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PERCEPTIONS, OPPORTUNITIES, AND CHALLENGES OF STEM INTEGRATION IN SECONDARY SCIENCE EDUCATION TO FACILITATE TVET IN KARACHI, PAKISTAN: A QUALITATIVE THEMATIC ANALYSIS

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Article Info

Abstract

The increasing need for technically competent workers in the 21st century has resulted in the need to integrate secondary science education with Technical and Vocational Education and Training (TVET) through Science Technology Engineering and Mathematics (STEM) approaches. However, in Pakistan, the gap between academic science education and vocational education, with poor teaching methodologies, institutional limitations, and social stigma associated with technical education, continues to hamper the preparation of an adequately skilled workforce. In this context, the current study aimed at investigating the perceptions, prospects, and challenges related to STEM integration in secondary science education to enhance TVET in Karachi, Pakistan. A qualitative descriptive methodology was adopted, consisting of semi-structured interviews of 30 in-service science teachers from secondary schools and colleges affiliated with Sindh Board of Technical Education. The data was analyzed using Braun and Clarke's (2006) thematic analysis approach via the use of NVivo software, with four major themes emerging: understanding and preparedness for STEM; STEM-TVET connection for workforce development; institutional support; and career preparation, industry collaboration, and educational equity. The findings showed that there were generally favorable views about the integration of STEM, with teachers acknowledging that it has the capability of improving employability skills, problem-solving skills, and technical skills while narrowing the gap between academic and vocational education. Nonetheless, there were many obstacles, among them inadequate preparation of the teachers, weak infrastructure, disconnect between policy and practice, and sociocultural problems like gender disparity and stigma associated with vocational education. The findings point out the need for contextualized and staged reforms based on professional development, inclusive curricula, institutionalization, and industry involvement.

Keywords: *Curriculum reform, qualitative thematic analysis, STEM, TVET, vocational education, workforce readiness*

1. Introduction

With more than 64% of the population being youths, a youth unemployment rate of 24.4%, and a TVET sector that is considered one of the weakest sectors in South Asia, Pakistan is faced with a unique challenge in terms of education and economics (Ali, 2023; World Bank, 2017). The need for structural changes that would align education with the rapidly evolving needs of the digitalized labor market has risen in light of the above converging factors. STEM education has emerged as a revolutionary teaching approach on a global scale that would allow learners to acquire the necessary interdisciplinary and problem-solving skills in today's economy (Bybee, 2023; Makgato, 2019). However, Pakistan's vocational education system is yet largely separated from science education as a result of the pedagogical practices based on memorization, exam orientation, and structural underfunding, even as the world-wide trend supports the integration of STEM-TVET. There is a significant discrepancy between employer demand and the supply of graduates with technical training. This discrepancy is partially attributed to out-of-date and inadequately science-informed vocational curriculum. The stigmatization of career paths by society and the ongoing exclusion of women from technical training exacerbate the issue in Pakistan (Khilji & Roberts, 2022). The results of Phase II of a two-phase mixed-method study are presented in this article. The curriculum environment in which STEM integration functions was developed by Phase I, which was released separately as a document study of secondary school science and TVET curricula in Karachi. This paper focuses on Phase II: the qualitative viewpoints of thirty science and technical educators regarding the opportunities, difficulties, and views of STEM integration in TVET. This phase's main research question is: How do educators in Karachi view the integration of STEM approaches into TVET, and what potential and difficulties do they see? By emphasizing teacher voice a viewpoint that is often ignored in top-down reform discourses and by producing contextually grounded insights relevant to policy, teacher education, and curriculum reform in Pakistan and similar developing-country contexts, the study timely adds to the body of literature.

2. LITERATURE REVIEW

2.1 Conceptualising STEM in Vocational Contexts

STEM education goes beyond just combining four academic fields. According to Bybee (2023), it is a transdisciplinary education that combines mathematical reasoning, engineering design, scientific investigation, and technological application into cohesive problem-solving experiences. Because practical problem-solving, iterative prototyping, and technical troubleshooting are already essential to professional practice, this integration is especially relevant for vocational education (Nugraha et al., 2020). The results of this study directly support the observation that vocational programs can be considered legitimate applied STEM contexts even if they are not officially designated as such. The concept of STEM education is increasingly being viewed as an approach characterized by inquiry, teamwork, creativity, and evidence-based decision making other than as curriculum content (Dixon et al., 2016). Such attributes seem to have close relationship with competency frameworks, which form the basis for present-day TVET reforms, for instance, the Competency-Based Training and Assessment (CBT&A) framework adopted by Pakistan's NAVTTC.

2.2 STEM-TVET Integration: Global Evidence and Rationale

Positive impacts on motivation levels, technical skills, and employability of students have been witnessed through the inclusion of STEM in vocational and technical education in an international setting. STEM integrated TVET curriculum fastens skill development, enhances problem-solving skills, and boosts vocational pathways, based on research carried out in Malaysia, South Korea, and Australia (Abu Bakar & Mahmud, 2020; Nugraha et al., 2020). Countries which include STEM in vocational education are always ahead of their competitors in productivity and innovation indices. According to Akmal et al. (2021), incorporating STEM into vocational programs enhances students' field-specific competencies as well as their overall preparedness for the job in emerging nations. Co-integration of STEM and TVET at the secondary level has positive educational and economic benefits, especially for students who would not otherwise pursue academic higher education, according to empirical findings presented by Dixon et al. (2016).

2.3 The Pakistani Context: Structural Barriers and Reform Imperatives

A persistent socioeconomic hierarchy that prioritizes academic education over vocational training, antiquated equipment, minimal public investment, and fragmented governance are the characteristics of Pakistan's TVET sector (Aslam & Saleem, 2022). The failure of the current technical education system to provide students with the skills necessary for the digital economy is documented by Khilji and Roberts (2022). According to Mahmood et al. (2025), the biggest obstacles to STEM adoption in Pakistani schools and institutions are institutional support and teacher preparation. The third structural barrier to consider is gender discrimination. According to Mumtaz and Nasreen (2025) and Wang & Degol (2017), in Pakistani societies, technical jobs are considered culturally a man's role, while the representation of women in TVET programs is still inadequate. Moreover, socioeconomic stratification plays a part in limiting access as learners from public schools, which do not have financial resources, cannot afford even the most fundamental laboratory equipment. Nevertheless, some encouraging policy changes have taken place. In its National Education Policy Framework and in the STEM Pakistan Project Report (2024), the country states that STEM integration is an important goal aimed at improving workforce outcomes. Nevertheless, it reminds that without adequate funding and monitoring systems, innovative projects do not produce results.

2.4 Teacher Perceptions and Pedagogical Readiness

It is common to see teacher readiness and perceptions discussed as significant mediators in STEM implementation literature. Felder and Brent (2024) argue that if policy implementation ignores the organizational incentive structure, professional knowledge deficits, and contextual constraints that affect teaching, then it falls apart. According to Soomro and Malik (2025), who find that pedagogical skills related to STEM instruction exist in disjointed and implicit ways among practicing teachers in Pakistan, sustained and context-specific CPD initiatives are superior to one-off workshops. Therefore, the literature presents teacher perceptions as gateways to the structural factors that enable or hinder education reform efforts, rather than purely attitudinal information. Qualitative inquiry into these perceptions provides a solid basis for crafting contextually appropriate interventions.

3. METHODOLOGY

3.1 Research Design

A qualitative descriptive research design based on the epistemological perspective of constructivism, according to which reality is socially constructed through interactions and personal perceptions (Cohen et al., 2018), was employed in the current investigation. To explore educators' perception of STEM integration in practice without applying any preconceived theoretical framework and formulating grounded theory, a generic qualitative research design outlined by Babchuk (2017) and Merriam & Tisdell (2016) was chosen. This step was preceded by a document analysis (Phase I), in which the National Secondary Science Curriculum (Grades 6-8) and NAVTTC TVET curricula in five vocational areas, Electrical, Mechanical, Civil, Computer/IT, and Chemical Technology, were systematically reviewed for the presence of STEM alignment. Phase I results offered a context for developing an interview protocol for Phase II.

3.2 Participants and Sampling

Using non-probability purposive sampling, thirty in-service teachers were chosen from Karachi's TVET and secondary schools. In order to guarantee variety in terms of institution type (public and private), sector (secondary science and TVET), gender, and years of experience, participants were chosen. A minimum of five years of teaching experience, active participation in science, math, or STEM-related courses, at least graduate-level credentials in a science-related discipline, and voluntarily informed consent were all prerequisites for selection. Teachers from six institutions Aligarh Institute, Jinnah Polytechnic Institute, Government College of Technology for Girls (Karimabad), St. Patrick's Institute of Science and Technology, National High School, and The Academy were included in the sample. The range of teaching experience was five to forty-two years, and the educational background included MPhil and graduate-level science degrees. The qualitative dataset's representativeness was enhanced by the range of experiences and institutional affiliations.

3.3 Data Collection

Face-to-face, audio-recorded, semi-structured interviews were used to gather data at the institutions of the participants. Prior to the primary data collection, two professional educators piloted a 24-question methodology for each interview, which lasted between thirty and forty-five minutes. Four theme categories comprised the protocol: (1) scientific education and the current curriculum; (2) STEM concepts and their applicability; (3) TVET structures and practices; and (4) STEM as an enabler of TVET. Open-ended questions were intended to elicit reflexive, in-depth answers while enabling participants to bring up personal salient problems.

3.4 Data Analysis

Braun and Clarke's (2006) six-phase framework for thematic analysis was used: getting acquainted with the data, creating preliminary codes, looking for themes, evaluating themes, defining and labeling themes, and creating the final analysis. Fifty initial codes were systematically managed and visualized using NVivo (Version 15). These codes were then repeatedly revised and unified into four main themes. To preserve the genuineness of participant voice, verbatim citations were used throughout.

The use of informed consent, pseudo names of participants' identities, confidentiality in data storage, and absence of identifiable institution information from the findings helped ensure that ethical standards were maintained. Triangulation was achieved by comparing the data obtained through interviews with the documents reviewed during Phase I (Merriam & Tisdell, 2016).

4. FINDINGS

Analysis of the 30 interviews yielded four overarching themes, each encompassing multiple sub-themes and supported by rich participant testimony. Table 1 provides an overview of the thematic structure.

Table 1 : ***Overarching Themes and Key Sub-Themes Emerging from Thematic Analysis***

Theme	Theme Title	Key Sub-Themes
1	**STEM Understanding, Curriculum Enactment, and Pedagogical Preparedness**	Conceptual awareness; gap between understanding and enactment; demand for professional development
2	**STEM and TVET Synergy for Workforce and Technical Skill Development**	Complementarity of STEM and TVET; applied problem-solving; employability and innovation
3	**Systemic and Institutional Support for STEM and TVET**	Infrastructure deficits; policy–practice disconnects; resistance to change; CPD gaps
4	**Career Readiness, Industry Partnership, and Equity in STEM-Inspired TVET**	Career pathways; industry collaboration; gender and socioeconomic equity; digital inclusion

As per the research analysis these themes give an overall insight into the integration of STEM in secondary school science and TVET curriculum in Karachi. These themes indicate the participants' views towards the integration of the STEM approach with secondary science and TVET curricula in Karachi. The themes emerged are:

- STEM Understanding, Curriculum Integration, and Pedagogical Readiness.
- STEM and TVET Synergy for Workforce and Technical Skill Development.
- Systemic and Institutional Support for STEM and TVET.
- Career Preparedness, Industry Partnerships, and Equity in STEM-Influenced TVET.

4.1 STEM Understanding, Curriculum Enactment, and Pedagogical Preparedness

Theme one includes teachers' self-perceptions on pedagogic preparedness, experiences implementing STEM in practice, and conceptual knowledge about STEM. It was evident among the participants that STEM was an integrated and problem-based learning strategy rather than a cluster of disciplines. This knowledge is well captured in the following statement made by Noman:

> *"STEM is an educational programme developed to prepare primary and secondary students for college, graduate study, and careers in these fields. In my perspective, it aims to foster inquiring minds, logical reasoning, and collaborative skills."*

Despite not being formally termed or systematized, many participants noted that aspects of STEM practice already existed in their teaching environments. TVET instructor Imtiaz thought:

> *"We primarily discuss STEM as something that is occurring in the West. But actually, our science class could already become STEM-based if we incorporate real-world problems and use some technical skills."*

This finding is consistent with a notion that Pakistani teachers frequently possess STEM competencies in implicit or fragmented forms. Participants noted that the problem is not that there isn't STEM-aligned practice, but rather that it isn't recognized, systematized, or supported by institutions. One recurrent theme was the disconnect between intellectual endorsement and pedagogical enactment. One major barrier, according to Raza, is the curriculum's disconnection from real-world issues:

> *"We teach science as a subject in isolation, but STEM requires us to connect it with real-life problems. That connection is missing."*

Examples of project-based, inquiry-driven learning, such as robotics, agri-tech, and environmental monitoring, were enthusiastically embraced by participants; yet, these methods remained isolated rather than institutionalized. Noman openly admitted this disparity:

> *"I teach science with a purpose of making it relevant, but I don't believe we've ever learned to teach STEM as an organised process."*

The important sub-theme that emerged here was pedagogical preparedness. The participants from all sorts of institutions required professional development that was structured and integrated within the context. As noted by Bilal, integration requires the qualification of teachers:

> *"It is possible for teachers to bring STEM and technical education together in the classroom, but only if the teacher is qualified and professionally developed."*

This dilemma of implementation was highlighted by the observation of Usman that:

> *"STEM education is being introduced but our students and teachers are not ready for its proper implementation."*

This finding is consistent with the argument that in emerging environments, policies often outstrip institutional capacity.

4.2 STEM and TVET Synergy for Workforce and Technical Skill Development

The second theme centers on the way that STEM and TVET are seen as complementary, particularly regarding the development of technical skills and preparing for the workplace. In pointing out the intrinsic links between STEM learning and vocational training, members of TVET institutions were very articulate. Zeeshan explained this convergence:

> *"STEM is a natural fit for TVET. We project, we design, we repair machinery. The problem is we don't call it STEM, so people believe it's manual labour."*

These points were further reinforced by Usman:

"We teach them how to innovate and analyze. But there is no recognition of the fact that this is the convergence of science, technology, and engineering".

The above discussion validates the claim that TVET environments are genuine STEM contexts. Such an interpretation could have far-reaching implications for how vocational education is perceived and funded. The participants often linked increased employability with the integration of STEM and TVET, especially in technical areas under development. Maliha gave a nuanced perspective on the contribution of STEM to TVET:

"TVET has always been pragmatic, but STEM adds a vision, it introduces creativity and problem-solving to the training."

It was also noted that interdisciplinary STEM-TVET approaches had an element of motivation in them. It was noted that students became highly involved once they were engaged in cross-disciplinary activities that combined aspects of science and engineering.

"Even if you have a master's degree, without proper technical skills, you may end up doing clerical work,"

Ali explained, making a point of the financial implications.
The ability of STEM to raise the social image of TVET was one of the sub-themes that emerged. According to the participants, rebranding of vocational education as "applied STEM" would help dispel deficiency myths and attract more talented students to technical studies. The need for workforce development was explained by Omar thusly:

"STEM and technical education can practically prepare students for work."

4.3 Systemic and Institutional Support for STEM and TVET

The institutional and structural factors that either support or hinder STEM integration are covered in the third theme. Participants found a widespread disconnect between classroom reality and policy rhetoric. Faisal's innate directness helped him capture this disconnect:

"We have policies that speak about innovation, but at the classroom level, nothing changes in the absence of support."

One of the most pressing challenges identified was the challenge of infrastructure. Raza observed that:

"Our schools do not have the infrastructure to facilitate STEM learning," and

Nisha pointed out that:

"Technical colleges are underfunded and have poor quality teachers,

which impacts students negatively."

Omar noted that:

"There is no capacity to teach STEM in our schools."

Individual teachers faced an unreasonable load due to the lack of models and frameworks for STEM adoption. Zeeshan's testimony shed light on the solitude that many instructors face in their careers:

"We are given directives to implement STEM, but no model or training. It's up to us to create it ourselves."

"Regarding the curriculum, it could say anything, but without any facilities and trained teachers, how is STEM education possible?" Imtiaz highlighted the fundamental paradox within the intention of the policy and reality on the ground. The results are consistent with the findings of prior research which found inconsistencies in policies and lack of facilities as systematic barriers to successful implementation of STEM programs.

Another important sub-theme was resistance to innovative teaching and organizational inertia. It is important to note that hierarchies in curriculum development process, departmental silos, and emphasis on examinations were structural barriers to the formation of integrative inquiry approach necessary for STEM education.
Noman succinctly expressed the issue:

"No matter how many systems we introduce, we must first mend the broken

infrastructure of technical education,"

4.4 Career Readiness, Industry Partnership, and Equity in STEM-Inspired TVET

The final theme focuses on the longer-term consequences that participants associate with integrating STEM and TVET. The key concerns identified include education equality, industry involvement, and career readiness. According to Zareena, "careers in industries that require technical and STEM-based knowledge which is not covered in the normal curriculum" were a primary reason that participants associated STEM with.

A significant point of agreement emerged regarding the necessity of industry partnerships. Aslam said that "practical experience and industry exposure should be a part of student learning," an opinion echoed by participants from both TVET institutions and secondary schools. Participants universally deplored the lack of formal mechanisms for industry participation, ranging from internships and mentorship programs to curriculum designed using input from industry representatives, although successful collaboration occurred at times.

Education equality and access formed some of the most passionate sub-themes. Zanira directly tied inequities in resource distribution to access to STEM education:

"In rural or less affluent schools, there are no labs. How can we expect

them to think creatively when they haven't even handled a microscope?"

The power of integrating STEM and TVET for democratization was reaffirmed when Ali opined that:

"STEM can make the students work in varied streams and not only in stereotypical jobs."

Particular focus was paid to gender inequality in TVET. The lack of female-only technical schools and the societal perception of technical work as suitable for men were observed by the participants. Noman Said:

"STEM is for everyone, but the myth needs to be shattered that it is only meant for science toppers or for boys."

Nisha added:

"In many societies, technical education is often viewed as inappropriate for girls, which discourages female students from choosing STEM-related careers despite their talent and interest."

She further stated:

"Female students frequently encounter hidden challenges in STEM and TVET fields, such as societal pressure, inadequate institutional support, and limited opportunities in comparison to male students."

Zanira said, advocating for structural intervention. STEM education shouldn't be considered a luxury.

"If we truly want to build Karachi's human capital, we need to start by filling the gaps in education in public schools and poor neighborhoods. STEM education should not be considered a luxury."

Thus, the theme reiterates that STEM-led TVET must be integrated within inclusive, equity-centered frameworks that aggressively combat socioeconomic and gendered barriers to participation in order to realize its transformative potential.

5.DISCUSSION

5.1 Perceptions of STEM: From Conceptual Endorsement to Implementation Complexity

The results show a recurring pattern of strong ambivalence over execution coupled with conceptual support for STEM inclusion. The significance of STEM as a problem-centered, interdisciplinary pedagogy that can bridge the academic and vocational divide was confirmed by educators from a variety of institutions and experience levels. This is consistent with Soomro and Malik's (2025) discovery that Pakistani instructors possess fragmented STEM competencies despite having little formal training, as well as Bybee's (2023) description of STEM as a pedagogical disposition rather than a subject area. Importantly, the study's TVET educators often noted that their current methods fault diagnosis, iterative prototyping, and safety-constrained experimentation were intrinsically STEM-aligned. What this means is that the problem with integrating STEM in TVET may actually be more one of language and institutions than concept; people are doing STEM-related work without naming it as such and do not have the professional, curricular, or resource structures in place to enhance and integrate it. Therefore, renaming TVET as "applied STEM" might be an approach both for curriculum development and equity."

5.2 Opportunities: The STEM-TVET Complementarity

It appears that there is a natural fit between the applied, industry-oriented nature of TVET and the problem-based, holistic nature of STEM. Participants recognize this fit as both pedagogically exciting and practical, as suggested by international literature Nugraha et al. (2020) and Abu Bakar and Mahmud (2020). For Pakistan, where youth unemployment and skills mismatches cost the economy heavily, the possibility of employing STEM-TVET integration to raise the status of vocational education, which is undermined by the traditional social hierarchy of education, carries a special significance. One approach to organizing the integration is by utilizing the existing connection between the learning outcomes of the secondary science curriculum and the competencies outlined in the TVET framework. identified in Phase I (document analysis). The results of this phase show, however, that this link has not been translated into practice yet. Thus, one plausible strategy is to bridge this gap between the intended and the implemented curriculum.

5.3 Challenges

The statistical analysis showed three kinds of challenges associated with each other. The most urgent structural barriers to STEM-TVET integration, as stated by the participants, are the following: the outdated infrastructure, shortage of resources, and policy-practice gaps. The findings are consistent with those obtained by Rehman et al. (2025), revealing how the high goals set by educational reforms in Pakistan often surpass institutional capacity. The absence of continuous and contextually relevant CPD emerged as an important barrier in the workplace setting. The participants emphasized the need for continuous and school-based mentored professional learning communities, appropriate for interdisciplinary inquiry-based instruction and not additional workshops that were perceived to be scarce and poorly implemented. This finding is in agreement with the research-based recommendation of Felder and Brent (2024) on continuous CPD. The gender discrimination against women students taking technical courses and social stigma associated with TVET are sociocultural barriers that cannot be addressed through curriculum reform. As recommended in national policy assessments, such barriers should be tackled through multi-level interventions involving community participation, scholarship programs, policies, and awareness campaigns.

Table 2: Ranking of Challenges by Frequency Reported by Teachers

Rank	Challenge	Frequency Reported by Teachers
1	Lack of infrastructure and resources	Very Frequently Reported
2	Insufficient teacher training and CPD opportunities	Frequently Reported
3	Gap between policy and practical implementation	Frequently Reported
4	Social stigma linked with TVET	Moderately Reported
5	Gender-related barriers and inequality in technical education	Moderately Reported

The ranking presented above illustrates the common challenges repeatedly identified by participants during interview coding and thematic analysis.

5.4 Reform Through Transition: Examining Divergent Perspectives

A few of the respondents, however, did discourage the implementation of new STEM reforms before correcting any deficiencies in the existing system. This is not an obstructive position at all, but one born out of Pakistan's bitter experiences with repeated reform cycles, which brought new policies without building the necessary capacity for them. This approach, consistent with the findings of, calls for the gradual implementation of STEM reforms based on the strengths of the existing system and demonstrated impact before expanding it further.

6. IMPLICATIONS AND RECOMMENDATIONS

6.1 Policy Implications

The findings have direct impacts on national and local policies in several ways.

- The national framework for integrating STEM into the curriculum should have specific objectives for integrating STEM into both pathways and recognize the complimentary value of secondary science and TVET curriculums in promoting STEM competency among students.
- In cases where the focus is to integrate STEM and TVET, a phased or pilot approach that tests low-cost integration models before national rollout is more effective than a comprehensive mandatory transformation strategy.
- TVET programs could be less socially stigmatized and improve enrollment quality when branded as "Applied STEM" pathways in national policies and certification schemes.
- Any strategy for integrating STEM and TVET nationally should be coupled with equity goals like gender parity objectives and budgets that favor public institutions.

6.2 Professional Development Implications

Teacher professional development should not be considered as a series of discrete seminars but rather should be reconsidered as a continuous process:

- It will be necessary to evaluate the effectiveness of school-cluster CPD models where instructors collaborate to create interdisciplinary curriculum.
- Micro-credentials related to cheap laboratory pedagogy, design-based learning, and project assessment would help fill the specific gaps identified by the teachers.
- Mentorship programs for pairing technical teachers with experienced STEM educators would speed up the contextualization process.

6.3 Curriculum and Institutional Implications

These findings suggest that institutional considerations include:

- The exam-only approach should steadily make way for a competence-based evaluation system that fosters design thinking, problem-solving portfolio assessments, and collaborative projects.
- Cheaper and scalable approaches to infrastructure provision, including equipment sharing among industries, maker carts, and affordable scientific kits, can help address resource shortages in poorly funded institutions.
- Internship pathways, mentoring programs, and industry advice in curriculum development are some ways through which collaboration between industry and institutions can be mainstreamed.

7.CONCLUSION

Based on the qualitative testimonies of thirty educators of science and technology in Karachi, the study explored the attitudes, possibilities, and challenges of STEM integration in TVET. All findings lead to one conclusion: the respondents believe that STEM integration is highly desirable and highly constrained by professional, sociocultural, and institutional factors which do not seem to be adequately addressed within the current policy framework. STEM-TVET integration presents a definite opportunity. A reform strategy with great economic and social promise is supported by the natural complementarity of TVET's pragmatic orientation and STEM's holistic teaching, latent STEM practices in technical education, and the powerful workforce development rationale. Considering the youthfulness of its population, the reform is particularly urgent for Pakistan. However, fulfilling this, demands more than merely revising the curriculum. However, prior to any such changes, there must be a coordination in initiatives taken towards teachers' training, infrastructure improvement, assessment process, industry linkages, and inclusivity. This is necessary to be done in consecutive order and earnestly. According to the results of this study, it is safe to conclude that STEM integration in Pakistan is more a systematic continuation of what knowledgeable and dedicated teachers already strive to achieve and not an innovation introduced from outside. Future directions in this regard will include gender-wise research on participation and performance, comparison in various provinces and urban-rural comparisons, and longitudinal analysis of STEM-TVET pilots. Such data will provide the firm empirical basis required for educational transformation.

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