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Shaping the Future: Exploring the Role and Impact of STEM Education in Modern Educational Landscapes

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Abstract: Across the world, STEM education obtains tremendous attention from educationists and shows the urge to prepare students as global citizens. This study is an effort to investigate the impact of STEM-focused Teachers' Professional Development Training Programs on teachers' understanding of STEM education, its principles for improving teaching practices in the growing need for quality STEM education, and the integral role of teachers in preparing the skillful workforce of the future. A quantitative approach was used, and a survey questionnaire was designed for STEM teachers employed at STEM-focused schools in Karachi. The data was collected from 100 STEM teachers. The recorded data was analyzed by SPSS. With percentage frequency, descriptive statistics were used for data analysis. The data analysis of this study revealed that Teachers' Professional Development in STEM education significantly enhances teachers' understanding of STEM education and their proficiency in STEM instruction. These training programs improve their self-efficacy and equip them with essential skills and expertise for effective STEM teaching which enhances students learning. This research presents practical implications, including curriculum adjustments to align with student preferences, targeted professional development for teachers, and a focus on prioritized STEM literacy skills. Collaboration between policymakers, academia, and stakeholders is also recommended to create a comprehensive and tailored approach to STEM education that meets the evolving needs and preferences of students.

Key Words: *Professional Development, STEM, quality education,*

Introduction

The acronym "STEM" (which stands for science, technology, engineering, and mathematics) has become a great deal of interest who are advocating for reforms in education. These reforms aim to enhance the competitiveness of the next generation by fostering their problem-solving capabilities and creativity, as discussed in studies by Zhan et al., 2022.

STEM education can be described as the mathematical and scientific concepts, the incorporation of engineering, and the appropriate use of technology, as defined by Kelly & Knowles, 2016.

In the set of empirical studies, STEM serves as a way to integrate science, mathematics, technology, and engineering into real-world problem-solving contexts, as described in studies conducted by Bissaker, 2014; Martín-Páez et al., 2019; Falloon, 2021; Sulaeman, 2022.

In the current digital age, the significance of STEM education cannot be overemphasized. To develop STEM curricula, it is essential to focus on teachers for teaching STEM effectively. Through comprehensive and effective Professional Development training programs it can be achieved, as suggested by Chui et al., 2021. Teachers are the primary source of imparting knowledge. In the context of pedagogical and curriculum reforms professional development training in teachers' programs plays a critical role, highlighted by Dare et al., 2021. Thus, the importance of such training programs for implementing STEM education remains consistent.

Consequently, effective teacher professional development requires essential components such as content-focused, active learning approaches, collaborative efforts, expert guidance, feedback and self-reflection, and sustained, continuous duration. For shaping and structuring effective teacher professional development, these elements are universally recognized as key factors described by Darling-Hammond et al., 2020.

Several studies highlighted the significance of teachers' professional development in STEM education, but there is still a significant gap in quality research regarding professional development specifically aimed to equip teachers with the necessary skills for integrating STEM education.

Purpose of the study

The purpose of this study is to explore and evaluate the impact of Teachers' Professional Development in STEM education on the improvement of teaching abilities. The study aims to address the growing need for quality STEM education and the integral role that teachers play in shaping students' understanding and interest in these critical disciplines.

Objectives of the study

The objectives of the study are as follows:

- To investigate the impact of STEM-focused Professional Development on teachers' under

- To assess STEM-focused Teachers' Professional Development program improves teaching skills.
- To examine Teachers' Professional Development in STEM education enhances STEM education quality.

Research questions

- The research questions of the study are as follows:
- Q 1. Does STEM-focused professional develop-ent impact teachers' comprehension of STEM education principles and practices?
- Q 2. Does a STEM-focused teachers' professional development program improve teaching skills?
- Q 3. How do teachers' professional development programs focus on STEM education impact the quality of STEM instruction?
- Q 4. Do STEM-focused teachers' Professional Development programs prepare teachers for future trends and emerging technologies?

Hypothesis

1. The teachers' professional development program focused on STEM education has a significant impact on teachers' understanding of STEM education.
2. The teachers' professional development program focused on STEM education has a significant effect on improving teaching skills.

Review of Literature

Within the context of an instructional plan and curriculum, STEM education can be described as a teaching methodology that integrates the disciplines of science, technology, engineering, and mathematics, to develop problem-solving skills, creativity, and technological literacy in learners. STEM education enhances understanding of each discipline under the umbrella term experiential learning through real-world exposure and hands-on learning. Since the beginning of the 1990s, the STEM approach has gathered the attention of all progressive mindset educationists and industrialists to prepare competent and skillful students for future success in the continuously evolving scientific society. Therefore, there is a dire need to improve technological and scientific literacy, which is only possible through the STEM approach.

STEM instruction is a shift from conventional teaching to student-centered learning. (Smith & Karr-Kidwell, 2000) described STEM instruction as a means of incorporating teamwork and appropriate use of technology as it includes solving problems that explain concepts and procedures from science, mathematics, and engineering. The attitude of students toward their future careers and interests through STEM instruction has changed positively because it enhances learning effectiveness, and content is developed according to the needs of the future skillful workforce (Sari, Alici, & Sen, 2018). Several pedagogical strategies in STEM education effectively foster engagement and achievement in students in STEM disciplines identified by McDonald, 2016, including cooperative learning, inquiry-based learning, digital learning, computer programming, and hands-on assessment. The six essential components for designing STEM instruction identified by Pawilen and Yuzon (2019) 1. Topic and activities of students' interest 2. Accessibility of resources 3. Relevance of the content and activities for the students, 4. Applicable to student routine lives, 5. Curriculum aligned with the contents and activities, and 6. Integration of science, technology, engineering, and mathematics. STEM education aims to develop logical thinking, create innovative ideas, teamwork, and problem-solving skills in learners.

The STEM curriculum aims to enhance the learning experience for students on both an individual and broader level. This is achieved by providing opportunities for interdisciplinary collaboration, which is believed to lead to more relevant, cohesive, and engaging experiences for students. Working in a team, peer collaboration, and thinking outside the box are the abilities that Teachers must possess to coordinate their teaching across disciplines in STEM education. For teaching STEM education faculty must be professionally trained in STEM education to prepare responsible, all-rounder, and global citizens. The integration of STEM into an existing educational system that is structured around segregated and discipline-based approaches requires significant revisions to the curriculum and teaching methods (Nadelson & Seifert, 2017).

Educationists and researchers have highlighted the significance of a standardized curriculum in a STEM education program as it encompasses scientific concepts such as life sciences, physical sciences, and chemical sciences, technology concepts including the use of technology as a tool, as an idea, and as a product of science, engineering design concepts including models, designs, problem-solving, communicating ideas, planning, and implementation, and mathematical concepts including numbers, problem-solving, geometry, measurement, and the representation of mathematical ideas using objects, symbols, and words.

STEM education plays a significant role in the country's scientific and economic advancement It is a means to stimulate innovation, creativity, and future

job growth (Ahmed, 2016). Furthermore, fostering curiosity, questioning, and developing connections helps students better understand the world around them. However, current classroom practices often prioritize addressing accountability standards, often with severe consequences for those who fail to meet them (Higgins, J., & Moeed, A., 2017)

(Freeman, 2005; Lacey & Wright, 2009) highlighted the significance of STEM education and recommended that individuals qualifying for and pursuing STEM professions can improve the global economy. As a consequence, to meet future needs and growing demands, it is critical to develop individuals with STEM education (Rozek et al., 2017).

To enhance the quality of education in the classroom and promote active learning, professional development for teachers is a strategy that incorporates both natural and intentional learning experiences, whether formal or informal, planned or unplanned (Gemeda et al., 2014). Craft (2005) emphasized the importance of teachers' professional development programs as they maintain and enhance the quality of teaching and learning within the educational setup. Teachers are the primary factor that influences the quality of education; therefore, professional development programs have significant importance as they transform teachers' classroom practices. Teachers refine their practices, develop innovative instructional techniques, explore new roles, and expand their horizons as educators and individuals through professional training programs (Komba and Nkumbi, 2008). Teachers serve as the principal providers of information, expertise, sagacity, and examples for students.

Professional development is a vital aspect of enhancing teachers' content knowledge and teaching skills through practical application, reflection, and collaboration with peers and administrators, as described by (Gore, J., & Rosser, B., 2022)

Teachers' willingness to improve themselves as STEM instructors have significantly enhanced STEM education (Sulaeman et al., 2022) The relationship between teachers' readiness and improvement in students' academic progress is noteworthy (Lynch et al., 2017), as the ability of teachers to engage in teaching activities have a profound effect on the learning process of the students (Johnson, 2017).

Implementation of STEM education is heavily dependent on the proficiency of the teaching faculty and technology education is a crucial component. Technology education goes beyond the discipline of technology and enforces the development of related skills and literacy in students, as well as creating authentic contexts and problems (Herrington, J., & Kervin, L., 2007).

Teachers' Professional development training is crucial as it improves teachers' knowledge, boosts confidence, and reduces turnover (Kelley et al., 2020; Parker et al., 2020). Zhou et al.,2023 in their study emphasized the significance of training programs as they improve teaching pedagogy and mastery in teaching STEM content, which leads to positive teacher outcomes. Additionally, these training programs improve teachers' self-efficacy and enable them to plan lessons based on the STEM content.

Teachers' understanding of STEM education involves recognizing it as an interdisciplinary approach to teaching and learning, where these core subjects are integrated to solve real-world problems. STEM education emphasizes fostering critical thinking, creativity, and analytical skills in students, encouraging them to explore and apply knowledge in practical ways. Teachers understand that STEM education is not just about memorizing facts but about engaging students in hands-on activities, experiments, and projects that promote active learning and collaboration. They also grasp the importance of staying updated on the latest advancements in STEM fields and aligning their teaching methods with curriculum standards. Furthermore, teachers recognize the significance of promoting diversity and inclusivity in STEM education to ensure all students have equal opportunities to excel in these subjects. Overall, teachers' understanding of STEM education encompasses the idea that it equips students with the skills and knowledge needed to thrive in an increasingly technology-driven and complex world.

Research methodology

Materials and methods

The Research design used in this research study was quantitative as well as descriptive in nature. The researcher has taken a non-experimental research approach and followed a survey design to carry out the research objectives.

Research design

In this study, a survey design was used to find answers to the research questions. Survey design was used because this study aims to investigate and analyze how Teachers' Professional Development in STEM education improves teaching skills in STEM-focused schools located in Karachi.

Population and sample

The targeted population was teachers employed at STEM-based schools located in Karachi. Simple random sampling techniques were used for the selection of the sample. The sample size consists of 100 STEM teachers employed at STEM-focused schools in Karachi. The researcher aims to collect the

responses from the teachers employed at different STEM-based schools located in Karachi for data collection purposes.

Data Collection Tool

A detailed survey questionnaire was prepared with demographic details. For data collection, a questionnaire was designed with an expert research supervisor and a review of related literature. The survey questionnaire was used as it is the main means of collecting quantitative primary data from the STEM teachers employed at STEM-based schools in Karachi. A five-point Likert scale survey questionnaire was used to collect opinions of Teachers on STEM-focused professional Development teachers' training. The researchers used this technique to gather information to ensure the questionnaire's effectiveness. The questionnaire was passed through the pilot study to check the validity and reliability of the tool. A survey instrument with demographic details of the teachers to know the background like gender, age, and education level and their perception regarding Professional Development in STEM education.

Results and findings

Data analysis and interpretation

The information obtained from the data was systematically gathered and documented, and later, it was analyzed by the percentage frequency method using SPSS.

Demographic Information

The first section of the questionnaire consisted of demographic details, and frequency tabulation was used for the analysis.

Table 1: Demographic Details of STEM Teachers

Variables		Frequency	Percentage
Gender	Male	27	27.0
	Female	73	73.0
Age	21 - 30	54	54.0
	31 - 40	39	39.0
	41 - 50	7	7.0
Qualification	Graduate	75	75.0
	Post-Graduate	25	25.0

Table 1 provides the demographic details of STEM teachers.

In this study, 100 teachers participated who were teaching STEM education. The majority of the respondents were Female i.e. (73%), and (27%) were Male. The results reveal the distribution of STEM teachers across the different age groups. The majority (54%) of STEM teachers fell in the 21-30 age group, (39%) in the 31-40 age group, and (7%) in the 41-50 age group. The results of the distribution of educational qualifications of the respondents revealed that a substantial portion of STEM teachers (75%) were graduates, while (25%) had postgraduate qualifications.

Research Question and Item-wise Analysis

The development of items of tools stemmed from four Research questions. An analysis of these research questions is presented below.

Research Question No.1: Does STEM-focused professional development impact teachers' comprehension of STEM education principles and practices?

Items No.1, 2, 3, and 4 were designed to address Research Question 1.

Table 2: Professional development training in STEM education enhances your understanding of STEM education.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	1	1.0	1.0	5.0
	Agree	54	54.0	54.0	59.0
	Strongly agree	41	41.0	41.0	100.0
	Total	100	100.0	100.0	

Table 2 reveals the findings of Item 1"Professional Development Training in STEM Education enhances your understanding of STEM Education", (3%) of the participants responded " Strongly disagree",(1%) responded "Disagree"(1%) responded "Neutral", and (54%) majority of participants responded "Agree" suggesting that professional development training affects their understanding of STEM education positively, and (41%) responded "Strongly Agree" which indicates that they believe that STEM-focused professional development training has significantly enhanced their understanding of STEM education.

Table 3: Do You Feel Confident in Your Understanding of STEM Education Principles?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	8	8.0	8.0	12.0

	Agree	56	56.0	56.0	68.0
	Strongly agree	32	32.0	32.0	100.0
	Total	100	100.0	100.0	

Table 3 reveals the results of Item 2 "Do You Feel Confident in Your Understanding of STEM Education Principles?", (3%) of the participants responded " Strongly disagree", (1%) responded "Disagree"(8%) responded "Neutral", while (56%) majority of the participants responded "Agree", and (32%) of the participants responded "Strongly Agree", which indicates that they possess a high level of confidence in their understanding of STEM education principles.

Table 4: Receiving Feedback from Students Indicates a Positive Impact on Your STEM Teaching Methods

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.0	2.0	2.0
	Disagree	2	2.0	2.0	4.0
	Neutral	2	2.0	2.0	6.0
	Agree	56	56.0	56.0	62.0
	Strongly agree	38	38.0	38.0	100.0
	Total	100	100.0	100.0	

Table 4 reveals the results of Item 3"Receiving Feedback from Students Indicates a Positive Impact on Your STEM Teaching Methods", (2%) of the participants responded " Strongly disagree",(2%) responded "Disagree"(2%) responded "Neutral", while (56%) majority of participants responded "Agree", indicating that receiving feedback from students has a positive impact on their STEM teaching methods, while a significant portion of the participants i.e. (38%), responded "Strongly Agree" which suggest that receiving student feedback has a significant positive influence on their STEM teaching methods.

Table 5: Regular Collaboration with Other Educators Enhances Your Understanding of STEM Education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.0	2.0	2.0
	Disagree	2	2.0	2.0	4.0
	Neutral	14	14.0	14.0	18.0
	Agree	44	44.0	44.0	62.0
	Strongly agree	38	38.0	38.0	100.0
	Total	100	100.0	100.0	

Table 5 reveals the results of Item 4 "Regular Collaboration with Other Educators Enhances Your Understanding of STEM Education", (2%) of the participants responded " Strongly disagree",(2%) responded "Disagree", (14%) responded "Neutral", while (44%) participants responded "Agreed" with the statement, that regular collaboration with peers has positively impacted their understanding of STEM education, while (38%) responded "Strongly Agree", which suggest that they had found regular collaboration with other STEM teachers was beneficial for their understanding of STEM education.

Research Question No.2: Does a STEM-focused teachers' professional development program improve teaching skills?

Items No.5, 6, 7, and 8 were designed to address Research Question 2.

Table 6: STEM professional development is essential for educators.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	1	1.0	1.0	5.0
	Agree	60	60.0	60.0	65.0
	Strongly agree	35	35.0	35.0	100.0
	Total	100	100.0	100.0	

Table 6 reveals the results of Item 5 "STEM professional development is essential for educators", (3%) of the participants responded " Strongly disagree",(1%) responded "Disagree"(1%) responded "Neutral", (60%) of the participants responded "Agree" with the importance of professional development training programs, while (35%) responded "Strongly agree", which indicates a strong consensus in favor of Professional Development in STEM education.

Table 7: STEM-related training opportunities enhance your teaching skills.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.0	2.0	2.0
	Disagree	2	2.0	2.0	4.0
	Neutral	2	2.0		
	Agree	58	58.0	58.0	62.0
	Strongly agree	38	38.0	38.0	100.0
	Total	100	100.0	100.0	

Table 7 reveals the results of Item 6 "STEM-related training opportunities enhance your teaching skills", (2%) of the participants responded " Strongly disagree",(2%) responded "Disagree", (2%) responded "Neutral", while (58%) of the participants responded "Agree", and (38%) of the participants responded "Strongly agree" which suggests that STEM-related training opportunities enhance their teaching skills.

Table 8: Effective STEM teacher training programs incorporate assessment techniques that measure both student and teacher performance.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	14	14.0	14.0	18.0
	Agree	55	55.0	55.0	73.0
	Strongly agree	27	27.0	27.0	100.0
	Total	100	100.0	100.0	

Table 8 reveals the results of Item 7 "Effective STEM teacher training programs incorporate assessment techniques that measure both student and teacher performance", (3%) of the participants responded "Strongly disagree",(1%) responded "Disagree"(14%) responded "Neutral", (55%) of the participants responded "Agree", while (27%) responded "Strongly agree" which suggests that effective STEM teacher training programs incorporate assessment techniques that measure both student and teacher performance.

Table 9: The STEM education professional development program focuses on integrating real-world applications and industry-relevant skills into the curriculum.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	6	6.0	6.0	10.0
	Agree	40	40.0	40.0	50.0
	Strongly agree	50	50.0	50.0	100.0
	Total	100	100.0	100.0	

Table 9 reveals the results of Item 8 "The STEM education Professional Development program focuses on integrating real-world applications and industry-relevant skills into the curriculum", (3%) of the participants responded " Strongly disagree",(1%) responded "Disagree"(6%) responded "Neutral", (50%) of the participants responded "Strongly agree", while (40%) of the participants responded "Agree", which indicates that they have a positive perspective about the Professional Development program effectively integrates real-world applications and industry-relevant skills into the curriculum.

Research Question No.3: How do teachers' Professional Development programs focus on STEM education impact the quality of STEM instruction?

Items No. 9, 10, 11, and 12 were designed to address Research Question 3.

Table 10: Professional development in STEM education enhances teachers' knowledge of the latest advancements and trends in STEM fields.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	4.0	4.0	4.0
	Disagree	2	2.0	2.0	6.0
	Neutral	5	5.0	5.0	11.0
	Agree	49	49.0	49.0	60.0
	Strongly agree	40	40.0	40.0	100.0
	Total	100	100.0	100.0	

Table 10 reveals the results of Item 9 "Professional development in STEM education enhances teachers' knowledge of the latest advancements and trends in STEM fields", (4%) of the participants responded " Strongly disagree",(2%) responded "Disagree"(5%) responded "Neutral", (49%) of participants responded "Agree", while (40%) responded "Strongly agree", which suggests that Professional Development programs in STEM education enhance their knowledge of the latest advancements and trends in STEM fields.

Table 11: Professional development in STEM education equips teachers with effective strategies to address the diverse learning needs of students in STEM classrooms.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	8	8.0	8.0	11.0
	Neutral	9	9.0	9.0	20.0
	Agree	46	46.0	46.0	66.0
	Strongly agree	34	34.0	34.0	100.0
	Total	100	100.0	100.0	

Table 11 reveals the results of Item 10 "Professional Development in STEM education equips teachers with effective strategies to address the diverse learning needs of students in STEM classrooms", (3%) of the

participants responded“ Strongly disagree”,(8%) responded “Disagree”(9%) responded “Neutral”, while a substantial portion i.e. (46%) responded “Agree”, and (34%) responded “Strongly agree” The findings reveal that most STEM teachers have a positive perception regarding the effectiveness of Professional Development in STEM education as these programs address the diverse learning needs of students in STEM classrooms.

Table 12: Participation in professional development in STEM education improved student performance in STEM subjects.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	14	14.0	14.0	18.0
	Agree	48	48.0	48.0	66.0
	Strongly agree	34	34.0	34.0	100.0
	Total	100	100.0	100.0	

Table 12 reveals the results of Item 11 “Participation in professional development in STEM education improved student performance in STEM subjects”, (3%) of the participants responded “ Strongly disagree”,(1%) responded “Disagree”(14%) responded “Neutral”, while a substantial portion i.e. (48%) responded “Agree”, and (34%) responded “Strongly agree” which suggests that STEM teachers had a positive view that professional development programs have a positive impact on their ability to enhance student performance in STEM subjects.

Table 13: STEM professional development positively impacted the overall quality of STEM education at your school.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	17	17.0	17.0	21.0
	Agree	34	34.0	34.0	55.0
	Strongly agree	45	45.0	45.0	100.0
	Total	100	100.0	100.0	

Table 13 reveals the results of Item 12 “STEM professional development positively impacted the overall quality of STEM education at your school”, (3%) of the participants responded “ Strongly disagree”,(1%) responded “Disagree”(17%) responded “Neutral”, while (34%) of participants responded “Agree”, and (45%) responded “Strongly agree”, which indicates that majority of the STEM teachers had a positive perception that participating in Professional development has improved the quality of education in their school.

Research Question No.4: Do STEM-focused teachers’ Professional Development programs prepare teachers for future trends and emerging technologies?

Items No. 13, 14, 15, and 16 were designed to address Research Question 4.

Table 14: Do you actively seek information about the latest developments in STEM teaching methods and technologies?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	4.0	4.0	4.0
	Disagree	2	2.0	2.0	6.0
	Neutral	11	11.0	11.0	17.0
	Agree	55	55.0	55.0	72.0
	Strongly agree	28	28.0	28.0	100.0
	Total	100	100.0	100.0	

Table 14 reveals the results of Item 13 “Do you actively seek information about the latest developments in STEM teaching methods and technologies?”, (4%) of the participants responded “Strongly disagree”, (2%) responded “Disagree” and (11%) responded “Neutral”. In comparison (55%) of participants responded “Agree”, and (28%) responded “Strongly agree”, which suggests that STEM teachers are strongly committed to staying informed about the latest developments in STEM education.

Table 15: Do you agree that staying updated on future trends in STEM education is important for your professional growth?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	9	9.0	9.0	13.0
	Agree	39	39.0	39.0	52.0
	Strongly agree	48	48.0	48.0	100.0
	Total	100	100.0	100.0	

Table 15 reveals the results of Item 14 “Do you agree that staying updated on future trends in STEM education is important for your professional growth?”, (3%) of the participants responded “ Strongly disagree”,(1%) responded “Disagree”(9%) responded “Neutral”, while, (39%) of participants responded

"Agree", and (48%) responded "Strongly agree", which suggests that the majority of the STEM teachers know the significance of staying updated with future trends in STEM education for their professional development.

Table 16: Do you agree that there is a direct connection between addressing future trends and challenges in STEM education and improving student outcomes?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	16	16.0	16.0	20.0
	Agree	35	35.0	35.0	55.0
	Strongly agree	45	45.0	45.0	100.0
	Total	100	100.0	100.0	

Table 16 reveals the results of Item 15 "Do you agree that there is a direct connection between addressing future trends and challenges in STEM education and improving student outcomes?", (3%) of the participants responded " Strongly disagree",(1%) responded "Disagree"(16%) responded "Neutral, while (35%) responded "Agree", and (45%) responded "Strongly agree", which indicates that STEM teachers have a strong consensus about the direct relationship between addressing future trends and challenges in STEM education and the improvement of student outcomes.

Table 17: Do you feel prepared to adapt to changes and seize opportunities in the evolving landscape of STEM education?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	3.0	3.0	3.0
	Disagree	1	1.0	1.0	4.0
	Neutral	20	20.0	20.0	24.0
	Agree	38	38.0	38.0	62.0
	Strongly agree	38	38.0	38.0	100.0
	Total	100	100.0	100.0	

Table 17 reveals the results of Item 16 "Do you feel prepared to adapt to changes and seize opportunities in the evolving landscape of STEM education?", (3%) of the participants responded " Strongly disagree",(1%) responded "Disagree"(20%) responded "Neutral", while (38%) responded "Agree", and (38%) responded "Strongly agree", which suggests that STEM teachers have shown a willingness to adapt to changes and seize opportunities in the evolving landscape of STEM.

Discussion

The present study highlighted the results of the impact of STEM-focused Teachers' Professional Development training on teachers' comprehension of STEM education principles and practices. The findings have shown that professional development programs have impacted positively as they enhance their understanding, proficiency, and principles of STEM education consequently improving their teaching practices. Additionally, effectiveness in STEM education has significantly improved through collaboration with peers and the feedback mechanism enhances their teaching methods. The findings emphasize that STEM professional development is essential for STEM instructors as it is not only important for their professional growth but also improves their teaching practices. Furthermore, the results highlighted that trained STEM teachers can integrate real-world applications and industry-relevant skills into their curriculum proficiently and how to measure the performance of both students and teachers through assessment techniques. The findings recommend that STEM-focused professional development training has improved the quality of education as these training programs equip STEM teachers with effective strategies to address diverse learning needs, contribute to improving the performance of the students, and elevate the quality of STEM education at schools. However, the results also indicate that STEM-focused trained teachers are aware of future trends and emerging technologies and they are actively engaged in seeking information about the latest advancements in technologies and teaching practices. Moreover, the findings further suggest that STEM teachers know the importance of staying updated on future trends and believe in the direct connection between addressing these trends and improving student outcomes, and they are also prepared to adapt to changes and seize opportunities in the evolving landscape of STEM education. These findings highlight the proactive and forward-thinking approach of educators in STEM fields, which is essential for their continued professional growth and for maintaining the quality and relevance of STEM education.

Conclusion

The analysis leads to the subsequent conclusion that Teachers' Professional Development in STEM education has a positive impact on STEM teachers. It is evident from the findings of this study that STEM-focused Professional development has enhanced their understanding of STEM Education which is crucial for teaching practices, and highlighted the importance of a collaborative and supportive learning environment and their commitment to continuous professional growth. STEM teachers recognize that there is a direct connection between addressing future trends and challenges in STEM education and improving student learning outcomes. Additionally, findings suggest that STEM teachers are prepared to adapt to changes and seize opportunities in the evolving landscape of STEM education. In a nutshell, the findings of the study emphasize the importance of ongoing Professional Development training programs as the key driver for

the enhancement of STEM education and are ultimately beneficial for the students. This study provides valuable insights for policymakers, educational institutions, educationists, and teachers to follow the path of the provision of Professional Development in STEM education. This will prove to be a base foundation for the future workforce.

Recommendations

The following are the recommendations that policymakers and academia can consider for implementing STEM-based education processes:

1. Teachers need ongoing STEM-focused professional development training programs to stay up-to-date with the latest advancements as the STEM field constantly evolves with new technologies and methodologies.

2. STEM education works as a dual-mode change system where on one hand it guides the teachers to not only facilitate but also promote critical thinking, problem-solving, and applying collaboration skills among the students. Whereas, for students, it provides guidelines to explore the real-world solutions to real-world problems.

3. Using STEM Education and its disciplines, teachers can integrate technology into their current educational and training practices. Whether this is the use of digital tools, software solutions, or anything that can step up the learning process about technology, STEM education helps enable students to engage themselves with analysis, data, simulations, and even software programming.

4. No one student can be compared to another in terms of their learning styles, their learning abilities, and what interests them as career and professional growth. The teachers require an in-depth instruction-based system to use STEM subjects to cater to student needs and access to education.

5. STEM represents all sorts of learners with the introduction of diverse and context-based learning for any sort of student, belonging to any culture or demographic background. The teachers and educationists need to learn the proper strategies to promote this while being part of the STEM education system

6. If we perceive students and educationists as a community, then STEM provides a community with opportunities for career development and creating growth for students and teachers alike.

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