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Impact Of STEM Education on Creativity of University Students

Dr Rabia Tabassum[1*], Dr Sabiha Iqbal[2], Anam Haneef[3], Merha Yaseen[4], Dr Rifat Tahira[5], Kausar Rasheed[6], Dr Saira Taj[7], Minahil Ahmed[8]

[1*]Lecturer, Department of STEM Education, Faculty of Education, Lahore College for Women University, Lahore.
[2]Assistant Professor, Department of Education, The Islamia University of Bahawalpur, Bahawalpur
[3]PhD Scholar (Education), Government College University, Faisalabad.
[4]PhD Scholar (Education), Government College University, Faisalabad.
[5]Assistant Professor, Department of Education, The Islamia University of Bahawalpur, Bahawalpur
[6]PhD Scholar, Department of Education, Lahore College for Women University, Lahore
[7]Assistant Professor, Department of STEM Education, Faculty of Education, Lahore College for Women University, Lahore
[8]MS Education, Sports Instructor cum Teaching Assistant, Lahore College for Women University, Lahore

***Corresponding Author:** Dr Rabia Tabassum
*Email: rgreat786@yahoo.com, rabia786@lcwu.edu.pk

Abstract
This research investigated the impact of STEM education on the creativity of students, focusing on understanding how Science, Technology, Engineering, and Mathematics disciplines influenced creative thinking among learners. The objectives of the study included assessing the extent to which STEM education enhanced creative skills and identifying factors within STEM curricula that contributed to fostering creativity. A descriptive research methodology was employed to explore the relationship between STEM education and creativity. The study utilized a quantitative approach, employing questionnaires to gather data on students' creative abilities. The study targeted undergraduate students enrolled in STEM programs across diverse educational institutions in a public university, encompassing a sample size of 300 participants. Data collected through questionnaires were analysed using statistical methods, including descriptive statistics and inferential techniques, to examine correlations and patterns related to creativity in STEM education. The research revealed a significant positive correlation between participation in STEM activities and the development of creative skills among students. Specifically, engagement in interdisciplinary projects and hands-on learning experiences emerged as critical factors contributing to enhanced creative thinking abilities. Based on the findings, recommendations included integrating more interdisciplinary approaches within STEM curricula, enhancing professional development opportunities for educators in creative pedagogies, and advocating for policies that support equitable access to STEM education for diverse student populations. Overall, the study underscored the importance of STEM education in nurturing creativity among students, suggesting that fostering a conducive learning environment with innovative teaching strategies empowered learners to become adaptive problem-solvers and innovative thinkers in a rapidly evolving global landscape.

Keywords: STEM Education, Creativity, Problem Solving Skills, Higher education

Introduction

Creativity – also defined as the ability to generate new and valuable ideas, is considered as one of paramount goals of education along with the transmission of knowledge and development of critical thinking skills (Silvia, 2015). It not only plays a vital role in artistic expression , rather it is also playing a vital role in fostering problem-solving, innovation, and adaptability skills and move them, and would love with the method against a bone(Hanif et al., 2019), all of which, are considered as essential qualities of successful life (Saunders, 2019). Likewise, natural science subjects always occupy a unique position among the all-other disciplines of knowledge. It these of the audio is considered as a catalyst for cultivating creativity in students (Eroglu & Bektas, 2022). Therefore, it is considered that there is an intricate relationship between science education and students' creativity. Therefore, it has been a focus of discussion at different fields of education i.e., implications of curriculum design, pedagogical practices, and educational policies (He et al., 2023).

Therefore, a necessity to inoculate natural sciences in the other disciplines was strongly felt. The inoculation of STEM (Science Technology Engineering and Mathematics) and STEAM (Science Technology Engineering, Arts and Mathematics) was started both at teaching learning techniques, and subjects (Costello et al., 2023). This merged the traditional view of science education i.e., acquisition of factual knowledge and procedural skills as contemporary approaches to the all subjects (Fan et al., 2023). Thus, process to nurture creative thinking abilities alongside content mastery as boosted up by involving the science processes of curiosity, exploration, experimentation and problem-solving in all subjects (Tabassum, Fatima Kashif, et al., 2024). The present research was done to understand level of creativity by involving STEM education processes into other streams of education.

Problem Statement

The research was aimed to understand impact of STEM education on creativity level of university students. The study also explored diverse factors that may influence the students' creativity such as instructional strategies, classroom environments, teaching practices, and cultural contexts. Moreover, the study involved emerging science processes such as inquiry-based learning, project-based approaches, interdisciplinary connections and the integration of technology.

Significance of the Study

Typical stakeholder of an educational research are students, their parents, teachers, administration, policy-makers and society at-large. The study holds different significant aspects for different stakeholders. Under the following paragraphs, there is given a brief significance of the study.

For students: the use of interdisciplinary education in the form of STEM, invites students to learn, and think outside the typical subject nutshell, approaching problems with a creative mindset, to generate new ideas and technologies. This fosters all-round holistic skill development, divergent thinking, and problem-solving abilities among students. Creative problem-solving is considered as essential in an ever-changing global landscape. Moreover, the STEM as new engagement may raise up their motivation level and thus may increase their academic performance rate as well.

For university faculty and administration: the study findings may be important to develop new pedagogical insights into effective teaching methods within STEM disciplines. The curriculum designers may also get insight in integrating creative elements into STEM courses. Moreover, the existing programs can also be enhanced by incorporating arts to STEM components in the form of STEAM.

Ultimate impact on society: the broader societal impact of understanding the relationship between STEM education and creativity, may create a workforce with greater innovative ideas and greater market demands. Innovative minds can also better address the societal issues, and may contribute to the knowledge economy.

Research Objectives

Main objective of the study was to find out the impact of STEM education on creativity of university students.

Research Hypothesis

In the light of that research objective, it was hypothesized that
H01. There is no impact of STEM education on creativity of university students.

Literature Review

STEM education is becoming increasingly important as the world relies more on science and technology (Robison, 2018). This approach to learning focuses on practical applications and combines different scientific disciplines (Tabassum, et al., 2024). However, there is a concern that this emphasis on STEM might neglect other important aspects of education, especially creativity (Ku et al., 2022). Creativity is essential for innovation and problem-solving in all fields, not just artistic ones. Because of this, researchers are looking at how STEM education can be designed to nurture creativity alongside technical skills. According to them, creativity may help students become well-rounded individuals who can be innovative leaders in their chosen fields (Sesay, 2023).

STEM education aims to equip students with critical thinking, problem-solving, and technical skills (Sajid, 2022). However, there are concerns about the impact of a strong STEM focus on other aspects of student development, particularly creativity. Creativity is essential for innovation, adaptability, and holistic problem-solving in the 21st century (Garza, 2020). Understanding how STEM education influences creativity is crucial for educators and policymakers (Freedman et al., 2023).

The review analysed empirical STEM and STEAM-based educational interventions from 2010 to 2020. Both STEM and STEAM (STEM + Arts) approaches were considered. Researchers often used Likert-type tests to evaluate creativity (Sung et al., 2023). Evidence suggests positive effects on student creativity for both STEM and STEAM approaches. Arguing for STEAM education over STEM solely for creativity development is not supported by empirical studies. The review highlights the need for well-rounded educational strategies that integrate technical knowledge and creative thinking (Chidayati et al., 2021; Khalil et al., 2023).

Literature indicated that the sustained engagement in STEM education not only improves technical competencies, but also fosters creative abilities. A developmental study over five years indicated that students who consistently participated in STEM program, exhibited significant growth in creative thinking and problem-solving skills (Slavit et al., 2016). Another longitudinal research made over similar context revealed that long-term involvement of students into STEM programs, demonstrated increased proficiency in creative thinking skills such as ideas generations, originality of work, and ability to connect disparate concepts (Ramli, 2015). It was also revealed that the consecutive exposure to STEM education may cultivate persistence, resilience and willingness to experimentations. These attributes were considered as vital mindsets for creation of ideas and things in complex and novel situations (The STEM Committee, 2017).

This creation of ideas to novel or existing situations is termed as creativity. This is marked by some key cognitive aspects such as intrinsic motivation, divergent and convergent thinking by different psychologists. Divergent thinking is defined as the eruption of multiple or varied ideas for a problem, while refining a best solution from multiple ideas, is termed as convergent thinking (Topsakal et al., 2022). On the other hand, emotional resilience, and intrinsic motivation support the process of creativity (Ku et al., 2022). Like other usual psychological constructs, environmental contexts also influence and shape

creativity. Some researchers even demonstrated creativity as an interplay between individuals' work and societal validation (Gullapyan, 2020).

Yao (2019) asserted that creativity not only involves generation of new and valuable ideas, rather it is also marked up with originality and usefulness of concepts and ideas as well. They further linked divergent and divergent thinking, mentioned as hallmarks of creativity before – to brainstorming of ideas or methods, and then selecting the best one. Researches also indicated that STEM education fosters creativity through its interdisciplinary approach. This approach encourages students to see connections between different subjects and use that knowledge to solve complex problems (Fortus et al., 2016). Project-based and problem-based learning are two important key characteristics of STEM education that cultivate creativity among students (Olivera, 2022). The students work on real-world problems. During this discourse, they learn to collaborate with each other, design different ideas, select the best one, and learn how to execute the most appropriate solutions. All of these steps stimulate their minds to adopt or adapt innovative ideas and learn from their mistakes. Moreover, they learn proper use of technology to explore solution of their problems or create projects (Martín et al., 2015).

However, like other innovations, adoption of STEM education in developing countries is very slow, and same is in Pakistan (Aslam et al., 2023). Therefore, the study was undergone to highlight the significance of STEM education and its role in the creativity of students at higher education.

Research methodology

The study adopted descriptive survey design. Population of this study comprised of all students of BS programs of session 2020-2024 at public sector universities of Lahore. Purposive sampling technique was used. By applying purposive sampling technique, the sample of the study was the students enrolled in their bachelor of education programs of public or private sector institutions in Lahore. The Sample of the study was 300 students.

Table 1: Description of Sample w.r.t gender

Demographic Variable	Categories	Frequency	Percent
Gender	Male	117	39.0
	Female	180	60.0
Total		300	

The table below provides a detailed breakdown of the demographic variables for the study sample, which includes a total of 300 respondents. The demographic variables categorized by gender. Gender wise representation of the sample indicates a higher representation of female participants than males.

Research instrument

Self-constructed questionnaire based on 5-point Likert scale responses (from strongly disagree to strongly agree), was used as research instrument for the study. The questionnaire was content validated by sending to ten experts. The 80% of the experts approved the questionnaire. This was considered sufficient according to Gay et al (2012). However, still necessary modifications were made as per their provided feedbacks.

Final questionnaire comprised following three sections:

1. A demographic part that comprised of 4 items of demographic information i.e., age, gender, institute and education level.
2. The second section, focusing on STEM education, which further comprised 36 items of sub- variables academic performance, cross-disciplinary thinking, perceptions of STEM integration in non-STEM subjects and practical application.
3. The third section assessed creativity which comprises of 18 items, encompassing problem-solving and innovation skills, as well as curiosity and questioning tendencies

Data collection

The data were collected from three hundred students selected by convenient sampling. For these purposes, Permission to conduct the study was obtained through formal consent letters submitted to the institutes the researcher visited. For data collection from participants, the questionnaire includes a brief explanation outlining the research purpose and emphasizing anonymity was included at the beginning of the questionnaire to obtain informed consent from the respondents. A total of 400 responses were gathered. Following data cleaning procedures to ensure accuracy and completeness, a final dataset of 300 responses was used for further analysis.

Data Analysis

Data was analysed using Statistical Package for Social Sciences (SPSS version 29). The findings of the study are shown below.

Table 2: Description of Sum of the Variables

Variables	level	Frequency	Percent
Perceptions of STEM Integration to other Subjects	Low (<= 12.00)	1	.3
	Medium (13.00 - 36.00)	29	9.7
	High (37.00+)	266	88.7
Role of STEM in enhancing academic performance	Low(<= 10.00)	1	.3
	Medium(11.00 - 30.00)	31	10.3

	High(31.00+)	266	88.7
Role of STEM in boosting Problem-Solving skills	Low (<= 7.00)	1	.3
	Medium (8.00 - 23.50)	29	9.7
	High (23.51+)	267	89.0
STEM and Cross-disciplinary thinking	Low (<= 6.00)	1	.3
	Medium (7.00 - 23.00)	17	5.7
	High (24.00+)	279	93.0
STEM and Practical application learning	Low (<= 6.00)	1	.3
	Medium (7.00 - 22.50)	26	8.7
	High (22.51+)	270	90.0
STEM in raising curiosity	Low (<= 5.00)	1	.3
	Medium (6.00 - 25.00)	20	6.7
	High (26.00+)	273	91.0

The table below provides a comprehensive analysis of student perceptions on various aspects of STEM (Science, Technology, Engineering, and Mathematics) education. Sum of responses was categorized into three levels i.e., (Low, Medium, High) for each variable.

Most of the students agree that STEM integration into other subjects at high level i.e., 88.7% indicating strong recognition of the interdisciplinary nature of STEM; a small proportion of the students have medium perception regarding that 9.7%; while only .3% students agree at low perception indicating minimal recognition

In case of second variable i.e., "role of STEM in Enhancing Academic Performance", 88.7% students believe that STEM significantly enhances academic performance, 10.3% have medium perception of its role, and .3% perceive low role.

The third variable was the "Role of STEM in Boosting Problem-Solving Skills", majority students 89.0% recognize the role of STEM in boosting problem-solving skills, 9.7% have medium perception, while .3% perceive a low role.

Fourth variable was "STEM and Cross-Disciplinary Thinking". Majority of students (93.0%) perceive a high impact of STEM on cross-disciplinary thinking, 5.7% perceive a medium impact, and .3% perceive a low impact.

Fifth variable was "STEM and Practical Application Learning". In this case, majority students (90.0% recognize a high impact of STEM on practical application learning, 8.7% perceive a medium impact, and .3% perceive a low impact.

Sixth variable was "STEM in Raising Curiosity". In this case majority students 91.0% believe that STEM significantly raises curiosity, 6.7% have a medium perception, while .3% perceive a low role.

Summing up the analysis, the number of students with high perception of STEM education across various dimensions was very high. This indicates, that STEM education is highly valued for students in its value of integration with other subjects, enhancement of academic performance, problem-solving skills, cross-disciplinary thinking, practical application learning, and raising curiosity.

Table 3: Gender and Creativity

	Levene's Test for Equality of Variances		t-test for Equality of Means			
	F	Sig.	t	df	Sig. (2-tailed)	Mean Diff
Academic performance	.580	.447	.364	295	.716	.014
Problem solving	16.876	.000	1.976	294	.049	.074
Cross disciplinary thinking	5.495	.020	1.153	294	.250	.035
Practical application	.462	.497	-.364	294	.716	-.013
Curiosity and questioning	5.685	.018	1.171	291	.243	.039

The table 3 describes results of independent t-test to find out impact of gender on the Creativity of the university students. The p-values indicated that there is no significant mean difference for the creativity of the students. It means that the gender has no effect on the creativity of the university students.

Table 4: Impact of STEM on Creative thinking skills

	Sum of Squares	Mean Square	F	Sig.
Academic performance	5.298	2.649	29.823	.000
Problem solving	5.467	2.734	32.881	.000
Cross disciplinary thinking	4.137	2.069	38.743	.000
Practical application	6.651	3.326	47.073	.000
Curiosity and questioning	4.487	4.487	73.332	.000

Analysis of Variance (ANOVA) was applied on the data, to find out impact of STEM education on creative thinking skills. All of the five dimensions of creativity were analysed as dependent variable including academic performance, problem-solving, cross-disciplinary thinking, practical application, and curiosity and questioning. The results for each sub-variable of STEM education indicated highly significant mean differences which shows that the null hypothesis i.e., *"there is no impact of STEM education on creativity of university students"* was rejected. Detailed description of the table indicated p-values for all dimensions of creativity i.e., academic performance, problem-solving skills, cross-disciplinary thinking, practical application learning, and curiosity and inquiry approach among the university students.

Discussion

Analysis revealed that STEM integration to the education subjects, help in fostering all-round skill development of the students including academic outcomes, critical problem-solving skills, curiosity driven learning attitudes. The minimal percentage in the low-category of creativity, further highlights the overall, positive perception of students regarding STEM integration into their studies and raised level of creativity. The results were supported by various researches (Eroglu & Bektas, 2022; He et al., 2023). Moreover, no study against the findings was found in literature. ANOVA results further strengthened the evidence of significant impact of STEM integration on various creativity dimensions. Each dimension—academic performance, problem-solving, cross-disciplinary thinking, practical application, and curiosity and questioning—indicated a statistically significant relationship with STEM education.

Conclusion

In conclusion, understanding the demographic structure is vital for interpreting the study's outcomes and for ensuring that any generalizations or policy recommendations consider the specific characteristics and potential biases of the sample.

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