



# Teacher Education for STEM Education in Under-Resourced Areas

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## Abstract

Teacher education plays a crucial role in improving the quality of Science, Technology, Engineering, and Mathematics (STEM) education, particularly in under-resourced areas where educational inequalities are deeply rooted. Teachers act as the primary mediators between curriculum objectives and classroom practices; therefore, their preparation and continuous professional development significantly influence students' learning experiences in STEM. Under-resourced areas are commonly characterized by inadequate infrastructure, limited instructional materials, a shortage of trained STEM teachers, and socio-economic challenges that affect both teaching and learning. This paper examines the significance of teacher education in strengthening STEM education in such contexts. It analyzes the concept of STEM education, the meaning and importance of teacher education, and the specific characteristics of under-resourced areas. A review of related literature highlights persistent challenges and inequities in STEM teacher preparation and deployment. The paper further discusses major challenges faced by STEM teachers and explores effective strategies such as contextualized and practice-based training, inquiry- and project-based learning, continuous professional development, appropriate use of technology, and collaborative partnerships. The paper also emphasizes the role of policy and institutional support. The paper concludes that context-sensitive and sustained teacher education is essential for promoting equity, improving instructional quality, and enhancing STEM learning outcomes in under-resourced areas.

**Keywords:** STEM education, teacher education, under-resourced areas, professional development, educational equity.

## Introduction

STEM education has gained global importance due to its role in fostering scientific literacy, technological competence, innovation, and economic growth. Skills related to science, technology, engineering, and mathematics are increasingly necessary for individuals to participate effectively in modern knowledge-based societies. Despite this emphasis, access to quality STEM education remains highly unequal across regions and socioeconomic groups. Students in under-resourced areas such as rural regions, tribal communities, and economically

disadvantaged urban areas often experience limited opportunities to engage meaningfully with STEM subjects. Teacher education is one of the most influential factors affecting the quality of STEM education in these contexts. Teachers are responsible for translating curriculum frameworks into classroom practice. Students' engagement and achievement in STEM subjects suffer when teachers lack adequate subject knowledge, pedagogical skills, or professional support. Conversely, well-prepared teachers can adapt teaching strategies, use locally available resources, and foster problem-solving and critical thinking even



in resource-constrained environments. The conceptual research approach is based on a critical review of scholarly literature, national policy documents, and international reports related to STEM teacher education in under-resourced areas. The purpose is to analyze challenges, identify effective strategies, and highlight policy implications for strengthening teacher education in STEM.

### **Theoretical Foundations of Teacher Education in STEM Education**

#### **Constructivist Learning Theory**

Constructivist learning theory emphasizes that learners actively construct knowledge through experiences and interaction with their environment. In STEM education, this theory supports inquiry-based learning, problem-solving, and hands-on activities. Teacher education programs grounded in constructivism prepare teachers to facilitate learning rather than merely transmit information. In under-resourced areas, this approach encourages the use of locally available materials and real-life contexts, enabling meaningful STEM learning despite limited infrastructure.

#### **Social Constructivism**

Social constructivism highlights the role of social interaction, collaboration, and cultural context in learning. According to this perspective, knowledge is co-constructed through dialogue between teachers and learners. Teacher education informed by social constructivism equips educators to promote group work, peer learning, and collaborative problem solving in STEM classrooms. This theory is particularly relevant in under-resourced settings, where shared learning and community involvement can compensate for resource limitation.

#### **Experiential Learning Theory**

Experiential learning theory focuses on learning through direct experience, reflection, and application. STEM education strongly aligns with this theory, as it involves experimentation, observation, and real-world problem solving. Teacher preparation based on experiential learning helps educators design practical

activities that connect theory with practice. In under-resourced schools, experiential strategies allow teachers to engage students using everyday experiences, making STEM concepts accessible and relevant.

#### **Pedagogical Content Knowledge Theory**

Pedagogical Content Knowledge (PCK) theory emphasizes the integration of subject matter knowledge with appropriate teaching strategies. Effective STEM teaching requires teachers to understand not only scientific and mathematical concepts but also how to present them in ways students can understand. Teacher education programs focusing on PCK help educators address student misconceptions and adapt instruction to diverse learning needs, which is essential in under-resourced classrooms with varied student backgrounds.

#### **Technological Pedagogical Content Knowledge Framework**

The Technological Pedagogical Content Knowledge (TPACK) framework extends PCK by integrating technology into teaching and learning. It emphasizes the balanced use of content knowledge, pedagogy, and technology. In under-resourced areas, teacher education based on TPACK encourages the use of low-cost digital tools, mobile learning, and open educational resources. This framework supports teachers in enhancing STEM instruction even with limited technological infrastructure.

#### **Critical Pedagogy**

Critical pedagogy focuses on education as a tool for social transformation and equity. It encourages teachers to address issues of inequality and empower marginalized learners. Within STEM education, this theory supports the inclusion of local problems, community issues, and culturally relevant examples in teaching. Teacher education grounded in critical pedagogy prepares educators to promote inclusive STEM learning and reduce educational disparities in under-resourced areas.



### **Teacher Education in STEM Contexts**

To acquire the knowledge, skills, attitudes, and values required for effective teaching. It includes pre-service education, in-service training, mentoring, and continuous professional development. In STEM contexts, teacher education must address both subject matter knowledge and pedagogical competence. Teachers require strong conceptual understanding as well as the ability to implement inquiry-based, project-based, and learner-centered strategies. Assessment literacy, classroom management, and inclusive practices are also essential. For teachers working in under-resourced areas, teacher education plays a vital role in building confidence and professional competence. Effective programs enable teachers to respond creatively to contextual constraints and improve the quality of STEM instruction.

### **Educational Context of Under-Resourced Areas**

Under-resourced areas are characterized by inadequate infrastructure, a shortage of teaching materials, and limited access to technology. Schools may lack laboratories, libraries, and reliable electricity or internet connectivity. Class sizes are often large, and teachers may be required to teach multiple subjects. Socioeconomic challenges further influence educational outcomes. Students may come from families with limited financial resources and low levels of parental education. Language diversity and migration also affect classroom dynamics. Teachers in under-resourced areas frequently experience professional isolation and limited access to training opportunities, which points to the need for responsive teacher education programs.

### **Review of Related Literature**

Research consistently emphasizes the central role of teachers in effective STEM education. Shulman (1987) highlights the importance of pedagogical content knowledge in shaping instructional quality. Darling-Hammond (2017) notes that disadvantaged schools are more likely to employ underqualified or inexperienced STEM teachers.

The National Research Council (2011) stresses inquiry-based and interdisciplinary approaches as essential for effective STEM teaching. However, traditional teacher education programs often emphasize theory over practice. Studies by Borko (2004) and OECD (2019) show that sustained professional development models are more effective than short-term workshops.

UNESCO (2017) highlights the role of low-cost and appropriate technologies in supporting inclusive STEM education. Overall, the literature underscores the need for context-sensitive, sustained, and practice-oriented teacher education models.

### **Challenges in STEM Teacher Education in Under-Resourced Areas**

#### **Shortage of Trained STEM Teachers**

Many under-resourced schools lack qualified STEM teachers, with subjects like science, mathematics, and technology often taught by non-specialists. This reduces the quality and depth of instruction, leading to rote teaching instead of inquiry-based learning. High workloads and multiple subject assignments further limit teachers' ability to provide individualized support. Addressing this shortage through proper training and targeted recruitment is essential for improving STEM learning outcomes and reducing educational inequalities.

#### **Limited Professional Development Opportunities**

Teachers in under-resourced areas often have few opportunities for continuous professional development. Training programs may be infrequent, centrally located, or disconnected from classroom realities, limiting exposure to innovative STEM teaching methods. Without ongoing support, teachers struggle to update their skills, reducing instructional quality and student engagement.

#### **Inadequate Infrastructure and Resources**

Under-resourced schools often lack laboratories, equipment, and digital tools, limiting hands-on STEM learning and experimentation. Teachers are forced to rely on textbook-based instruction, reducing opportunities for practical, inquiry-based



learning and affecting overall student engagement and understanding.

### **Gap Between Theory and Practice**

Teacher education programs sometimes focus more on theory than practice. As a result, teachers may be well-versed in pedagogical models but find it difficult to apply them in classrooms with limited resources, reducing the effectiveness of STEM instruction.

### **Motivation and Retention Issues**

Challenging working conditions, lack of support, and minimal incentives lower teacher motivation and contribute to high turnover. Frequent staff changes disrupt continuity in STEM programs, affecting both teacher performance and student learning outcomes.

### **Role of Teacher Education in Addressing Challenges**

Teacher education plays a crucial role in overcoming the challenges faced by STEM teachers in under-resourced areas. Pre-service and in-service programs can equip teachers with strong subject knowledge, practical teaching strategies, and problem-solving skills that are adaptable to resource-limited classrooms. Through field-based experiences, mentoring, and reflective practice, teachers can learn to implement inquiry- and project-based learning effectively, even when laboratories or equipment are limited. Teacher education also supports the development of inclusive and culturally responsive pedagogies, enabling teachers to connect STEM concepts to students' real-life experiences and local contexts. Moreover, continuous professional development strengthens teacher confidence, reduces professional isolation, and encourages the adoption of innovative teaching methods. By addressing both pedagogical and motivational needs, well-designed teacher education programs can improve instructional quality, enhance student engagement, and contribute to equitable STEM learning outcomes in disadvantaged areas.

### **Strategies for Strengthening STEM Teacher Education**

Strengthening STEM teacher education in under-resourced areas requires a comprehensive, context-sensitive, and practical approach. Effective strategies focus on enhancing teachers' knowledge, pedagogical skills, and confidence while addressing the unique challenges of resource-constrained environments.

#### **Contextualized and Practice-Based Training**

Teacher education programs should be designed to reflect the realities of under-resourced classrooms. Pre-service and in-service training must prioritize hands-on learning, the use of locally available and low-cost materials, and activities connected to students' daily lives. Practical experiences, such as school-based internships and supervised teaching practice, help teachers translate theoretical knowledge into effective classroom strategies.

#### **Inquiry- and Project-Based Learning Approaches**

Teachers should be trained to implement inquiry- and project-based learning, which encourages students to investigate real-world problems and apply scientific and mathematical reasoning. Even in schools with minimal infrastructure, teachers can design experiments using simple materials, data from the local environment, and collaborative student projects to promote critical thinking and problem-solving skills.

#### **Continuous Professional Development**

Ongoing professional development is crucial for sustaining instructional quality. Workshops, peer collaboration, mentoring, and professional learning communities enable teachers to update their content knowledge, reflect on their teaching practices, and adopt innovative strategies. Sustained support reduces professional isolation and builds confidence in applying STEM pedagogy effectively.

#### **Appropriate and Inclusive Use of Technology**

Technology, when used judiciously, can enhance STEM teaching and learning. Teacher education should emphasize the use of low-cost, accessible



tools such as offline digital content, mobile applications, and virtual simulations. Integrating technology in ways that are meaningful and relevant helps teachers facilitate understanding without inequalities.

### **Strengthening Content Knowledge and Pedagogical Skills**

Many teachers in under-resourced areas teach subjects outside their specialization. Teacher education programs must focus on enhancing both subject knowledge and pedagogical skills. Refresher courses, interdisciplinary modules, and scenario-based training help teachers improve confidence, accuracy, and instructional quality in STEM subjects.

### **Collaboration, Partnerships, and Community Engagement**

Partnerships with universities, NGOs, industries, and local communities can provide additional expertise, resources, and professional support. Engaging with the community allows teachers to contextualize STEM concepts and make learning more relevant and meaningful for students.

### **Policy-Aligned and Institutional Support**

Sustainable improvement in STEM teacher education requires alignment with educational policies and institutional support. Adequate funding, incentives for teachers in disadvantaged areas, and strong leadership in schools and teacher education institutions are essential to implement these strategies effectively.

### **Policy and Institutional Support**

Strong policy frameworks and institutional backing are essential for improving STEM teacher education in under-resourced areas. Governments should prioritize equitable distribution of qualified teachers, provide financial support for professional development, and offer incentives for teaching in disadvantaged schools. Policies should also encourage collaboration between schools, teacher education institutions, and community organizations to ensure contextually relevant and sustainable

STEM learning. Teacher education institutions play a critical role in aligning curricula with contemporary STEM pedagogical practices and local needs. Providing ongoing training, mentorship programs, and accessible resources helps teachers implement effective instructional strategies despite limited infrastructure. Additionally, supportive school leadership, clear guidelines, and recognition of teacher achievements can motivate educators, enhance retention, and ensure the long-term success of STEM education initiatives.

### **Discussion**

Teacher education is a key factor in implementing STEM education in under-resourced areas. The quality of instruction depends on teachers' subject knowledge, pedagogical skills, and ability to adapt to local constraints. Contextualized and practice-based training enables teachers to use local materials, implement inquiry- and project-based learning, and develop students' problem-solving and critical thinking skills even with limited resources. Sustained professional development, including mentoring and peer collaboration, supports teacher confidence and reduces professional isolation. The appropriate use of low-cost technology further enhances instruction by providing access to interactive learning resources.

### **Conclusion**

Teacher education is a foundational element of effective STEM education in under-resourced areas. Preparing teachers with strong content knowledge, pedagogical skills, and contextual awareness enables them to overcome resource limitations and support diverse learners. Investment in sustained and context-sensitive teacher education is essential for achieving equity and quality in STEM education. In under-resourced areas, this impact is particularly significant, as education serves as a powerful tool for social transformation. Sustained efforts to enhance teacher education, supported by inclusive policies and institutional commitment, can bridge educational disparities and promote equal opportunities for all learners.



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