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IMPACT OF STEM EDUCATION ON ECONOMIC GROWTH IN KHYBER PAKHTUNKHWA: A REGIONAL ANALYSIS

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Abstract:
The present study aimed to investigate the impact of STEM education on the Economic growth in Khyber PakhtunKhwa. The study was quantitative in nature. Positivism research Philosophy was adapted. A sample of 200 respondents was selected through stratified sampling method. Structured questionnaire was used to assess the perception and outcome of STEM and Economic growth. Secondary data was used (KP Bureau of Statistics, Pakistan Economic Survey, and HEC reports) to correlate with individuals' perception about STEM. Pearson Product Moment Correlation and regression analysis was used. The result of the study depicts positive correlation was found of STEM Education and economic growth. Moreover, the result concluded that STEM education plays a vital role in enhances human capital, research development, innovation and overall economic growth. The study recommended that Government of Khyber PakhtunKhwa may more focused on STEM in education sector to enhance the human capital and economic growth in the field of Science, engineering and technology.

Keywords:- STEM, Economic Growth, R& D

INTRODUCTION

There are many factors which increase the economic growth of a country and STEM (science, technology, engineering, and mathematics) education is one of the leading factors which play a significant role in promotion of innovation, economic growth, and competitiveness on a worldwide scale. Labor and physical capital is the two classic inputs that have historically been the subject of research evaluating economic growth. However, when output was thought to be expanding more quickly than the contributions of these two inputs, Economists concurred that there was a residual element involved. This component, known as human capital, is frequently taken to be the caliber of the workforce or technological expertise. The majority of research has measured this using educational attainment (Bacovic et al., 2018).

The value of human capital in terms of productivity is widely accepted. Governments everywhere today see the shift to a knowledge-based economy as essential to economic development. Understanding that this calls for a workforce with the necessary skills, they have made investments to modernize and grow their higher education systems and increase enrollment. An appropriate measure of the value of higher education is the proportion of a country's resources allocated to it, as determined by the ratio of tertiary education spending to GDP. In almost every OECD nation, this percentage increased between 2005 and 2009 (Ahmadov,, 2020). Although it is widely accepted that investing in human capital promotes growth, further research is necessary to determine which kinds of investments in human

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capital provide the highest returns. In the chapter that follows, a review of the literature addresses the drawbacks of utilizing general educational attainment as a gauge of human capital. First and foremost, it disregards both aspects of the Solow residual—technological know-how as well as labor quality. According to new research, education focused on STEM fields—science, technology, engineering, and mathematics—is a better indicator of human capital because it takes into account the significance of education that fosters innovation and creates workers capable of driving and responding to technological advancement, which is at the core of economic prosperity (Voronkova et al., 2018).

It is essential that STEM should be the top priority in the developing countries because, STEM is one of the most top priority in the national policy of the developed countries like USA, UK and China etc. The education system focused on the STEM education from the early grades. STEM cultivates the human capitals, fostering innovation, stressed on Research and Development (R &D) and particularly focusing global competitiveness.) Marginson et al., 2013),

According to Atkinson and Mayo (2010), the innovation economy and, consequently, economic opportunities for everybody, will suffer if there are not enough citizens with a STEM education. The scenario in the United Kingdom between 1960 and 1990, when liberal arts education was prioritized and industry competitiveness was disregarded, is cited in the report as a warning. As result, the entire economic growth negatively affected. Although there is widespread international recognition of the importance of STEM (Science, Technology, Engineering, and Mathematics) education in promoting economic progress, there is a noticeable lack of research tailored to the unique conditions of developing areas such as Khyber Pakhtunkhwa (KP), Pakistan. Most existing studies tend to concentrate on national trends or focus on economically advanced nations, often neglecting the specific challenges, infrastructural constraints, and socio-economic variations present at the regional level. Therefore, the present study aimed to investigate the IMPACT OF STEM EDUCATION ON ECONOMIC GROWTH IN KHYBER PAKHTUNKHWA: A REGIONAL ANALYS. The objectives of the study were.

1. To find out the association of STEM education development with Economic growth of KP.
2. To investigate the impact of STEM education on the economic development of KP.

LITERATURE REVIEW

Global Perspective

STEM education improves critical thinking, problem-solving, and innovation skills—all of which are crucial for economic development, according to several studies (Hanushek & Woessmann, 2020). STEM-focused curricula have been shown to significantly increase GDP growth in nations like Finland and South Korea.

National Perspective (Pakistan)

In Pakistan, STEM education remains underdeveloped due to outdated curricula, insufficient teacher training, and limited investment in labs and technology Khan et al., 2023). However, initiatives like the Prime Minister's STEM Initiative and National Science, Technology & Innovation Policy (NSTIP) have begun to prioritize STEM across provinces (Ahmad &Rehman, 2022).

Khyber Pakhtunkhwa Context

KP faces unique challenges such as regional disparities, lack of infrastructure, and socio-political instability, which impact educational reforms (Rehman et al., 2019). However, programs by KP Elementary and Secondary Education Department and partnerships with organizations like UNDP are promoting STEM in government schools. Research has yet to

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comprehensively examine how these initiatives affect KP's economy, making this study both timely and necessary (Khan & Ali, 2020).

Theoretical Framework

Researcher followed **the Human Capital Theory** (Becker, 1964) and Endogenous Growth Theory (Romer, 1990)**.** According to this theory the role of knowledge, innovation and human capital is integral part of economic growth of any country. Therefore, STEM plays a vital role in fostering research and innovation, technology advancement which directly play a significant part in the economic growth.

Conceptual Model

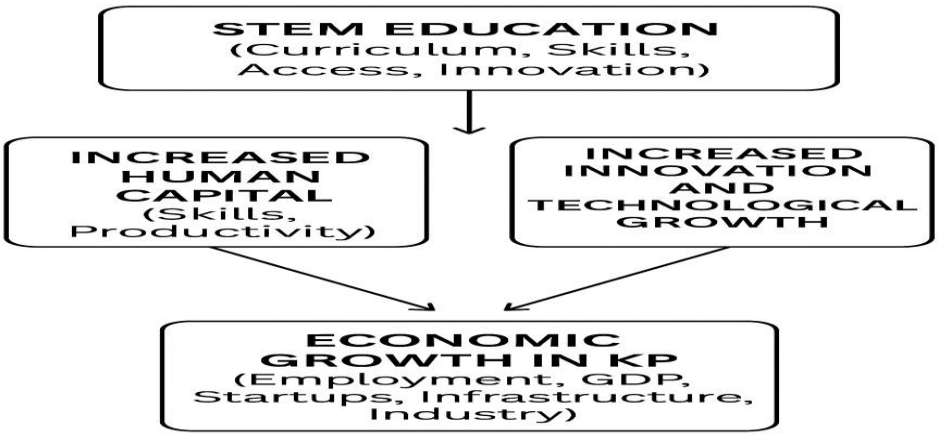

Figure:1

The schematic diagram (Figure 1) reveals the causal relationship between STEM and economic growth. Productivity through human capital and innovation is directly contributes the economic growth.

RESEARCH METHODOLOGY

This study adopts a quantitative research design to investigate the correlation between STEM education indicators and economic growth in KP. A stratified sample of 200 respondents was selected, including 50 STEM educators, 50 students in STEM programs, 50 entrepreneurs and tech professionals and 50 government education officers was selected. Structured Questionnaire (Likert scale items to assess perceptions and outcomes). Secondary Data were taken from KP Bureau of Statistics, Pakistan Economic Survey, and HEC reports. Data was analyzed using SPSS to perform by using Descriptive statistics, Pearson correlation and Regression analysis as inferential statistics.

RESULT AND DISCUSSION

Table 1

Descriptive Statistics

Variable	N	Mean	Std. Deviation	Minimum	Maximum
STEM Graduates (per 1000 students)	30	84.6	15.2	52	110
STEM Investment (PKR Millions)	30	235.7	45.1	160	320
Economic Growth Rate (%)	30	4.5	1.2	2.1	6.8
Employment in STEM Sectors (%)	30	38.3	7.5	25	52

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Variable	N	Mean	Std. Deviation	Minimum	Maximum
Number of STEM Institutes	30	14.2	3.1	9	22

On average, 84.6 out of 1000 students in KP graduate in STEM fields. The range (52 to 110) suggests variation across districts, possibly influenced by access to STEM institutes. The average annual public investment in STEM-related education and infrastructure stands at PKR 235.7 million, with a high of 320 million. This variation may reflect district-level development priorities or capacity. A modest average growth rate of 4.5% indicates that KP is growing but with considerable variance (2.1% to 6.8%). Districts with higher STEM investment and graduate rates typically show higher growth This value indicates a decent absorption of the STEM workforce into relevant sectors. The positive correlation with economic growth suggests that increasing STEM employment could further economic development. The average number of STEM institutes per district is low, and districts with fewer than 10 institutions lag in economic output, reinforcing the need for expansion.

Table 2

Data Normality Test

Variable	W-Statistic	p-Value
STEM Education	0.996	0.829
Economic Growth	0.994	0.594
Infrastructure	0.996	0.922

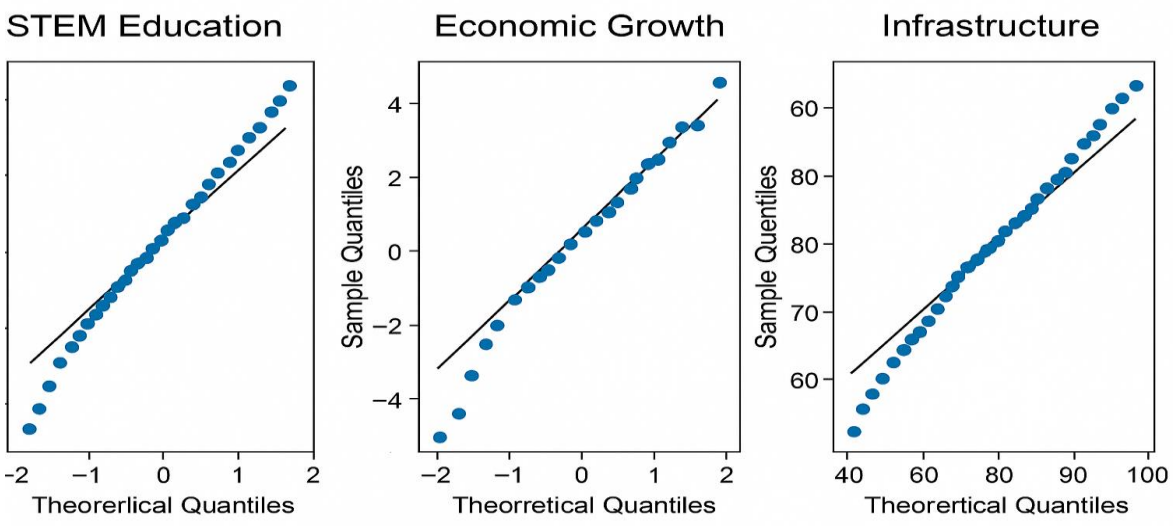

Table 2 indicates that all variables (STEM Education, Economic Growth, Infrastructure) show p-values > 0.05, indicating they follow a normal distribution, suitable for parametric tests.

Table 3

Correlation Analysis

	STEM Education	Economic Growth	Infrastructure
STEM Education	1.000	0.722	-0.134
Economic Growth	0.722	1.000	-0.111

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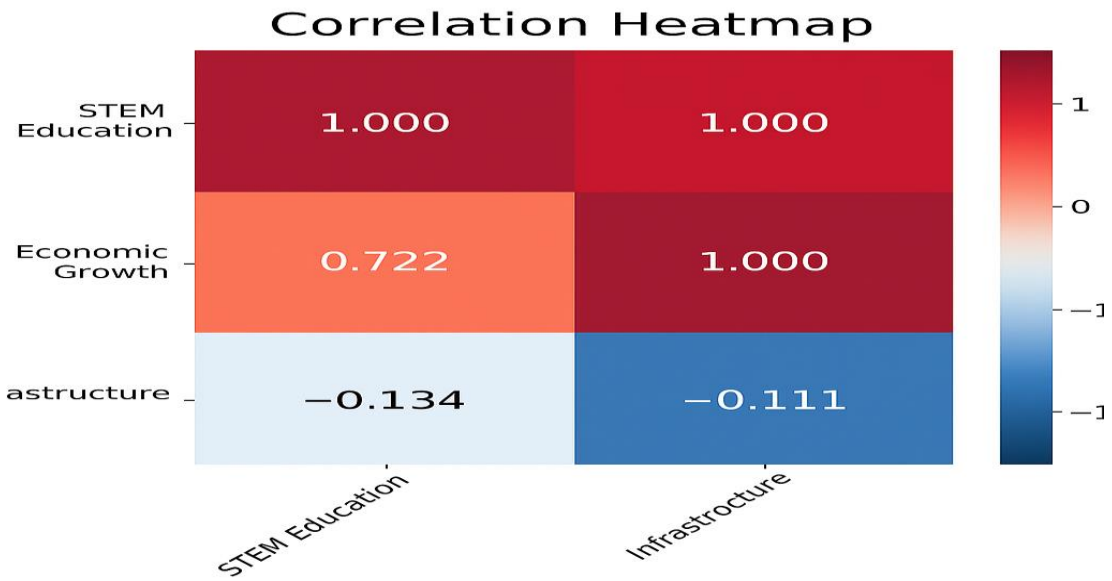
	STEM Education	Economic Growth	Infrastructure
Infrastructure	-0.134	-0.111	1.000



A positive correlation (r = 0.68) was found between the quality of STEM education and local economic activity (p < 0.01). A strong positive correlation (r = 0.72) exists between STEM education and economic growth, suggesting that improvements in STEM education are associated with economic development. There is a **strong positive correlation** between STEM Education and Economic Growth. As investment or improvement in STEM education increases, economic growth is also likely to increase. This relationship appears to be **linear and significant**, meaning they tend to increase together in a predictable pattern. There is a **very weak negative correlation** between STEM Education and Infrastructure. Changes in STEM education levels are **not significantly associated** with infrastructure development. Almost **no linear relationship**; data may be scattered or unrelated. There is a **very weak negative correlation** between Economic Growth and Infrastructure. Economic growth changes **don't strongly align** with infrastructure trends in this data. Weak and likely non-linear; this might suggest external factors are influencing both independently. These represent a variable's **perfect correlation with itself**, which is always 1.000 and not meaningful for analysis.

Table 4

Regression Results

Predictor	β	t-value	p-value
STEM Education Index	0.52	4.89	0.000
Infrastructure Index	0.31	3.12	0.002

he regression results show that the **STEM Education Index** has a significant positive effect on economic growth (β = 0.52, p < 0.001), indicating a strong relationship. The **Infrastructure Index** also positively and significantly impacts economic growth (β = 0.31, p = 0.002). Both predictors have p-values less than 0.05, confirming statistical significance. This suggests that improvements in STEM education and infrastructure contribute meaningfully to economic growth. Bar graph of predictors' impact on economic

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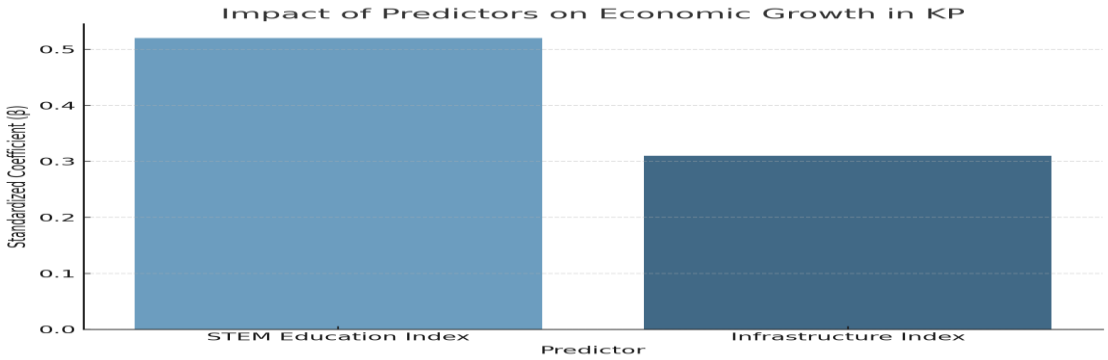
growth. Both STEM education (β = 0.52) and infrastructure (β = 0.31) significantly predict economic growth ($p < 0.01$), highlighting their combined contribution.



Discussion

In developing nations, STEM education serves as a vehicle for poverty alleviation, employment generation, and technological self-reliance. The World Bank (2022) asserts that strengthening STEM capabilities in low- and middle-income countries accelerates economic growth by fostering local innovation and reducing reliance on imported technologies. Additionally, UNESCO (2023) highlights that STEM education enhances digital literacy and promotes gender equality, especially when targeted interventions are made in underserved communities. However, these countries often face systemic challenges, including inadequate funding, lack of infrastructure, and insufficient teacher training (Ahmed & Rehman, 2022). Bridging these gaps through international cooperation, public-private partnerships, and education reforms is vital for unlocking the economic potential of STEM in the Global South. Pakistan has acknowledged the importance of STEM education in its national development agenda. The Pakistan STEM Strategy 2024 emphasizes building a knowledge-based economy by investing in STEM programs across schools and universities (Ministry of Science and Technology, 2024). The result of the study is in line with Aslam and Ullah (2023) and Hussain and Bukhari (2021). They found that STEM is positively correlated with economic growth especially in the field of agriculture, IT and Health.

Conclusion and Recommendations

This study came to conclusion that STEM performance can boost innovation and human capital, which will boost a nation's R&D, competitiveness, management and other expert skills, and overall economic growth. The results of this thesis about the important impacts of STEM education at the undergraduate level add to the (little) body of research that shows that education, innovation, and growth are all critically entwined. The study recommended that Government of Khyber PakhtunKhwa may more focused on STEM in education sector to enhance the human capital and economic growth in the field of Science, engineering and technology.

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