International Journal of Contemporary Issues in Social Sciences
Volume 3, Issue 2, 2024 ISSN(P):2959-3808 | 2959-2461

ANALYZING THE IMPACT OF STEM CHALLENGES ON 21ST CENTURY SKILLS IN PRIMARY GRADE STUDENTS IN CONTEXT OF PAKISTAN

Tasneem Saifuddin[*1], Shairoz Anis [2], Neelum Siddiqui [3], Maria Khan [4], Sonia Ishrat[5]

[*1]Lecturer (NUML Karachi Campus); [2,3,4,5]Research Scholar (NUML Karachi Campus)

[*1]tasneem@numl.edu.pk; [2]shairozanis25@gmail.com; [3]nilamsidiqui@gmail.com;
[4]mariaa.khan87@gmail.com; [5]soniaishrat943@gmail.com

Corresponding Author: *

Received: 05 May, 2024 **Revised:** 04 June, 2024 **Accepted:** 15 June, 2024 **Published:** 29 June, 2024

ABSTRACT

The aim of the current study is to find out the impact of STEM challenges on the 21st century learning skills on primary grade students in an elite school of Pakistan. STEM challenges proved to be the one of the leading approaches now a days to develop 21st century skills among students (Nadelson and Seifert, 2017). Many elite schools in our context are currently utilizing learner centered pedagogies to develop critical thinking and problem-solving skills in students. The study was designed to find out the integration of STEM challenges into the curriculum to find out its effectiveness in developing 21st century skills among students. Action Research was designed for the study, data being collected in form of scores on adapted rubrics and analysis was done on SPSS version 23. Analysis revealed that the school is already integrating STEM challenges likely produce significant effect on development of 21st century skills. The study also revealed the gender equality in learning STEM challenges as results showed no significant differences in development of 21st century skills among male and female students, both performed equally well. The study also directed future researchers to explore the efficacy of STEM Challenges in government schools.

Keywords: *STEM* Challenges, 21st century learning skills, teaching, learning

INTRODUCTION

Science, technology, engineering, and mathematics (STEM) education plays a crucial role in building a nation's workforce and propelling economic and social development. It equips individuals with critical thinking, problem-solving, and innovation skills, empowering them to meaningfully contribute to a rapidly changing world. However, concerns remain regarding equitable access to quality STEM education, particularly for girls in many developing countries, such as Pakistan.

In today's rapidly evolving world, it is crucial to equip students with the necessary skills to thrive in the 21st century. STEM education plays a significant role in increasing the 21st-century skills of grade 4 and 5 students. STEM education, which integrates science, technology, engineering, and mathematics, not only provides students with a strong foundation in these subjects, but also fosters the development of critical thinking, innovation, problem-solving, and other essential skills. By engaging in hands-on, inquiry-based learning experiences, students are encouraged to explore and experiment, promoting critical thinking and problem-solving skills.(Sirajudin et al., 2021, Shukri et al., 2020 and Kelley & Knowles, 2016)

Furthermore, STEM education promotes collaboration and communication skills because students work together to develop creative solutions to real-life challenges. Additionally, STEM education allows students to apply their content knowledge in innovative ways, encourages creativity, and enhances their ability to think outside the box. Moreover, STEM education provides students with opportunities to develop essential life and job skills such as time management and self-direction. Their problem-solving and decision-

making skills are enhanced, which has an indirect impact on their practical life, making them capable of better job pursuits (Morrison 2006). Overall, STEM education in grades 4-5 not only prepares students for future careers in STEM fields, but also equips them with the 21stcentury skills necessary for success in any field. STEM education in grades 4-5 is vital for equipping students with the necessary skills to thrive in the 21st century.

The development of analytical and logical reasoning is central to this toolkit. By engaging with scientific inquiry and engineering design, individuals learn to scrutinize information critically, formulate well-founded judgments, and approach problem solving using a structured, systematic approach. This ability to think critically and objectively, honed through STEM practices, translates seamlessly to everyday life, empowering individuals to navigate complex issues and make informed decisions, be it deciphering news articles or weighing personal choices.

Moreover, STEM education fosters the essential soft skills that are highly sought after in contemporary workplaces. Through collaborative projects and scientific presentations, students develop effective communication skills and learn to clearly and persuasively articulate complex ideas. Likewise, creative problem solving, and resourcefulness nurtured through experimentation and design challenges translate into the ability to tackle diverse situations with innovation and adaptability. These transferable soft skills are consistently rated as critical for both individual and team success, transcend specific career paths, and equip individuals to navigate the dynamic landscapes of modern life.

In recent years, there has been growing recognition of the importance of STEM (Science, Technology, Engineering, and Mathematics) education in fostering innovation, economic development, and global competitiveness. However, despite the emphasis on STEM education, a persistent gender gap remains, particularly in countries such as Pakistan. Gender disparities in STEM participation and achievement have been well documented, with girls often underrepresented in STEM fields (Herschbach 2011). Addressing this gender gap is not only crucial for promoting equity and social justice but also for harnessing the full potential of the workforce and driving sustainable development.

This study investigates the current state of STEM education and its interplay with gender equality in the context of Grade 4 and 5 students in one of the schools in Karachi, Pakistan. It explores the existing disparities in participation, attitudes, and achievement between boys and girls, aiming to illuminate the factors contributing to these inequalities and pave the way for effective intervention.

Pakistan faces ongoing challenges in achieving gender equality in the realm of education, particularly in the fields of Science, Technology, Engineering, and Mathematics (STEM). Although enrollment rates have improved, girls continue to lag behind boys in key areas. According to UNESCO Institute for Statistics (2023) data, the primary education enrollment rate for girls is lower than that of boys (89% compared to 94%). Additionally, although tertiary education enrollment appears to be near parity, women remain significantly underrepresented in STEM careers. For instance, the British Council in Pakistan (2023) reports that women earn substantially fewer PhDs and hold minimal representation in fields such as engineering. Several factors contribute to these disparities. Sociocultural norms often discourage girls from pursuing STEM education, emphasizing traditional gender roles and domestic responsibilities over professional aspirations. Stereotypes portraying STEM fields as more suitable for boys create negative perceptions and limit girls' self-efficacy (Singh et al., 2020). Furthermore, curricular and pedagogical approaches may lack inclusivity, failing to address the specific learning needs and interests of girls (Ali & Shah, 2019). Additionally, limited access to resources and infrastructure in certain schools can exacerbate existing inequalities.

Research from other South Asian contexts provides relevant insights. Singh et al. (2020) found that girls in India, a country with similar societal structures, reported lower confidence in their STEM abilities compared to boys, attributing their success to external factors like luck or teacher support. Similarly, Ali and Shah (2019) observed that Pakistani female students perceived STEM subjects as difficult and uninteresting, highlighting the need for more engaging and relatable teaching methods. These findings suggest that addressing sociocultural norms, promoting self-efficacy, and implementing inclusive pedagogies are crucial steps towards achieving gender equality in STEM education in Pakistan.

Globally, gender disparities persist in Science, Technology, Engineering, and Mathematics (STEM) education, limiting opportunities for girls and hindering societal progress. While Pakistan has seen improvements in enrollment rates, pronounced gender gaps remain, particularly evident in higher education and professional STEM fields. Understanding these disparities at the elementary level is crucial, as early experiences can shape girls' academic trajectories and future career aspirations. This study aims to specifically investigate gender disparities in STEM education among students in Grades 4 and 5 at a school in Karachi, Pakistan.

Research suggests that early exposure to engaging and inclusive STEM education can spark girls' curiosity and ignite their passion for STEM subjects. However, studies indicate that girls in Grades 4 and 5 often exhibit lower interest and engagement compared to boys. This phenomenon, if left unaddressed, can solidify into persistent gender gaps later in education and limit opportunities for girls in STEM careers. Addressing these disparities at the elementary level is critical for fostering a more inclusive learning environment that empowers girls to develop their full potential in STEM fields (Tyler ,2020).

By investigating the specific challenges faced by girls in Grades 4 and 5 at this Karachi school, this study holds significant importance for promoting gender equality and fostering a future generation of skilled and diverse professionals in STEM fields. The findings can inform the development of targeted interventions and strategies specifically tailored to the needs and interests of girls at this crucial stage in their educational development.

1.2 Research Objectives: This study will employ quantitative research methods to examine the enhancement of 21st Century skills amongst grade 4 and 5 students through STEM challenges and also to identify the difference in the attitude of the students towards STEM activities. By identifying key bottlenecks and opportunities, the study aims to develop actionable recommendations for promoting gender equality in STEM education at the elementary level.

1.3 Research Questions:

This study aims to address the following research questions:

1. What are the specific differences in participation, attitudes, and achievement towards STEM education between boys and girls in Grade 4 and 5 at the chosen school in Karachi, Pakistan?
2. How do self-efficacy beliefs and perceptions of STEM subjects differ among girls and boys in Grade 4 and 5 at the school?

This study acknowledges several limitations that may affect the generalizability and comprehensiveness of its findings. Firstly, the small sample size, focusing on a single private school in Karachi, Pakistan, restricts the generalizability of results to the broader population of Grade 4 and 5 students nationwide. Public schools, with different resource constraints and student demographics, might present distinct dynamics regarding gender disparities in STEM education. Additionally, the study's focus on simpler activities related to specific class topics potentially limits the understanding of student engagement and attitudes towards broader STEM concepts and real-world applications. Furthermore, a short-term analysis might miss insights into the evolution of these disparities over time or the impact of future interventions. Lastly, while individual factors like self-efficacy and perceptions are explored, the study acknowledges the need for further investigation into broader societal and systemic factors, such as teacher training, curriculum design, and resource access, for a more holistic understanding of gender disparities in STEM education. These limitations highlight the need for future research with larger and more representative samples, exploring diverse school contexts, delving into real-world applications of STEM, utilizing various data collection methods, employing longitudinal designs, and comprehensively examining both individual and systemic factors to provide a more robust understanding of gender disparities and inform effective interventions in promoting gender equality in STEM education at the elementary level in Pakistan.

2.Literature Review

In an era marked by constant change, the 21st century demands a new set of skills from individuals entering the workforce. As highlighted by the World Economic Forum (2020), "future-oriented skills" like critical thinking, communication, collaboration, and problem-solving are crucial for navigating the complexities of the contemporary world. These "21st century skills" are deemed essential not only for

success in diverse careers but also for navigating an increasingly interconnected and information-driven global landscape (Partnership for 21st Century Learning, 2019). Recognizing this shift, educators and policymakers are actively seeking effective approaches to equip students with the necessary tools for future success. One approach gaining significant traction is STEM education, encompassing Science, Technology, Engineering, and Mathematics (Bybee, 2010). This literature review delves into existing research on how STEM challenges impacting the development of 21st century skills in Grade 4 and 5 students. We specifically examine the potential of such challenges to nurture critical thinking, communication, collaboration, and problem-solving abilities within this age group. Additionally, we explore the issue of gender disparity in STEM education, considering how these challenges might influence the engagement and skill development of both male and female students. Finally, the review narrows its focus to the context of Karachi, Pakistan, acknowledging the need for research specific to this geographical and cultural setting.

2.1Importance of 21st Century Skills

The evolving landscape of education is driven by the dynamic nature of the 21st century workforce. Automation and technological advancements have disrupted traditional job markets, demanding a shift in the skillset required for success (World Economic Forum, 2020). The emphasis on 21st century skills, encompassing critical thinking, communication, collaboration, and problem-solving, arises from this very transformation. These skills are deemed crucial not only for specific jobs but also for navigating the ever-evolving complexities of the 21st century economy (World Economic Forum, 2020).

Numerous studies and reports echo this growing need. A study by the McKinsey Global Institute (2017) explores the potential impact of automation on jobs across various sectors. While acknowledging potential risks, the report emphasizes the need for individuals to develop skills that complement, rather than compete with, automation. These skills, including complex problem-solving, critical thinking, creativity, emotional intelligence, and social skills, all align with the broader umbrella of 21st century skills (McKinsey Global Institute, 2017).

Similarly, the Partnership for 21st Century Learning (2019) emphasizes the critical role of 21st century skills in equipping students for success in their educational and professional lives. Their framework outlines four key areas: core subjects integrated with 21st century content, learning and innovation skills, information literacy, and life and career skills. This framework highlights the importance of not only acquiring foundational knowledge but also developing the ability to apply that knowledge effectively in real-world scenarios, fostering a holistic approach to preparing students for future challenges (Partnership for 21st Century Learning, 2019).

In conclusion, the changing nature of the workforce necessitates a focus on developing critical thinking, communication, collaboration, and problem-solving skills in students. These skills equip individuals not only with the ability to navigate an evolving job market but also with the adaptability and resilience necessary for lifelong success.

2.2 Fostering 21st Century Skills in STEM Education:

The evolving landscape of education necessitates equipping students with critical skills for the 21st century. In this context, STEM education, encompassing Science, Technology, Engineering, and Mathematics, has emerged as a promising approach for cultivating vital skills like critical thinking, communication, collaboration, and problem-solving (Bybee, 2010).

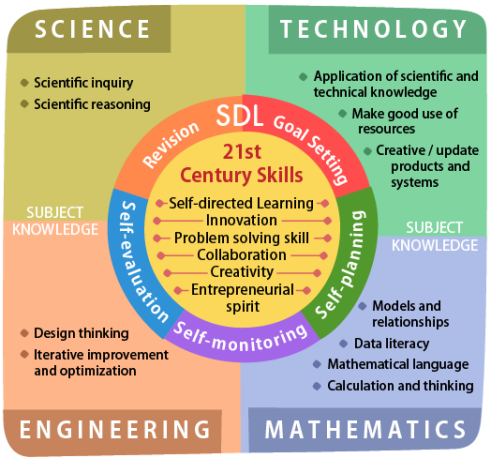

Figure 1Adopted from: (What Is STEM? – Jockey Club Self-Directed Learning in STEM Program, 2020)

Research demonstrates the effectiveness of STEM activities in promoting these crucial skills in various ways:

2.2.1Critical Thinking: STEM activities often involve open-ended problems that require students to analyze information, evaluate different solutions, and make informed decisions. For instance, a design challenge tasking students with building the tallest and sturdiest bridge using limited materials encourages critical thinking as they experiment, analyze their designs, and adapt them based on results (Hacıoğlu and Gülhan 2021).

2.2.2Communication: Collaboration is inherent in many STEM activities, requiring students to effectively communicate ideas, explain their reasoning, and listen to different perspectives. Group projects, where students work together to complete a task, necessitate clear communication, negotiation, and consensus building (Barlex, 2020).

2.2.3. Collaboration: STEM activities often necessitate teamwork, fostering collaboration and interpersonal skills as students work together towards a common goal. Collaborative activities like building robots or conducting scientific experiments require effective communication, coordination, and conflict resolution within the team (Sahni and Park 2022).

2.2.4Problem-Solving: At the heart of STEM education lies problem-solving. Students encounter real-world or simulated problems that require them to apply their knowledge and skills to develop solutions. Open-ended engineering challenges, such as designing a water filtration system or building a solar-powered car, encourage students to employ creative problem-solving strategies (Moore et al., 2014).

However, concerns regarding resource limitations in under-resourced schools can hinder the implementation of STEM education. Fortunately, research highlights the effectiveness of utilizing readily available, low-cost materials in facilitating engaging and effective STEM activities (Kennedy and Odell 2014).

2.3Gender Disparities in STEM Education:

Despite the potential benefits of STEM education, existing research highlights a persistent gender gap, with females remaining underrepresented in STEM fields (Stein etal.,2017). This disparity is evident in both participation and achievement, with girls and women less likely to pursue STEM careers compared to their male counterparts (National Center for Education Statistics, 2023). While the gap may narrow in specific areas like life sciences, it persists in fields like engineering and computer science (National Center for Education Statistics, 2023).

Several factors have been identified as potential contributors to this gender gap, including:

2.3.1Stereotypes: Socially constructed stereotypes that portray STEM fields as masculine can discourage girls from pursuing them due to fear of not belonging or not being valued (Murphy et al., 2018). These stereotypes can be particularly harmful in younger students, with research suggesting that girls as young as grade 6 begin to develop negative self-perceptions of their abilities in math and science (OECD, 2018).

2.3.2Lack of female role models: The limited visibility of female scientists, engineers, and mathematicians can hinder girls from seeing themselves in these roles and fostering aspirations for STEM careers (Cheryan et al., 2015). Studies focusing specifically on the impact of role models in elementary school settings are limited, but research suggests that exposing young girls to female role models in STEM fields can positively impact their interest and self-efficacy (Murphy et al., 2018).

2.4Teaching approaches: Traditional teaching methods in STEM fields may inadvertently favor certain learning styles, potentially disadvantaging girls who learn differently (Hill et al., 2010).

Furthermore, research suggests that gender differences, although not absolute, may influence engagement with STEM activities. Studies involving students in grades 4 and 5 have shown that

girls might be more drawn to collaborative and socially oriented approaches to STEM learning, such as activities that involve teamwork, communication, and real-world applications (Pantoja Amaro et al. , 2020) whereas boys may exhibit a stronger preference for individual problem-solving activities, particularly those involving competition or hands-on construction (Hill et al., 2010)However, it is crucial to acknowledge that these are general trends and individual preferences can vary significantly within both genders.

While a broader gender gap persists in STEM fields overall, research suggests differing areas of interest between genders (OECD, 2015). Girls and boys exhibit similar interest in life sciences, particularly biology and environmental science. However, a slight male preference emerges in physical sciences

like physics and chemistry, though the gap is narrowing. Engineering and computer science remain the fields with the widest gender disparity, highlighting the need for addressing stereotypes and promoting female role models to encourage girls' interest in these areas (Cheryan et al., 2015).

Understanding these complexities is crucial for designing inclusive and engaging STEM education experiences that cater to the diverse needs and interests of all students. By employing inclusive pedagogy, incorporating diverse role models, and offering a variety of learning approaches, educators can empower students of all backgrounds to cultivate 21st century skills through engaging and impactful STEM experiences.

2.5 Case Studies and Research in Pakistan

Although research on STEM education in Pakistan is experiencing growth, studies directly exploring the effectiveness of STEM challenges on 21st century skills development in Grade 4 and 5 students, disaggregated by gender, are scarce (Abbas et al., 2021). However, existing research focusing on broader aspects of STEM education in Pakistan offers valuable context for the proposed case study investigating these areas within Karachi, a specific city with its own unique social and educational landscape.

A review by Abbas et al. (2021) highlights a critical gap in Pakistani research on the impact of STEM education on student learning outcomes. They emphasize the need for further studies to understand the effectiveness of STEM education in various contexts, highlighting the potential for the proposed case study to contribute valuable original research (Abbas et al., 2021). Additionally, research by Hussain et al. (2019) explores the complex factors contributing to the gender gap in STEM education within Pakistan. This study identifies socio-cultural factors, economic limitations, and institutional biases as significant barriers to girls' participation in STEM fields (Hussain, 2022). The research underscores the relevance of analyzing data by gender in the proposed case study, allowing for a nuanced understanding of how STEM challenges might impact the development of 21st century skills differently for boys and girls.

2.6 Research Hypothesis

Based on literature above hypothesis thus develop for the study are:

- H1: STEM integration positively influences the development of 21st –century skills among the students.
- H2: The impact of STEM integration on the development of 21st-centry skills varies significantly between male and female students

This review of the literature has highlighted the growing interest in STEM education in Pakistan but also revealed a critical gap in understanding its impact on student learning outcomes within the specific context (Abbas et al., 2021). While research by Hussain (2022) emphasizes the need to address the gender gap in STEM education, existing studies offer a national perspective, limiting insights into the localized nuances of implementing and evaluating STEM initiatives in different Pakistani cities.

This proposed case study in Karachi aims to address this gap by investigating the effectiveness of STEM challenges in fostering 21st century skills, such as critical thinking, communication, collaboration, and problem-solving, within Grade 4 and 5 students. Additionally, the study will explore potential gender differences in the impact of these challenges.

By focusing on this specific age group, context, and disaggregating data by gender, the research holds significant potential to contribute to the understanding of how STEM challenges can impact the development of 21st century skills among students in Karachi. The findings can inform the design and implementation of effective STEM education initiatives that foster crucial skills for the 21st century while addressing the persistent gender disparity in the field. This research holds the potential to enhance educational practices and promote equitable access to the benefits of STEM education for all students in Karachi.

3. Research Methodology

This section describes the methodology employed in the current study. For the present study Action Research study, with quantitative approach was utilized to find out the impact of STEM challenges on the development of the 21st century learning skills. Instead of utilizing pre- and post-tests, student data was continuously observed and quantitatively analyzed over an extended period. This allowed for the longitudinal assessment of skill development in

21st-century competencies within the context of STEM education. The study aligns with constructivist epistemology, acknowledging the active role of students in constructing knowledge through their engagement with the STEM activities. Additionally, a social constructivist ontology is implied, recognizing the influence of social interactions and collaborative learning on individual understanding.

3.1 Sampling Procedure:

The research was conducted in a single private school located in Karachi, Pakistan, leveraging the researcher's existing teaching experience with Grades 4 and 5. Driven by a keen interest in understanding potential gender disparities in STEM engagement at this critical developmental stage, a convenience sample of 40 students from both grades was recruited. This sampling method was chosen due to accessibility within the school setting. To ensure collaborative learning environments and minimize potential gender bias within group dynamics, students were divided into mixed-gender groups, fostering diverse perspectives and problem-solving approaches. This deliberate participant selection process established the foundation for investigating the intricate relationship between gender and STEM engagement, paving the way for valuable insights into this underexplored area of the Pakistani education system especially in grade 4 and 5 context.

3.2 Research Strategies:

The research employed three carefully chosen STEM activities designed to resonate with students' prior knowledge and foster sustained engagement over a three-month period. The first activity, "Design a structure for John to sit in his new house," likely tapped into engineering and design principles, encouraging students to apply creative problem-solving and spatial reasoning skills. Similarly, "Design an unsinkable boat" delved into the realm of physics and buoyancy, requiring students to experiment with materials and understand the principles of floatation. Finally, the third activity "Create the longest possible chain with the help of ONE A4 paper" challenged students' geometric understanding and problem-solving abilities within a resource-constrained context. Moreover, it also focuses on the systems present in the human body involving integration like neurons. This deliberate selection provided a diverse range of experiences, allowing students to explore various facets of STEM while capitalizing on their existing knowledge base.

In this three-month, challenge-based STEM study, the teacher acts as a critical facilitator, guiding students through a series of open-ended problems designed to cultivate 21st-century skills across genders in grades 4 and 5. Their role goes beyond simply presenting information. The teacher sparks curiosity and ignites student investment by introducing each challenge, ensuring it connects to students' prior knowledge. They then provide a safe and supportive environment where students are encouraged to define the problem, brainstorm solutions, and ultimately create prototypes of their most promising ideas (adapted from Stanford Design Thinking Model of STEM Education). Through careful questioning and discussions, the teacher facilitates exploration and helps students articulate their thought processes. Furthermore, by encouraging peer collaboration and reflection on the learning experience, the teacher fosters the development of critical thinking, communication, and teamwork skills, all crucial for success in the 21st century. Finally, the teacher plays a vital role in data collection by observing and documenting student behavior, particularly focusing on potential differences in the development of these skills between genders.

To evaluate student performance and skill development, a standardized rubric shared by the supervisor was utilized. This rubric focused on four key aspects of 21st-century skills deemed crucial for STEM education: creativity and innovation, problem-solving, research and information fluency, and prototype and presentation flow & visual appeal. By employing a consistent evaluation tool across the three activities, the research aimed to gain a comprehensive understanding of students' strengths and weaknesses across these critical skill areas, ultimately offering valuable insights into their engagement with STEM. In order to avoid any bias, the school coordinator and other Science and Mathematics teachers were also involved, and the results were evaluated by other teachers.

The extended three-month duration of each activity allowed for sustained engagement, enabling students to delve deeper into the challenges, experiment with different approaches, and refine their skills through iterative feedback and practice. This approach provided a richer learning experience compared to a single-day activity, potentially leading to more

meaningful skill development and a deeper understanding of the STEM concepts explored.

4.Data Analysis

Data were collected through a period of three months on rubrics and scores were analyzed on SPSS version 23 to find out the effectiveness of the STEM challenges applied and also to observe the difference in male and female performance as some literature suggest that Mathematics is more likely adopted by male students (Mendick,2005) and as STEM has mathematics integration so is more liked by male students.

Demographic details

Total Number of students	40
Number of male students	20
Number of female students	20

Table 4.1 demonstrates the demographic. details of the data.

The study involved a sample of 40 students (20 male and 20 female) aged 9-11 years, enrolled in Grades 4 and 5 at a school located in North Nazimabad, Karachi, Pakistan. All students came from well-off family backgrounds with educated parents, mostly professionals. Notably, most students had been attending the same school since nursery, indicating a potentially consistent educational environment. Additionally, these students had prior exposure to STEM concepts through various STEM challenges offered by the school, both physically before the COVID-19 pandemic and online during the lockdown period. This pre-existing familiarity with STEM activities may have influenced their engagement with the research intervention.

The table below (Table 4.2) below shows descriptive statistics of the data. Data was collected from two classes having a varied number of male and female students. The mean score for all activities came out to be almost equal with a standard deviation ranging from 1.86-2.72

Descriptive Statistic

Gender		N	Mean	Std. Deviation	Std. Error Mean
Activity 1	Boy	19	14.58	1.924	.441
	Girl	21	14.71	1.875	.409
Activity 2	Boy	19	14.26	2.725	.625
	Girl	21	14.48	2.713	.592
Activity 3	Boy	19	13.37	2.454	.563
	Girl	21	13.90	1.868	.408

Table 4.2 Descriptive Statistics)

The scoring of students ranges from 9-20 which is considered a developmental sign depicting students did well in all three activities. It is noted that in Activity :1 student majority secured 10 marks, in activities: 2 and 3, the major scoring is at marks of 14 thereby accepting the ***Hypothesis: 1.***

"STEM integration positively influences the development of 21st-century skills among students".

Scoring Frequency

	Activity :1		Activity 2		Activity 3	
	Scores	Freq	Scores	Freq	Scores	Freq
	11	1	10	2	9	2
	12	3	11	6	11	8
	13	7	12	3	12	2
	14	9	13	4	13	2
	15	10	14	7	14	10
	16	4	15	4	15	9
	17	2	16	4	16	5
	18	2	17	5	17	1

19	2	18	3	18	1
Minimum	11		10		9
Maximum	19		20		18

Table 4.3 (Scoring Frequency)

To find out differences in the development of skills between male and female students independent sample t-test is performed. An independent sample t-test is performed to test the significance of the difference between two independent groups (Ahmed et al., 2019). Table 4.3 revealed that there is no significant difference found between the development of 21st-century learning skills using STEM integration in male and female students.

Independence Sample t-test

Table 4.3 (Independent Sample t-test)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Score1	Equal variances assumed	.135	.716	-.225	38	.823	-.135	.601	-1.352	1.081
	Equal variances not assumed			-.225	37.381	.823	-.135	.602	-1.354	1.084
Score2	Equal variances assumed	.001	.977	-.247	38	.806	-.213	.861	-1.956	1.530
	Equal variances not assumed			-.247	37.569	.806	-.213	.861	-1.957	1.531
Score3	Equal variances assumed	1.108	.299	-.782	38	.439	-.536	.686	-1.924	.852
	Equal variances not assumed			-.772	33.528	.446	-.536	.695	-1.950	.877

Based on the analysis Hypothesis :2 is rejected:

"The impact of STEM integration on the development of 21st-century skills varies significantly between male and female students.". There is no difference in performance between male and female students.

Overall Findings

The data analysis suggests a positive impact of STEM integration on the development of 21st-century skills among the participating students. The observed consistency in performance across activities, with scores concentrated in the higher range (Tables 4.2 & 4.3), indicates that students likely improved their critical thinking, communication, collaboration, and problem-solving abilities through engagement with STEM activities. Furthermore, the independent samples t-tests (Table 4.3) revealed no statistically significant differences

in student performance between genders. This finding suggests that the implemented STEM integration strategies may have been effective in promoting gender equality in skill development.

However, it is important to acknowledge limitations like the small sample size and the lack of a control group. Future research with a larger and more diverse sample, employing pre- and post-testing, could solidify the observed trends and provide a more comprehensive picture of the long-term impact of STEM integration on 21st-century skill development across genders.

Conclusion and Recommendations

The purpose of the entire study is to find out the effect of STEM challenges on the development of 21st century skills among primary level students. Researcher performed three STEM challenges and compared it with the students. The impact of the scores were assessed on the adapted rubrics and it was found out that STEM challenges proved successful in students to develop their critical thinking skills, communication, collaboration, creativity and problem-solving skills. The study was also aimed to find out the gender differences on performing STEM challenges as literature suggested that STEM electives are more likely been selected by male students and less by female indicating girls don't like to perform on STEM challenges (Chan and Cheung, 2018). After analysis it was revealed that STEM challenges were beyond gender biasness, both male and female students equally participated and scored well.

The analysis of the previous scores also report that students were already performing well and were exposed to learner centered and innovative pedagogies that has helped to develop their critical thinking and problem-solving abilities. The school selected was elite, where parents were engaged kept informed with all the activities. Therefore, support from the parents also helped children for their social and intellectual development. The research highlights the major direction for future researchers to be performed in public schools or low-profile schools to assess the impacts of STEM challenges on the holistic development of the child as these schools follow traditional methodologies and were less equipped with teaching resources. STEM approach needs interdisciplinary knowledge among teachers, technology aids and subject experts that can deliver the content aiming to develop the intellectual skills of a child (Bybee 2013).

This research on gender disparities in STEM education proposes several recommendations for various stakeholders. Teachers are encouraged to integrate STEM challenges across the curriculum, utilizing readily available resources. Parents can play a crucial role by fostering children's interest in STEM through discussion and activities. School heads should prioritize professional development for STEM instruction and consider expanding STEM opportunities to younger grades. Future research should replicate the study in diverse settings and expand to lower grade levels to solidify the generalizability of the findings and provide a more comprehensive picture of STEM's impact on students**.**

References:

- Abbas, Q., Parveen, K., Rehman, M., Tabassum, S., & Ahmed, D. (2023). Teachers' Perspectives on the Benefits and Role of Stem Education in the Solution of Complex Global Challenges. *Journal of Education and Social Studies*, *4*(1), 183-191.
- Ali, Z., & Rehmat Shah, D. N. A. (2023). Determining The Science, Technology, Engineering, And Mathematics Teaching Capabilities Of Educators In Karachi, Pakistan. *Journal of Positive School Psychology*, 11-28.
- Barlex, D. (2020). Science and design & technology: An exploration of their relationship in the secondary school curriculum. In *STEM in Science Education and S in STEM* (pp. 103-125). Brill.
- British Council in Pakistan. (2023). Women in STEM: Bridging the gap.
- Bybee, R. W. (2013). The case for STEM education: Challenges and opportunities.
- Chan, A. K., & Cheung, A. K. (2018). Gender differences in choosing STEM subjects at secondary school and university in Hong Kong. *Hong Kong: The Women's Foundation*.
- Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying

stereotypes. *Frontiers in psychology*, *6*, 123074.

- Hacıoğlu, Y., & Gülhan, F. (2021). The effects of STEM education on the students' critical thinking skills and STEM perceptions. *Journal of Education in Science Environment and health*, *7*(2), 139-155.
- Herschbach, D. R. (2011). The STEM initiative: Constraints and challenges. *Journal of stem teacher education*, *48*(1), 96-122.
- Hill, C., Corbett, C., & St Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. American Association of University Women. 1111 Sixteenth Street NW, Washington, DC 20036.
- Husain, F. Y. (2022). *Investigating the themes and perceptions of the formal and informal STEM education programs, STEM career development, and their connections to the triple helix component in the UAE* (Doctoral dissertation, The British University in Dubai).
- Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM education*, *3*, 1-11.
- Kennedy, T. J., & Odell, M. R. (2014). Engaging students in STEM education. *Science education international*, *25*(3), 246-258.
- Mendick, H. (2005). A beautiful myth? The gendering of being/doing 'good at maths'. *Gender and education*, *17*(2),203-219
- Moore, M. L., Tjornbo, O., Enfors, E., Knapp, C., Hodbod, J., Baggio, J. A., ... & Biggs, D. (2014). Studying the complexity of change: toward an analytical framework for understanding deliberate social-ecological transformations. *Ecology and society*, *19*(4).
- Morrison, J. (2006). Attributes of STEM education: The student, the school, the classroom. *TIES (Teaching Institute for Excellence in STEM)*, *20*(2), 7.
- Murphy, E. J., Bolatto, A., Chatterjee, S., Casey, C. M., Chomiuk, L., Dale, D., ... & Wilner, D. (2018). Science with an ngVLA: The ngVLA science case and associated science requirements. *arXiv preprint arXiv:1810.07524*.
- Nadelson, L. S., & Seifert, A. L. (2017). Integrated STEM defined: Contexts, challenges, and the future. *The Journal of Educational Research*, *110*(3), 221-223.
- National Center for Education Statistics. (2023). *National Center for Education Statistics (NCES) Home Page, part of the U.S. Department of Education*. Ed.gov; National Center for Education Statistics. https://nces.ed.gov/
- OECD., K. (2018). *OECD science, technology and innovation outlook 2018*. Paris: OECD publishing.