching interdisciplinary STEM, so as to develop an idea on how to incorporate technology, engineering, and mathematics in addition to the conventional science education. According to (Shernoff et al., 2017) emphasis in PD should be put on assisting teachers in gaining confidence and competence in active learning models like project-based learning (PBL) and inquiry-based teaching. In addition (Milner-Bolotin, 2018) pointed out the necessity of the PD that is contextualized to the needs of teachers in low-resource environments.



Application of Technology to Stem Education

The potential is that technology can address most of the obstacles encountered in STEM education, especially in regions that were not well-funded. According to (Chacko et al., 2015), ICT tools such as mobile applications, virtual labs and interactive platforms can be used to improve teaching in STEM by ensuring that people can access interactive and engaging learning experiences. As (Rehman et al., 2025) note, mobile learning platforms can be used as the inexpensive alternatives to the learning resources of the traditional classroom to enable students to take the contents of STEM lessons and materials using their smartphones or other portable devices. To overcome this, (Karahan et al., 2015) suggest technology-based professional development (PD) where teachers are provided with tools and knowledge that can make them use ICT in their STEM classes. (Akerson et al., 2018) also emphasizes that online resources may be especially helpful in accessing the STEM content when the physical ones are scarce.

Stem Education in India

India's STEM education system has undergone significant reforms, but challenges persist, particularly in rural and under-resourced areas. (Ahmad & Sikandar, 2022) highlight the role of policy reforms such as the National Education Policy (NEP) 2020, which calls for the integration of STEM subjects and the development of 21st-century skills among students. However (Balwaria & Gupta, 2014) states that despite the government's push, gaps in STEM education remain, particularly in rural regions where teachers lack both the training and resources necessary to implement effective STEM education.

Discussion

According to the literature, teacher preparation and professional development (PD) is the key to effective STEM education in under-resourced areas. Project-based learning (PBL), inquiry-based teaching, and the incorporation of technology have become one of the global best practices to address resource shortages and motivate students to study STEM

disciplines (Shernoff et al., 2017). (Sujeewa Vijayanthi Polgampala, 2017) is convinced that interdisciplinary teacher training is essential, as it helps teachers to teach students in STEM disciplines and develop a sense of collaboration in solving problems. Such strategies can be used even in low-resource settings, and they can substantially improve the outcomes of STEM, as (Rehman et al., 2025) have shown in their article on the community-based STEM education. In the case of India, by incorporating such practices into the teaching education curriculum, it is possible to narrow the disparities across the regions and to give every student equal access to quality STEM education, especially in rural schools, as long as teachers are adequately trained in the integration of technologies (Suryadi et al., 2023).

(Çiftçi et al., 2022) argue that, when the use of technology is properly coordinated, it can benefit the learning process even in the resource-limited setting, but only in case the educators are properly trained on the integration of as such, India requires teacher training and ongoing PD to conquer its STEM education issues, particularly in the less developed areas.

Conclusion

To sum up, teacher education is a crucial factor to work with the difficulties of STEM education in under-resourced regions. According to the literature, interdisciplinary teaching, inquiry-based learning, and technology integration are effective interventions that can be used to enhance STEM achievement in low-resource areas (Benson, 2012) In the case of India, the solution to improvement of STEM education can be seen in the creation of local teacher education courses with a global best practices approach, yet concerned with the needs of rural and underserved regions. Such recommendations as the contextualization of professional development programs, the greater contribution to technology investment,

The enhancement of collaboration between educators are possible. Preparation and continuous professional growth of the teachers are important so that teachers are adequately prepared to impart high



quality integrated STEM education. Through these measures, India will be able to take a big step toward closing the gap in STEM education, so that every learner, wherever they are, may have access to the knowledge and skills they need in order to succeed in the 21st century.

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