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**Report of Policy Lab on  
Bridging Gaps in  
Economic Development Policies and their  
Implementation in Pakistan**

پاکستان میں اقتصادی بحران سے نمٹنے کی  
پالیسیوں کے اطلاق میں حائل رکاوٹوں کا خاتمہ

**Policy Analysis &  
Recommendations- Part-6 of 11  
Technical Education &  
STEM Advancement  
Reforming technical education  
and promoting STEM fields for  
technological innovation**

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بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ

إِنَّ اللّٰهَ لَا يُغَيِّرُ مَا بِقَوْمٍ حَتّٰی يُغَيِّرُوا مَا بِأَنْفُسِهِمْ

(سورة الرعد 13:11)

بے شک، اللہ کسی قوم کی حالت نہیں بدلتا جب تک وہ خود اپنی حالت کو نہ بدلے۔

Indeed, Allah does not change the condition of a people  
until they change what is in themselves.

(Surah Ar-Ra'd 13:11)

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ظَهَرَ الْفَسَادُ فِي الْبَرِّ وَالْبَحْرِ بِمَا كَسَبَتْ أَيْدِي  
النَّاسِ لِيُذِيقَهُمْ بَعْضَ الَّذِي عَمِلُوا لَعَلَّهُمْ يَرْجِعُونَ

(سورة الروم 30:41)

خشکی اور تری میں فساد ظاہر ہو گیا ہے، لوگوں کے اپنے ہاتھوں کے کیے ہوئے اعمال کی وجہ

سے، تاکہ اللہ انہیں ان کے کچھ اعمال کا مزہ چکھائے، شاید کہ وہ باز آ جائیں۔

Corruption has appeared on land and sea because of  
what the hands of people have earned, so that  
He may let them taste part of what they have done,  
that perhaps they will return (to righteousness).

(Surah Ar-Rum 30:41)

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# **Technical Education & STEM Advancement – Reforming technical education and promoting STEM fields for technological innovation**

Research Group

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## PREFACE

Economic development and policy reform are at the heart of Pakistan's progress toward sustainable growth and global competitiveness. Recognizing the need for evidence-based policymaking, this document presents the research outcomes of a Policy Lab Simulation Exercise on Strategic Task Forces for Economic Development and Policy Reform. The research was conducted by 44 members, divided into 11 groups, under the mentorship and leadership of Dr. Muqem Islam Soharwardy. This initiative aimed to explore key economic sectors, identify policy gaps, and propose actionable reforms for national progress.

The Policy Lab provided a dynamic platform for in-depth research, critical discussions, and practical policy recommendations. Each task force examined a specific economic theme, analyzing challenges and proposing forward-thinking solutions tailored to Pakistan's socio-economic landscape. The research outcomes compiled in this document serve as a valuable resource for civil servants, policymakers, academicians, and researchers engaged in public policy and economic reforms.

The key themes explored in this research include:

1. Integrated Industrial Development – Formulating a comprehensive industrial policy and planning framework at both provincial and federal levels.
2. Automobile & EV Industry Growth – Strengthening Pakistan's manufacturing sector by enhancing the production and quality of automobiles and electric vehicles.
3. E-Commerce for Economic Growth – Expanding and optimizing digital trade to boost economic activity.
4. Agricultural Mechanization & Innovation – Promoting modernized agriculture through mechanization, crop diversification, and precision farming.
5. Foreign Investment & Business Environment – Strengthening policies to attract foreign direct investment (FDI) and improving the ease of doing business.
6. Technical Education & STEM Advancement – Reforming technical education and promoting STEM fields for technological innovation.
7. Energy Sector Reform & Industrial Power Solutions – Developing cost-effective energy solutions to support industrial expansion and sustainability.
8. Public-Private Partnerships (PPP) for Development – Leveraging PPP models for large-scale industrial and infrastructure projects.
9. Startup Ecosystem for IT, Business & Industry – Creating a conducive environment for startups in IT, business, and industrial sectors.
10. Import Substitution & Export Promotion – Enhancing local production, reducing imports, and boosting exports to improve the trade balance.
11. Natural Resource Utilization for Economic Growth – Tapping into Pakistan's mineral, oil, and gas reserves for sustainable economic development.

The findings in this document reflect the collaborative efforts and expertise of the participating researchers, offering practical insights for policy formulation, economic reforms, and strategic decision-making. It is hoped that these research outcomes will

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contribute to Pakistan's economic transformation, fostering growth, innovation, and resilience in key sectors.

It is hoped that this document will serve as a significant milestone in the design, implementation, and facilitation of policies, paving the way for broader economic and industrial transformation in Pakistan, انشاء الله

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## Executive Summary

Pakistan's economic growth is intrinsically linked to its ability to foster industrial development, which in turn relies on technological advancement and innovation. A cornerstone of achieving this growth is investing in technical education and STEM (Science, Technology, Engineering, and Mathematics). This research delves into the current state of technical and vocational education and STEM across Pakistan, with a focus on the federal level and Khyber Pakhtunkhwa. By examining existing challenges and identifying gaps, the study proposes a comprehensive roadmap for improvement, aimed at aligning Pakistan's technical education system with international best practices to support sustainable industrial growth.

### Importance of Technical Education and STEM

Technical education refers to the acquisition of practical skills, knowledge, and competencies needed for specific trades or professions, often through hands-on training in fields such as engineering, manufacturing, and IT. STEM integrates science, technology, engineering, and mathematics to address complex problems, drive innovation, and support technological development. Both technical education and STEM play a pivotal role in preparing a skilled workforce, which is essential for increasing economic productivity, improving competitiveness, and ensuring long-term prosperity.

Innovation, which involves creating and applying transformative ideas or products, is a fundamental driver of economic growth. In the 2023 Global Innovation Index, Pakistan ranks 88th out of 132 economies, showcasing strong innovation outputs (68th) but weak inputs (113th), particularly in comparison to regional peers like India (40th). Despite outperforming many lower-middle-income economies, Pakistan's ability to generate and implement technological advancements remains hampered by several critical issues in the education and training sectors.

### Challenges Facing Pakistan's Technical Education and STEM Sectors

Several obstacles hinder the progress of technical education and STEM in Pakistan, including:

- **Inadequate Infrastructure:** A lack of modern facilities, equipment, and resources restricts the effectiveness of training programs.
- **Outdated Curricula:** Educational programs often fail to meet the dynamic needs of the global economy, leaving students ill-prepared for the modern workforce.
- **Insufficient Resources:** Chronic underfunding impedes the development of educational infrastructure, the updating of curricula, and the proper training of teachers.

- **Limited Practical Learning Opportunities:** Many programs emphasize theoretical knowledge over practical, hands-on training, which limits students' ability to apply their skills in real-world settings.
- **Teacher Training Deficiencies:** Inadequate professional development for instructors means that many teachers lack the up-to-date knowledge and skills necessary to effectively educate students in fast-evolving fields.

To address these issues, Pakistan has initiated several reforms aimed at aligning technical education and STEM with international standards. These reforms include enhancing curricula, implementing project-based assessments, encouraging industry internships, and focusing on professional development for educators. Collaboration between academia, industry, and international stakeholders is also being emphasized to promote innovation-driven growth.

## Research Methodology and Framework

This study employs a mixed-method approach, combining qualitative and quantitative techniques to assess the state of technical education and STEM in Pakistan. The methodology includes:

- **Situational Analysis:** A review of current policies, initiatives, and practices in the technical education and STEM sectors.
- **Literature Review:** An exploration of global best practices and successful models from other countries.
- **SWOT and PESTLE/GAP Analysis:** Identifying strengths, weaknesses, opportunities, and threats within the technical education and STEM sectors.
- **Log Framework Matrix:** Presenting a practical plan for actionable improvements.

The theoretical foundation of this research is grounded in the **Endogenous Growth Theory**, which emphasizes the role of technological innovation, human capital, and knowledge spillovers in sustaining economic growth. For Pakistan to enhance its industrial sector, investments in education, technology, and R&D are essential. By cultivating a skilled workforce and fostering industry-academia partnerships, Pakistan can drive productivity and accelerate technological advancements.

## Existing Policies and Practices

Pakistan has implemented various national policies and initiatives aimed at improving technical education and fostering innovation:

- **National Education Policy Framework 2018:** Focuses on enhancing education quality, particularly STEM education, to improve students' critical thinking and problem-solving skills.
- **TVET Policy 2018:** Aims to address skills gaps through competency-based training programs and stronger industry-academia links.
- **National Skills for All Strategy 2021:** Expands vocational training centers, integrates technology into training, and provides financial support to students.

- **National Science, Technology, and Innovation Policy 2022:** Promotes STEM education, increases R&D funding, and supports the establishment of innovation hubs.
- **STEAM Pakistan Initiative:** A holistic education initiative promoting critical thinking, problem-solving, and collaboration skills.
- **Prime Minister’s Youth Skill Development Program (PMYSDP):** Empowers youth through skill development programs, including high-tech training and apprenticeships.
- **Partnerships with International Organizations:** Collaborative efforts with entities like the European Union and the German Cooperation to enhance vocational training.

Despite these initiatives, several critical challenges remain, such as the limited reach of programs, quality assurance issues, and inadequate funding for sustained implementation.

## Legal and Institutional Frameworks

Key institutions involved in technical education and STEM in Pakistan include:

- **TEVTA:** Focuses on curriculum development, teacher training, and industry linkages.
- **NAVTTTC:** Oversees the TVET sector, ensuring alignment with industry needs through national policies and frameworks.
- **HEC:** Regulates higher education institutions offering STEM programs, funds R&D, and promotes international collaborations.
- **PSF:** Supports scientific research and innovation through grants, competitions, and outreach programs.
- **Provincial Education Departments:** Implement national policies at the local level, overseeing technical and vocational institutions.

While these institutions play a significant role, they face challenges such as bureaucratic hurdles, inconsistent funding, and limited capacity for implementation. For instance, HEC’s initiatives in promoting STEM education are often constrained by limited financial support and challenges in retaining trained educators.

## Comparative Global Practices

Several countries, including the **United States, South Korea, Germany,** and **Finland,** provide valuable lessons for Pakistan:

- **United States and South Korea:** These nations emphasize strong industry-academia partnerships, substantial funding, and curricula that foster critical thinking and problem-solving skills.
- **Germany and Finland:** Germany’s dual education system integrates vocational training with classroom instruction, while Finland emphasizes creativity and technology integration in education, ensuring a workforce that is well-prepared for the modern economy.
- **Best Practices from Global Models:** The U.S. STEM Education Coalition advocates for increased investment in STEM, while Finland and South Korea



prioritize collaboration between educational institutions and industries, fostering innovation and producing a skilled workforce.

## Conclusion and Recommendations

Pakistan's ability to achieve sustained industrial growth and economic development hinges on improving its technical education and STEM sectors. While progress has been made through various policy reforms and initiatives, significant challenges remain. The research proposes a detailed roadmap that includes:

- **Policy Alignment:** Ensuring policies are consistently updated to meet global standards.
- **Infrastructure Development:** Strengthening the physical and technological infrastructure supporting education and training.
- **Industry-Academia Collaboration:** Enhancing linkages between educational institutions and industry to ensure that training programs align with market demands.
- **Sustained Funding:** Increasing financial support for teacher training, curriculum development, and research projects.

Pakistan's economic progress hinges on the advancement of its industrial sector, which is closely tied to technological innovation and a skilled workforce. These are nurtured primarily through technical education and the integration of Science, Technology, Engineering, and Mathematics (STEM) disciplines. The current state of technical education and STEM in Pakistan, particularly at the federal and provincial levels, presents both significant challenges and opportunities for reform. This study examines the shortcomings in Pakistan's technical education ecosystem, offers recommendations for improvement, and presents a roadmap for overcoming these obstacles.

## Key Challenges

Pakistan's technical and STEM education systems face several structural and operational hurdles:

- **Outdated Infrastructure:** Many educational institutions, particularly in technical and vocational training, lack modern facilities and equipment necessary for hands-on learning.
- **Insufficient Funding:** Pakistan's expenditure on Research and Development (R&D) is low, with the country spending just 0.22% of its GDP on R&D, far behind its regional peers such as India (0.66%) and Bangladesh (0.39%).
- **Bureaucratic Inefficiencies:** Slow implementation of policies and initiatives is exacerbated by political instability and frequent changes in leadership.
- **Human Capital Challenges:** There is a high rate of brain drain, with many trained educators and researchers leaving for better opportunities abroad. Additionally, the allocation for education in Pakistan is lower than in comparable countries, affecting long-term educational development.
- **Cultural Barriers:** Women and underrepresented groups are disproportionately underrepresented in STEM fields, limiting diversity and innovation potential.

## Policy and Institutional Landscape

Pakistan has introduced various policies to address the deficiencies in its technical and STEM education systems. Key initiatives include:

- **National Education Policy Framework 2018:** Aims to improve educational quality and focus on STEM, although its practical application and industry integration remain weak.
- **Technical and Vocational Education and Training (TVET) Policy 2018:** Seeks to close the skills gap through competency-based training programs, although its reach is limited.
- **National Skills for All Strategy 2021:** Focuses on expanding access to technical education, but faces challenges in quality assurance.
- **National Science, Technology, and Innovation Policy 2022:** Proposes funding for R&D and establishes innovation hubs to drive technological advancements, though implementation lags due to funding constraints.
- **Collaborations with International Partners:** Pakistan has partnered with international organizations like the European Union and the Norwegian Embassy to improve vocational training through curriculum development and resource sharing.

Despite these initiatives, Pakistan's technical education and STEM sectors face critical gaps in infrastructure, funding, and human resource development. These challenges require both short-term interventions and long-term strategic reforms.

## Comparative Global Best Practices

Countries like the United States, South Korea, Germany, and Finland serve as exemplars for Pakistan in terms of integrating technical education and STEM into their economic development strategies:

- **The United States** promotes STEM through robust industry-academia partnerships and substantial government funding.
- **South Korea** focuses on strong collaborations between industries and educational institutions, resulting in rapid technological advancements.
- **Germany** implements a dual education system that combines vocational training with classroom instruction, producing a skilled workforce.
- **Finland** emphasizes creativity and collaboration, preparing students for the modern workforce with a focus on technology integration.

These models highlight the importance of aligning education systems with industry needs, investing in research, and ensuring a culture of innovation.

## Recommendations for Improvement

A holistic approach is required to address the challenges facing Pakistan's technical education and STEM sectors. Recommendations for reform include:

1. **Policy and Standards Development**

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- Formulate comprehensive national policies for technical education and STEM to align with global best practices.
  - Establish national standards for curricula, teacher qualifications, and student assessments to ensure consistency and quality across institutions.
- 2. Funding and Resource Allocation**
- Significantly increase budget allocations for technical education and STEM initiatives, particularly focusing on infrastructure development, teacher training, and R&D.
  - Encourage public-private partnerships (PPP) to establish technical institutes and STEM centers, leveraging the expertise and resources of both sectors.
- 3. National R&D Investment**
- Establish a national research and innovation fund to support STEM startups and research projects.
  - Invest in R&D to drive technological advancements, thereby contributing to economic growth and industrial development.
- 4. Public Awareness and Inclusivity**
- Launch nationwide campaigns to raise awareness about the importance of technical education and STEM careers, particularly to encourage women and underrepresented groups to pursue STEM education.
  - Implement targeted outreach programs to foster gender inclusivity in the STEM workforce.
- 5. Provincial and District-Level Reforms**
- At the provincial level, adapt national standards to local contexts and focus on developing the infrastructure for technical education.
  - Foster collaboration between local industries and educational institutions to ensure training programs meet market needs and encourage entrepreneurship.
  - At the district level, engage local communities and industries in supporting technical education, with an emphasis on resource mobilization and the integration of local businesses in the education process.

## **Conclusion**

For Pakistan to realize its industrial potential and achieve sustainable economic growth, it must address the critical gaps in its technical education and STEM sectors. By implementing the recommended policy reforms, increasing investment in infrastructure and R&D, and fostering industry-academia collaboration, Pakistan can develop a workforce that is capable of meeting the challenges of the global economy. Overcoming these challenges will require coordinated efforts at the federal, provincial, and district levels, but with a clear roadmap for reform, Pakistan can unlock the full potential of its human capital and drive technological innovation for future economic success.



## *Problem Statement*

Pakistan's economic growth depends on industrial development, which is inherently tied to technological advancement and innovation fostered through technical education and STEM. This research investigates the current ecosystem of technical and vocational education and STEM in Pakistan, focusing on the federal level and Khyber Pakhtunkhwa. The study identifies key shortcomings and proposes a practical roadmap for improvement.

## *Background*

Technical education involves acquiring practical skills, knowledge, and competencies related to specific trades or professions (Sather et al., 2016). It typically includes hands-on training in fields like engineering, manufacturing, and IT. STEM (Science, Technology, Engineering, and Mathematics) integrates these disciplines to solve complex problems, drive innovation, and support technological development (GOI, 2021). Together, technical education and STEM are critical for workforce preparation and enhancing economic productivity, competitiveness, and prosperity (Sather et al., 2016).

Innovation, defined as the creation and implementation of transformative ideas or products (Schilling, 2020), is central to economic growth. The Global Innovation Index (GII) ranks Pakistan 88th out of 132 economies in 2023, highlighting strong innovation outputs (68th) but weak inputs (113th) (Dawn, 2023). While Pakistan outperforms many lower-middle-income economies, it significantly lags behind regional peers like India (40th) (WIPO, 2023).

Challenges in Pakistan's technical education and STEM sectors include inadequate infrastructure, outdated curricula, insufficient resources, and limited practical learning opportunities (Sather, Singh, & Thurman, 2016). Chronic underfunding further hinders teacher training, infrastructure, and curriculum reforms (Zeb, Khan, & Ahmad, 2021). These barriers limit Pakistan's capacity to develop a skilled workforce capable of meeting global economic demands (Government of Pakistan, 2021).

Recognizing these issues, Pakistan has initiated reforms to align technical education and STEM with global standards. Key initiatives include curriculum enhancements, project-based assessments, industry internships, and professional development for educators. Collaboration among academia, industry, and international stakeholders is emphasized to foster innovation-driven growth.

## *Research methodology*

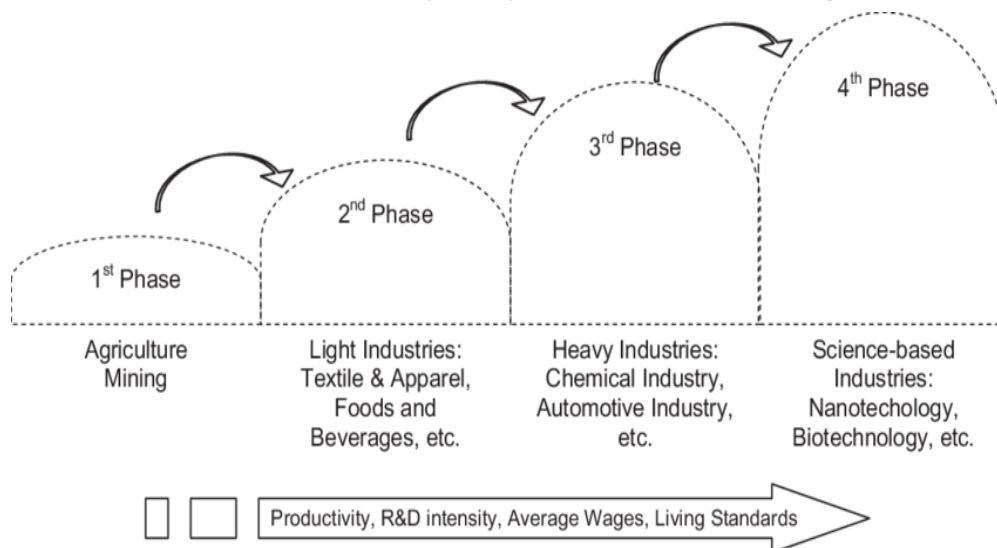
A mixed-method approach combining qualitative and quantitative methods employed. The methodology designed to comprehensively explore the current state of technical education and STEM fields in Pakistan, identify challenges and opportunities, and develop evidence-based policy recommendations. The study carried out situational analysis of current policies, initiatives, practices, and contributions, literature review, analysis of the existing legal and institutional framework, comparative analysis with global best practices, examining successful models from other countries will allow for a comparative analysis, highlighting best practices that can be adapted to Pakistan’s context. Additionally, SWOT Analysis of Technical Education and STEM Institutions and stakeholders’ interviews. PESTLE/GAP Analysis, practical plan using Log Framework Matrix to organize and present the recommended actionable plan.

### *Theoretical Underpinnings*

#### *Endogenous Growth Theory*

In the context of Pakistan's industrial development, the **\*\*Endogenous Growth Theory\*\***, proposed by Romer (1986), emphasizes the pivotal role of technological innovation, human capital, and knowledge spillovers in achieving sustained economic growth. For Pakistan to advance its industrial sector, substantial investments in education, technology, and research and development (R&D) are imperative. By cultivating a skilled workforce equipped with modern technological expertise and fostering innovative practices, Pakistan can enhance productivity and drive industrial progress. Furthermore, promoting knowledge spillovers through robust industry-academia partnerships and international collaborations can accelerate technological advancements and economic growth. Prioritizing these areas will enable Pakistan to establish a resilient and competitive industrial foundation, consistent with the principles of Endogenous Growth Theory.

#### *Analysis of Issues and Challenges*



#### *Situational Analysis of current Policies and Practices*

Federal Government has introduced a number of policies, initiatives and practices for technological advancement, innovation and STEM in the country. A brief situational analysis is as under:

**1. National Education Policy Framework 2018**

The framework emphasizes improving education quality at all levels, with a strong focus on STEM education. It aims to enhance students' critical thinking and problem-solving skills.

**2. Technical and Vocational Education and Training (TVET) Policy 2018**

This policy focuses on developing a skilled workforce through vocational and technical education. It addresses skills gaps by introducing competency-based training programs, enhancing industry-academia linkages, and promoting public-private partnerships.

**3. National Skills for All Strategy 2021**

This strategy ensures accessible, high-quality technical and vocational training for all. It involves expanding vocational training centers, integrating technology into training programs, and providing financial support to students.

**4. National Science, Technology, and Innovation Policy 2022**

This policy provides a comprehensive plan to foster innovation and technological development. It includes increased funding for R&D, the establishment of innovation hubs, and the promotion of STEM education.

**5. STEAM Pakistan Initiative**

Led by the Ministry of Federal Education and Professional Training, this initiative promotes holistic education to develop critical thinking, problem-solving, and collaboration skills.

**6. TVET Reform Initiative**

Supported by international partners, this initiative enhances equitable access to quality training and boosts employability.

**7. Prime Minister's Youth Skill Development Program (PMYSDP)**

This program empowers youth with skills, including high-tech training, conventional skill development for underprivileged areas, and apprenticeships.

**8. Partnerships with International Organizations**

Collaborations with entities such as the European Union, German Cooperation, and the Norwegian Embassy have improved vocational training through resource sharing, curriculum development, and best practices.

**9. Hands-On Practical Learning**

Vocational schools emphasize practical learning in fields like dental assistance, hardware repair, agriculture, and IT. Short-duration programs equip students with job-ready skills.

**10. Accessible and Inclusive Training**

Many government-funded and non-profit-led vocational programs are accessible to economically disadvantaged groups and include training for disabled individuals.

**11. Demand-Driven Skills**

Vocational training aligns with market demands, equipping students with high-demand skills, reducing the skills gap, and enhancing employability.

### ***Critical Review***

Vocational Training: Significant in industrial development through workforce skill enhancement, youth employment, and entrepreneurship (NAVTTTC, 2023; TEVTA, 2023).

National Education Policy Framework 2018: Lacks practical application and industry integration (Government of Pakistan, 2018).

TVET Policy 2018: Identifies skills gaps and promotes linkages but has limited reach (Government of Pakistan, 2018).

National Skills for All Strategy 2021: Broadens vocational training access but faces quality assurance challenges (Government of Pakistan, 2021).

National Science, Technology, and Innovation Policy 2022: Provides a solid foundation for innovation but requires increased funding and robust implementation (Government of Pakistan, 2022).

### ***Analysis of the Existing Legal and Institutional Framework***

#### ***Technical Education and Vocational Training Authority (TEVTA)***

TEVTA operates in the provinces, focusing on curriculum development, teacher training, and industry linkage programs.

#### ***National Vocational and Technical Training Commission (NAVTTTC)***

NAVTTTC plays a pivotal role in overseeing and coordinating the TVET sector in Pakistan. It develops national policies, standards, and frameworks to ensure alignment of technical education with industry requirements.

#### ***Higher Education Commission (HEC)***

The Higher Education Commission (HEC) of Pakistan regulates and accredits higher education institutions offering STEM programs. It provides essential funding for research and development, promotes quality assurance through accreditation and ranking systems, and encourages international collaborations to enhance STEM education.

HEC's initiatives include establishing research centers and technology parks within universities, promoting startup incubation, and funding technological research projects, which significantly contribute to technological advancement and innovation. Additionally, HEC supports digital learning through the Pakistan Education and Research Network (PERN), connecting academic institutions to digital libraries and high-speed internet (Tribune, 2022).

Despite these efforts, HEC's impact is constrained by bureaucratic challenges and inconsistent funding, hindering seamless implementation and program sustainability. Faculty development initiatives are beneficial, but retaining trained educators is challenging due to better opportunities abroad. There is limited funding for establishing reverse engineering programs, and the integration of reverse engineering concepts into engineering curricula is unclear. Faculty training workshops may lack standardization, leading to inconsistency. Furthermore, financial support for university-industry projects focused on reverse engineering is lacking, highlighting the need for targeted and sustained funding and support (HEC, 2023; Dawn, 2021;



Tribune, 2022).

***Pakistan Science Foundation (PSF)***

PSF supports scientific research and innovation in Pakistan by providing grants for research projects, organizing science competitions, and promoting STEM education through outreach programs. It aims to create a scientific culture and encourage young people to pursue STEM careers.

***Provincial Education Departments***

Provincial education departments implement national education policies at the local level and oversee technical and vocational training institutions.

***Comparative Analysis***

***United States and South Korea***

These countries excel through substantial funding, strong industry-academia partnerships, and curricula emphasizing critical thinking. Institutions like the National Science Foundation (NSF) and robust government policies bolster advancements (NSF, 2023; Ministry of Education, South Korea, 2023).

***Germany and Finland***

Germany’s dual education system integrates vocational training with classroom instruction, producing a highly skilled workforce. Finland emphasizes creativity, collaboration, and technology integration, preparing students for the modern workforce (Federal Ministry of Education and Research, Germany, 2023; Ministry of Education and Culture, Finland, 2023).

***United States, Finland, and South Korea***

The U.S. STEM Education Coalition advocates for policy changes and increased investment in STEM education. Finland integrates technology across curricula to foster creativity and critical thinking. South Korea promotes collaboration between educational institutions and industries, resulting in rapid technological advancements and a high number of STEM graduates (Ministry of Education and Culture, Finland, 2023; Ministry of Education, South Korea, 2023).

***SWOT Analysis of Education and STEM Related Institutions***

***SWOT for Federal Government***

Category	Strengths	Weaknesses
Internal Factors	1. Establishment of bodies like TEVTA and NAVTTC to regulate and promote technical education.	1. Many institutions lack modern laboratories and equipment necessary for hands-on learning.
	2. Partnerships with international organizations like the EU enhance resources and training quality.	2. Insufficient programs for continuous professional development of educators.
	3. A large, young population provides a significant pool of potential students for STEM fields.	3. Limited financial resources hamper the development and implementation of advanced educational programs.

	4. Ongoing efforts to update and align curricula with global standards and industry needs.	4. Persistent mismatch between industry requirements and the skills of graduates.
<b>Category</b>	<b>Opportunities</b>	<b>Threats</b>
<b>External Factors</b>	1. Potential for more collaborations with international educational and industry partners to enhance curriculum and training.	1. High inflation and economic challenges can limit funding and investment in education.
	2. Adoption of emerging technologies can modernize educational practices and improve learning outcomes.	2. Frequent changes in government and policies can disrupt long-term educational planning and initiatives.
	3. Increasing focus on promoting entrepreneurship amongst STEM students can drive innovation.	3. Societal norms may hinder the participation of women and underrepresented groups in STEM fields.
	4. New policies aimed at boosting vocational and technical education can improve the overall education landscape.	4. Rapid advancements in STEM education in other countries can leave Pakistan lagging behind if it does.

**SWOT for Higher Education Commission (HEC) of Pakistan**

Strengths	Weaknesses	Opportunities	Threats
Established authority for higher education.	Limited funding compared to global standards.	Attract international funding and partnerships.	Economic instability affecting funding and policy implementation.
Supports research and innovation through funding and policies.	Bureaucratic delays can hinder initiatives.	Leverage global focus on STEM education for development.	Political changes leading to policy discontinuity.
Facilitates international collaborations.	Inconsistent education quality across institutions.	Integrate advanced technologies in curricula.	Competition from private institutions with better resources.

**Pakistan Science Foundation (PSF)**

Strengths	Weaknesses	Opportunities	Threats
Promotes scientific research and STEM education.	Limited funding and resources compared to global standards.	Potential for international collaborations and funding.	Economic constraints limiting funding and resources.
Provides grants and funding for research projects.	Inadequate infrastructure for advanced scientific research.	Growing interest in STEM fields can drive program expansion.	Political instability affecting policy continuity.

Organizes science competitions and outreach programs.	Lack of coordination with other educational institutions.	Opportunities to integrate new technologies and methodologies in science education.	Brain drain with talented researchers and students moving abroad.
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***National Vocational & Technical Training Commission (NAVTTTC)***

<b>Strengths</b>	<b>Weaknesses</b>	<b>Opportunities</b>	<b>Threats</b>
<p>Central authority for vocational and technical training.</p> <p>Develops national standards and policies.</p>	<p>Limited reach and accessibility, especially in rural areas.</p> <p>Insufficient practical training infrastructure.</p>	<p>Potential for public private partnerships to enhance programs.</p> <p>Growing demand for skilled labor can drive program expansion.</p>	<p>Rapid technological changes requiring constant updates to programs.</p> <p>Economic challenges reducing funding and support.</p>
<p>Focuses on aligning training programs with industry needs.</p>	<p>Dependence on limited government funding.</p>	<p>Increasing global emphasis on technical skills attracting international support.</p>	<p>Competition from advanced international vocational training programs.</p>

***Technical Education and Vocational Training Authority (TEVTA)***

<b>Strengths</b>	<b>Weaknesses</b>	<b>Opportunities</b>	<b>Threats</b>
<p>Focuses on practical skills and competency-based training.</p> <p>Offers a variety of diploma and certification courses.</p> <p>Aims to develop a globally competitive workforce.</p>	<p>Limited infrastructure and resources for advanced training.</p> <p>Inconsistent quality of training across different regions.</p> <p>Challenges in keeping curricula up to date with industry needs.</p>	<p>Potential for increased collaboration with industry partners.</p> <p>Growing demand for skilled labor in various sectors.</p> <p>International partnerships and funding opportunities.</p>	<p>Economic instability affecting funding and resource allocation.</p> <p>Rapid technological advancements requiring continuous updates to training programs.</p> <p>Competition from private vocational training institutes with better facilities.</p>

### *Provincial Education Departments*

<b>Strengths</b>	<b>Weaknesses</b>	<b>Opportunities</b>	<b>Threats</b>
Implement national education policies at the local level.	Variability in policy implementation and educational quality across provinces.	Leverage local industry partnerships for vocational training.	Regional disparities in funding and resource allocation.
Manage funding and oversee the operation of training institutions.	Limited resources and infrastructure, especially in rural areas.	Address regional educational needs with tailored programs.	Political and administrative changes affecting policy continuity.
Play a crucial role in regional education development.	Bureaucratic challenges and inefficiencies.	Potential for increased funding and support from federal initiatives.	Economic challenges impacting the implementation of educational programs.

### *Industry*

<b>Strengths</b>	<b>Weaknesses</b>	<b>Opportunities</b>	<b>Threats</b>
Provide UpToDate industry relevant training. Flexibility to adapt quickly to changing industry needs.	May prioritize profit over educational quality.  Limited focus on broader educational outcomes beyond immediate industry needs.	Growing demand for skilled labor can drive private sector investment in education.  Opportunities for public private partnerships to enhance vocational training.	Economic downturns affecting private sector investment in education.  Competition from public institutions and international vocational training programs.
Resources to invest in advanced training infrastructure.	Potential disconnects with national education policies.	Potential to set industry standards for technical education.	Regulatory challenges and changes in education policy.

### *Nongovernmental Organizations (NGOs)*

<b>Strengths</b>	<b>Weaknesses</b>	<b>Opportunities</b>	<b>Threats</b>
Focus on improving access to quality education and vocational training. Ability to reach underserved and marginalized communities.	Dependence on donor funding, which can be unstable.  Limited scale and reach compared to government programs.	Potential to form partnerships with government and private sector.  Growing recognition of the importance of vocational training and STEM education.	Economic instability affecting donor funding.  Political changes impacting NGO operations and support.
Flexibility to innovate and adapt to local needs.	Challenges in sustaining longterm projects without consistent funding.	Opportunities to pilot innovative educational approaches.	Competition for limited funding resources from other NGOs.

### *GAP Analysis for Technical and STEM Education in Pakistan*

<b>Aspect</b>	<b>Current State</b>	<b>Gap</b>	<b>Desired State</b>
<b>Curriculum and Training</b>	Outdated curricula not aligned with industry needs	Modernized curriculum incorporating emerging technologies and global standards	Updated curricula aligned with industry and global standards, including practical learning experiences
<b>Infrastructure</b>	Educational institutions lack modern laboratories and equipment	Significant investment needed in infrastructure	Well-equipped laboratories and research facilities with modern teaching tools
<b>Teacher Training</b>	Insufficient training programs for educators	Comprehensive training programs for continuous professional development	Skilled educators with UpToDate pedagogical skills and subject knowledge
<b>Research and Development (R&amp;D)</b>	Limited funding and resources for R&D activities	Increased funding and resources for R&D	Enhanced R&D capabilities with strong international and private sector partnerships
<b>Industry Academia Collaboration</b>	Weak collaboration between educational institutions and industry	Strengthening partnerships and collaborative research projects	Robust industry academia partnerships with practical internship programs and joint research initiatives

## ***PESTLE Analysis of Technical and STEM Education in Pakistan***

### ***Political Factors***

Frequent government changes in Pakistan lead to inconsistent education policies, hindering long-term planning and development. Stable and consistent policies are essential.

### ***Economic Factors***

High inflation and funding constraints limit investments in education infrastructure and programs, widening the gap between the current and desired state of education.

### ***Social Factors***

Cultural barriers and a lack of awareness restrict participation in STEM fields, particularly for women and minorities. Policies and outreach programs promoting diversity and raising awareness about the benefits of STEM are needed to create an inclusive educational environment.

### ***Technological Factors***

Limited integration of modern technologies into the curriculum hinders students' ability to acquire necessary skills for today's technology-driven world. Updating educational technologies and incorporating cutting-edge tools and methodologies are crucial for preparing students for the modern workforce.

### ***Legal Factors***

Weak enforcement of existing legal frameworks results in variations in educational standards and quality. Strengthening these frameworks and enhancing enforcement mechanisms are necessary to ensure high standards in education.

### ***Environmental Factors***

Inadequate infrastructure and resource limitations affect the sustainability of education programs. Developing sustainable infrastructure and integrating environmental education into the curriculum are vital to addressing these challenges.

## ***Challenges for Pakistan***

### ***Outdated Infrastructure and Limited Funding***

- Pakistan's technological and educational infrastructure is significantly outdated, impeding effective learning and innovation.
- Expenditure on R&D is only 0.22% of GDP, compared to India's 0.66% and Bangladesh's 0.39% (World Bank, 2023).
- Limited financial resources hinder the sustainability of technological initiatives and the development of advanced research facilities.

### ***Policy and Implementation Issues***

- Bureaucratic delays and inefficiencies obstruct the smooth implementation of technological policies and programs.
- Frequent political changes result in inconsistent policies, disrupting long-term planning and stability in technological and educational sectors.

### ***Weak Industry-Academia Collaboration***

- Pakistan faces weak collaboration between educational institutions and industry,

unlike India, which has robust partnerships facilitating innovation and practical learning.

- Financial support for university-industry projects is often lacking, limiting collaborative innovation opportunities.

### ***Human Capital and Training Challenges***

- Pakistan allocated only 2.4% of GDP to education in 2022, compared to 3.1% in India and 2.8% in Bangladesh (UNESCO, 2023).
- Insufficient training programs for educators and significant brain drain as many trained professionals leave for better opportunities abroad.

### ***Slow Technology Integration***

- Slow integration of modern technologies into the educational system affects education quality and research capabilities.
- Initiatives like the Pakistan Education and Research Network (PERN) aim to improve digital connectivity, but broader access to high-speed internet and digital libraries remains limited.

### ***Economic and Social Barriers***

- Economic instability, including high inflation rates (21.3% in 2022), restricts investment in technological and educational infrastructure.
- Cultural barriers hinder the participation of women and underrepresented groups in STEM fields, with women making up only 18% of the STEM workforce in Pakistan compared to 30% in India and 25% in Bangladesh (World Economic Forum, 2023).

### ***Comparative Performance***

- India ranks 40th globally in the Global Innovation Index (GII) 2023, compared to Pakistan's 88th position and Bangladesh's 116th position (WIPO, 2023).
- India benefits from substantial funding, strong industry-academia partnerships, and a robust policy framework supporting sustained technological growth.
- Bangladesh has shown considerable progress in recent years, ranking higher than Pakistan in innovation inputs and outputs, effectively utilizing international partnerships to enhance its technological education and research sectors.

### ***Interviews with Experts (Primary Sources)***

Key points from Mr. Ijaz Khan (Vice President, Sarhad Chamber of Commerce):

- Industrial policies aim to promote trade and employment but face challenges like energy shortages and high costs.
- Development of industrial and economic zones under CPEC has seen limited progress.
- Lack of infrastructure, investors, and security hinders job opportunities and industrialization in KP.

### ***Key points from Mr. Munir Gul (Director, KP TEVTA):***

- Most industries in KP are closed or near closure, leading to reduced demand for skilled workers.
- TEVTA trains youth in technical skills, capitalizing on the fact that 60% of the population is young.
- Around 107 technical institutions provide skill development, but 80% of trained



manpower migrate abroad.

### *Conclusion*

Pakistan faces significant challenges in advancing technological innovation and education, which are essential for its industrial development and economic growth. The country's technological and educational infrastructure is significantly outdated, impeding effective learning and innovation. Limited funding for Research and Development (R&D) exacerbates this issue, with Pakistan's expenditure on R&D at only 0.22% of its GDP, compared to India's 0.66% and Bangladesh's 0.39% (World Bank, 2023). This financial constraint impacts the development of advanced research facilities and the implementation of sustained technological initiatives. Bureaucratic delays and inefficiencies further hinder the smooth implementation of technological policies and programs. Frequent political changes lead to inconsistent policies, disrupting long-term planning and stability in the technological and educational sectors.

Human capital development is also hampered by inadequate training programs and significant brain drain, with many trained educators and researchers leaving for better opportunities abroad. In 2022, Pakistan allocated only 2.4% of its GDP to education, compared to 3.1% in India and 2.8% in Bangladesh (UNESCO, 2023). The integration of modern technologies into the educational system is slow, affecting education quality and research capabilities. Initiatives like the Pakistan Education and Research Network (PERN) aim to improve digital connectivity, but broader access to high-speed internet and digital libraries remains limited. Economic instability, characterized by high inflation rates (21.3% in 2022), restricts investment in technological and educational infrastructure. Cultural barriers also impede the participation of women and underrepresented groups in STEM fields, with women constituting only 18% of the STEM workforce in Pakistan.

Addressing the multifaceted challenges in infrastructure, policy implementation, human capital development, and technology integration is crucial for Pakistan to advance its technological and educational capabilities and achieve sustainable growth.

### *Recommendations*

#### **1. Policy Formulation and National Standards**

- Develop comprehensive national policies for technical education and STEM, ensuring alignment with global best practices.
- Establish national standards and frameworks for curricula, teacher qualifications, and student assessments in technical and STEM education.

#### **2. Funding and Resource Allocation**

- Increase budget allocations for technical education and STEM initiatives, focusing on infrastructure development, teacher training, and research facilities.
- Provide grants and subsidies to encourage public-private partnerships (PPP) in establishing technical institutes and STEM centers.

#### **3. National Research and Development**

- Invest in national research and development (R&D) programs to drive innovation and technological advancements.
- Create a national innovation fund to support startups and research projects in STEM fields.

#### **4. *Public Awareness and Outreach***

- Launch nationwide campaigns to raise awareness about the importance of technical education and STEM careers.
- Promote gender inclusivity and diversity in STEM through targeted scholarships and outreach programs for underrepresented groups.

### ***Provincial Government Recommendations***

#### **1. *Curriculum and Teacher Training***

- Collaborate with federal authorities to adapt national standards to the provincial context, ensuring relevant and updated curricula.
- Implement continuous professional development programs for teachers to enhance their skills and knowledge in technical and STEM subjects.

#### **2. *Infrastructure Development***

- Invest in building and upgrading technical institutes, vocational training centers, and STEM-focused schools with modern facilities and equipment.
- Ensure access to high-quality internet and digital tools in educational institutions to facilitate eLearning and digital literacy.

#### **3. *Industry-Academia Collaboration***

- Foster partnerships between local industries and educational institutions to align training programs with market needs.
- Establish provincial innovation hubs and incubators to support students and researchers in developing and commercializing new technologies.

#### **4. *Monitoring and Evaluation***

- Set up provincial monitoring and evaluation units to assess the effectiveness of technical education and STEM initiatives.
- Use data-driven insights to inform policy adjustments and improvements in educational programs.

### ***District Level Recommendations***

#### **1. *Local Implementation of Programs***

- Implement provincial policies and programs at the district level, ensuring that they are tailored to local needs and contexts.
- Establish district education offices to oversee the administration and quality control of technical education and STEM initiatives.

#### **2. *Community Engagement***

- Engage local communities, including parents, businesses, and civic organizations, in supporting and promoting technical education and STEM fields.
- Organize local STEM fairs, competitions, and workshops to encourage student participation and interest in these areas.

#### **3. *Capacity Building***

- Provide training and resources for district education officers and school administrators to effectively manage and support technical and STEM education programs.
- Facilitate local teacher networks and professional learning communities to share best practices and resources.

#### **4. *Resource Mobilization***

- Encourage local businesses and industries to contribute resources, such as

equipment, internships, and scholarships, to support technical and STEM education.

- Leverage district-level funds and grants to address specific local needs and gaps in educational infrastructure and resources.

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