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ORIGINAL RESEARCH

STEM awareness among pre-service teachers

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Abstract
STEM stands for Science, Technology, Engineering, and Mathematics. STEM education has gained global attention for fostering interdisciplinary thinking and 21st-century skills. To effectively leverage STEM's potential in education, it is important to determine the level of STEM awareness among pre-service teachers. So that we can know their readiness towards adopting STEM practices in their Teaching-learning practices. This study aimed to assess STEM awareness among pre-service teachers and to examine differences by gender, year of study, programme, and locality. A descriptive survey design was employed, using convenience sampling, with a sample of 168 pre-service teachers from a central university in India. Data were collected using the standardized STEM Awareness Scale (Buyruk and Korkmaz, 2016). Descriptive statistics and independent samples t-tests were used for analysis. The findings revealed a high level of STEM awareness among participants. Significant differences were observed by gender and locality, but none by year of study or programme. The results indicate the need for structured STEM training in teacher education programs to enhance effective classroom implementation. The study contributes to the limited empirical literature on STEM awareness in the Indian teacher education context and provides direction for curriculum planning and STEM-oriented professional development programs.

Keywords: STEM Awareness · Pre-service Teachers · Teacher Education

INTRODUCTION

STEM Education integrates the various disciplines into a single field and helps students apply the lessons learned to real-world situations (Yang & Oh, 2024). Various countries are promoting STEM education to make their citizens understand STEM and its interdisciplinary approach. STEM has holistic profiles needed for the digital age (Pimthong & Williams, 2020). Countries compete and succeed alongside their counterparts through STEM education (Lacey & Wright, 2009). In this technological Era, there is consensus among educational policies that they must inculcate 21st-century skills among learners to compete in the global economy. 21st-century skills, including learning and innovation skills such as creativity, critical thinking, communication, and collaboration, as well as ICT skills like research, media literacy, and technological proficiency; and life and career skills, including adaptability, self-direction, cross-cultural understanding, productivity, and leadership (Larson & Miller 2011). For developing the above skills, the Multidisciplinary integrated STEM approach is suitable (Abdioglu et al., 2021). Because STEM not only teaches subject knowledge, it also encompasses the skills needed for holistic student development.

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The common reasons for introducing STEM in the curriculum are that most students showed little or no interest in Science and technology, scored low marks in national and global science and mathematics tests, and that it is intended to increase the number of STEM graduates. However, the literature shows that students' STEM learning experiences positively affect their interest in pursuing scientific and technological fields in higher education. (Chachashvili-Bolotin et al., 2016) To develop STEM Education and its literacy among the students, teachers play a vital role. There is a need to invest in STEM education to inculcate STEM literacy (Oner et al., 2016). STEM awareness refers to pre-service teachers' understanding of the nature, goals, interdisciplinary structure, and educational relevance of STEM education. Teachers from pre-primary to university must understand the nature of STEM, how the different disciplines (Science, Technology, Engineering, and Mathematics) are integrated, and how to teach this to students in a seamless way that supports their learning (Abdioglu et al. 2021).

For practical STEM Teaching, teachers should receive training in STEM Education, both in pre-service and in-service Settings. However, the studies revealed confusion among pre-service teachers in understanding STEM. By understanding their level of awareness and perceptions towards STEM, we can develop a STEM curriculum tailored to their needs and knowledge level (Pimthong & Williams 2020). So, it's necessary to study pre-service teachers' awareness of STEM for further implementation. The institution is responsible for training pre-service teachers with the skills necessary to effectively support 21st-century students (Tekerek & Karakaya 2018). A person with STEM awareness can understand STEM and its related concepts and perform logical deductions (Gürbüz & Karadeniz 2020).

In STEM education, numerous models and frameworks have been proposed to facilitate seamless integration. Here, "The 6E Learning by DeSIGN Model" is an extended version of the 5E instructional model. It has a sequential lesson structure with the components of Engage, Explore, Explain, Engineer, Enrich, and Evaluate. It is adopted by the BSCS (Biological Sciences Curriculum Study) 5E model (Bybee et al. 2006). It explains the design processes and the principles of scientific inquiry. STEM activities can be tailored to students' ages, needs, and interests (Petrovski 2023), making the learning approach more inclusive and holistic. The STEM education framework integrates disciplines in a cohesive manner, encompassing Science, technology, and mathematics within the engineering process. For the functional application, students should understand the concept of "need to know" and be able to build or test it. STEM Education stimulates inquiry and exploration by providing activities and building designs for students (Yata et al., 2020) In another study, teachers designed STEM activities, resulting in high STEM awareness and improved problem-solving skills (Baş & Büyükbayraktar 2024)

Need and significance of the study

As part of the research journey, the researchers planned to design and implement a STEM Orientation Programme for pre-service teachers. Before that, we need to know their levels of STEM awareness and understanding. So that we can customize the programme based on their awareness levels, STEM Education and its related studies are popular worldwide. However, in the Indian context, there are a limited number of studies in reputable journals that Soley studied on STEM Awareness. Some studies examine STEM Awareness among both pre- and in-service

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teachers, and one study found that teachers integrated IKS (Indian Knowledge System) into STEM Education awareness (Joshi & Bansal 2023). However, we need more studies to better understand pre-service teachers' STEM awareness and to develop a multidisciplinary approach in the Indian context. Due to the Indian education system's retrospective approach, which highly emphasizes traditional rote learning, it needs to adopt a more creative, inquiry-based STEM approach (Ratnam 2023). Despite growing policy emphasis on STEM education in India, empirical evidence on pre-service teachers' STEM awareness remains limited. Therefore, research is needed to assess pre-service teachers' STEM awareness for further development.

Review of Related Literature

This part of the study specifically addresses previous STEM awareness-related studies conducted worldwide and at the national level. This will add depth to the reasons why we need this study in the Indian context of teacher education. Tekerek and Karakaya (2018) focused on exploring the pre-service teachers' (N = 148) STEM awareness using the standardized SAS scale developed by Buyruk and Korkmaz (2016) in Turkey. Their findings revealed no differences in awareness scores based on students' gender, parents' income, or achievement scores. etc., they show differences by grade level. Tao (2019) examined kindergarten teachers' confidence in incorporating early childhood STEM education into their teaching. Although they had a positive attitude towards STEM teaching and learning, they didn't show confidence in its implementation. It explains the need for more intensive training, including hands-on practices, for teachers.

Aldahmash et al (2019) conducted a pre-test-post-test one-group design to assess the attitudes of science and mathematics teachers towards STEM teaching following a 6-day professional development program in Saudi Arabia. After the intervention, the teachers had improved self-efficacy and changes in their perceptions of STEM integration. Similarly, the study by Baran et al (2019) investigated the impact of the out-of-school STEM education program on students' attitudes towards STEM-based learning in Turkey. The study found significant differences in their understanding of STEM and its real-world applications, as well as in the design processes implemented after the programme. A study on Attitude towards STEM and 21st-century skills among 130 elementary school students in Indonesia. Their findings showed a moderate level of attitude of students towards STEM and 21st-century skills (Altakahyneh & Abumusa 2020). Zhao et al. (2022) conducted an Exploratory study (174 high school students in Indonesia) that examined factors contributing significantly to learning satisfaction in STEM education using structural equation modelling.

The findings revealed that factors such as playfulness, positive attitude, and perceived social norms play a vital role in learning satisfaction. Agoro & Adeboye (2023) studied the awareness and attitudes of 400 pre-service teachers towards STEM in colleges of Education in Nigeria. Their findings revealed a high level of understanding and a highly positive attitude towards adapting STEM education. Martynenko et al (2023) conducted a mini-literature review regarding STEM attitude studies in electronic databases. In this, studies illustrated investigate students' attitudes towards STEM using the STEM Attitudes Scale, a questionnaire for the STEM approach (Thibaut et al. 2019; TiMur et al. 2020; Sisman et al., 2021; Altakahyneh & Abumusa, 2020). It shows the significance of Students' and teachers' attitudes towards STEM in the effective teaching and learning process. Durmaz and Çelik Keser (2024) conducted one

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group pre-test-post experimental research among pre-service teachers. The results revealed that the participants not only demonstrated high awareness of STEM education but also understood the complexities of integrating STEM into real-world classroom settings and of its applications. The findings from Karisan et al. (2019) revealed that the STEM-based science methods course (12 weeks in duration) increased the pre-service teachers' awareness of STEM and inspired them to use STEM Teaching during their practice. It also aligns with studies by Gibson (2012), Ring et al. (2017) and Hacıömeroğlu (2018). Moreover, Nadelson et al. (2013) found that the three-day summer institute program develops teachers' awareness and self-efficacy towards the engineering design process and technology. Through lesson planning and designing, the teachers gained STEM awareness and confidence to create STEM activities (Kim & Bolger 2017)

Previous studies have examined STEM awareness, attitudes, and confidence among teachers and students in many international contexts. These studies demonstrate that structured training programs and hands-on STEM experiences can enhance awareness and understanding of STEM education. However, studies focusing specifically on STEM awareness among pre-service teachers in the Indian teacher education context are limited. Therefore, the present study is necessary to understand their awareness levels and to support curriculum planning and STEM-oriented programs in India.

Research Questions

RQ1: What is the level of STEM awareness among pre-service teachers?
RQ2: Does STEM awareness differ among pre-service teachers based on gender?
RQ3: Does STEM awareness differ based on year of study?
RQ4: Does STEM awareness differ based on programme of study?
RQ5: Does STEM awareness differ based on locality?

METHODOLOGY

This study applied a Descriptive survey design to assess the level of STEM awareness among Pre-service teachers. The survey method in research involves collecting responses used as information, gathered from questions asked of participants as individuals (Check and Schutt 2011). Additionally, it examined the factors influencing their Awareness level based on demographic variables, including gender, Programme, Year of study, and locality. This study employed a convenience sampling technique to select the sample from the population. The population of this study is students enrolled in the Teacher Education Institution. The sample for this study consists of 168 students from the B.Ed. and B.Sc.B.Ed., programs at a central university in India. Descriptive statistics such as Mean, Standard Deviation, frequency, and Percentage were used to summarize the data. Inferential statistics (an Independent t-test) were employed to examine differences in pre-service teachers' responses based on the demographic variable.

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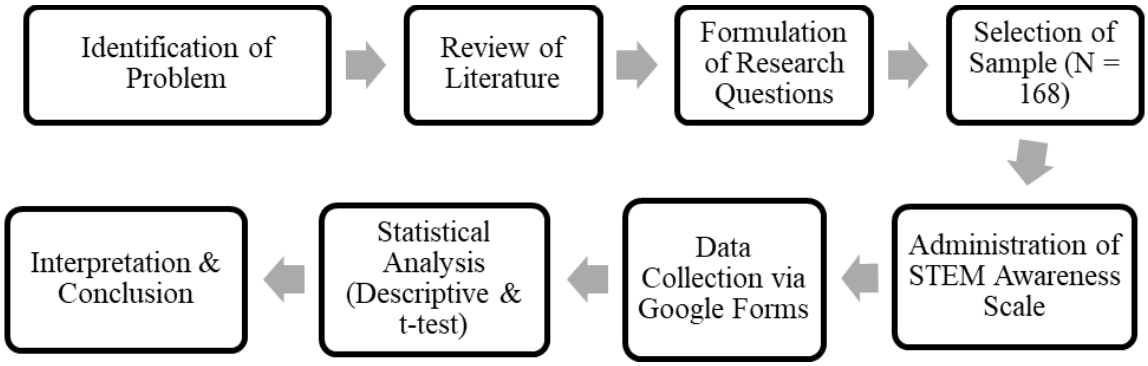

Figure 1. The authors created this Research Procedure flowchart using Microsoft PowerPoint

Tool description

The STEM Awareness scale, developed by Buyruk and Korkmaz (2016), was adopted for this study. This standardized Scale (5-point Likert scale varies from 1-5, such as Strongly Disagree to Strongly Agree. The data were collected using an online survey design in Google Forms and sent via the WhatsApp application adapted from Cohen et al (2007). The authors contacted the original developers of this Standardized Scale and obtained permission to use it for further study. They translated the Original Turkish version of the STEM Awareness Scale into the English version. The translated English version of the Scale underwent expert validation. The original Scale has a Cronbach's alpha value of 0.927. Higher Mean scores indicate greater STEM awareness.

Data Analysis

Prior to analysis, the collected responses were screened to ensure completeness and accuracy. Incomplete responses were excluded from the dataset, leaving 168 valid responses for the final analysis. The data were coded and entered into the Statistical Package for the Social Sciences (SPSS) software for analysis. Descriptive statistics, including mean, standard deviation, frequency, and percentage, were used to summarize the level of STEM awareness among pre-service teachers. To examine differences in STEM awareness by gender, programme, year of study, and locality, independent-samples t-tests were conducted. A significance level of $p < .05$ was used to determine statistical significance.

Table 1 Demographic Variable distribution

Variable	Category	n	%
Gender	Male	46	27.4
	Female	122	72.6
Year of study	First year	80	47.6
	Final year	88	52.4
Programme	B.Ed.	33	19.6
	B.Sc., B.Ed.	135	80.4
Locality	Rural	38	22.6
	Urban	130	77.4

Note. Percentages are based on the total sample (N = 168).

Table 1 presents the demographic profile of the study participants. A total of 168 pre-service teachers from B.Ed. and B.Sc. B.Ed. programmes participated in the survey. The sample was predominantly female (72.6%), with male participants accounting for 27.4%. In terms of

locality, the majority of participants were from urban areas (77.4%), whereas 22.6% were from rural areas. The distribution of respondents across different programmes and years of study provides a representative overview of the pre-service teachers enrolled in the teacher education institution selected for the study.

***RQ1**: What is the level of STEM awareness among pre-service teachers?*

Table 2. STEM Awareness Level of Pre-service Teachers

Variable	N	M	SD
STEM Awareness	168	70.5	6.0

The overall STEM awareness score among pre-service teachers was high (M = 70.5, SD = 6.0, N = 168).

***RQ2:** Does STEM awareness differ among pre-service teachers based on gender?*

Table 3 STEM Awareness Scores of Pre-service Teachers Based on Gender

Gender	N	M	SD
Male	46	68.2	6.4
Female	122	71.4	5.8

Note. $t(166) = 3.20$, p = .002. Cohen's d =0.53

An independent-samples t test indicated a significant difference in STEM awareness between male and female pre-service teachers, $t(166) = 3.20$, $p = .002$, d = 0.53, indicating a moderately strong effect of Gender on STEM awareness. Female pre-service teachers demonstrated significantly higher STEM awareness than male pre-service teachers.

***RQ3:** Does STEM awareness differ based on year of study?*

Table 4. STEM Awareness Scores of Pre-service Teachers Based on year of study

Year of Study	N	M	SD
First Year	80	69.8	6.2
Final Year	88	71.1	5.8

Note. $t(166) = 1.38$, p = .17, Cohen's d = 0.22

There was no significant difference in STEM awareness between first-year and final-year students, $t(166) = 1.38$, p = .17, d = 0.22, indicating a small effect of year of study on STEM awareness.

***RQ4**: Does STEM awareness differ based on programme of study?*

Table 5 Comparison of B.Ed., and B.Sc., B.Ed., STEM Awareness Scores of Pre-service Teachers Based on their programme

Programme	N	M	SD
B.Ed.	33	71.2	6.0
B.Sc., B.Ed.	135	70.3	6.0

Note. $t(166) = 0.78$, p = .44. Cohen's d = 0.15

No significant difference in STEM awareness was found between B.Ed. and B.Sc.,B.Ed. students, $t(166) = 0.78$, $p = .44$. d = 0.15, indicating a very small effect of the Programme on STEM awareness.

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RQ5: *Does STEM awareness differ based on locality?*

Table 6. STEM Awareness Scores of Pre-service Teachers Based on Their Locality

Locality	N	M	SD
Rural	38	68.7	6.4
Urban	130	71.2	5.8

Note. $t(166) = 2.35$, $p = .02$, Cohen's $d = 0.43$

A significant difference in STEM awareness was found between rural and urban pre-service teachers, $t(166) = 2.35$, $p = .02$, $d = 0.43$, indicating a moderate effect of locality on STEM awareness. Urban students demonstrated significantly higher STEM awareness than rural students.

Discussion

The pre-service teachers showed higher awareness of STEM. This finding was supported by other studies. It demonstrated the high awareness of pre-service teachers in STEM, as evidenced by studies such as Bakırcı and Karışan (2017) and Widiyatmoko et al. (2024). The heightened awareness of STEM among pre-service teachers can be attributed to various educational interventions and intrinsic motivations. Research indicates that participation in STEM-focused courses significantly enhances pre-service teachers' understanding and intentions to teach STEM subjects. This is evident from studies showing that after attending STEM methods courses, participants exhibited statistically significant increases in their awareness and teaching intentions (Karisan et al. 2019).

Furthermore, integrating STEM education practices has been shown to positively influence pre-service science teachers' awareness, underscoring the importance of interdisciplinary approaches in education (Durmaz and Çelik Keser 2024). Pre-service teachers generally express positive beliefs about STEM education, with High agreement on the benefits of STEM integration for developing 21st-century skills. However, some participants still exhibit negative perceptions, indicating a need for further education and support (Almarashdi et al. 2022).

Our findings reveal a significant difference in STEM awareness among pre-service teachers by gender. Female pre-service teachers demonstrated higher awareness than their male counterparts. It aligns with previous studies as well (Ergün 2019). In this study, there is no significant difference in STEM awareness scores among pre-service teachers based on year of study. In contrast to our result, some studies found that first-year students had lower awareness than seniors (Tekerek and Karakaya 2018; Ergün 2019). Previous studies have suggested that there is a need for more intensive STEM education programs to understand their integration strategies and pedagogical training in STEM, which will encourage pre-service teachers to incorporate STEM into their teaching (Pearson 2017).

Additionally, they may develop and integrate numerous new STEM education activities. The intervention with STEM-related programmes significantly influences the pre-service teachers' awareness of STEM (Karisan et al. 2019; Aldahmash et al. 2019).The programmes and activities needed for promoting STEM literacy among pre-service teachers. In this study, Urban students demonstrated significantly higher STEM awareness than rural students. It was aligning with the studies by Crain and Webber (2021) and (Septiyanto et al., 2024). It suggests more focus on rural areas for STEM Education development.STEM teaching differs from the

teaching of science, mathematics, technology, and engineering (Pimthong and Williams 2020). Students' learning outcomes and satisfaction are often linked to the teacher's competence, self-efficacy, and attitudes towards the content. Therefore, it is necessary to understand teachers' and students' attitudes towards STEM to design a course that suits them (Tao 2019; Ata & Çetin 2025).

Implications of the study

The implications of STEM awareness among pre-service teachers are significant, influencing their teaching efficacy, interdisciplinary understanding, and readiness to implement STEM education. Research indicates that enhanced awareness leads to greater confidence and a stronger intention to teach STEM subjects effectively. Participation in STEM-focused courses has been shown to significantly increase pre-service teachers' self-efficacy in teaching STEM subjects, as evidenced by improved scores in teaching efficacy belief instruments. The Increased awareness of STEM concepts correlates with a greater sense of competence in integrating these disciplines into their teaching practices (Akçakin & Cebesoy 2024). Pre-service teachers who engage in STEM activities develop a better grasp of the interconnectedness of science, technology, engineering, and mathematics, which is crucial for fostering a holistic educational approach (Durmaz & Keser 2024). Problem-based STEM implementations have been found to enhance pre-service teachers' perspectives on integrating STEM disciplines into the curriculum (Almarashdi et al. 2022).

Studies show that pre-service teachers' perceptions of their readiness to teach STEM are positively influenced by their experiences and training in STEM education (Karisan et al. 2019; (Hoon et al. 2022). High awareness and confidence in STEM practices can lead to more effective learning environments that foster 21st-century skills among students. Conversely, some pre-service teachers may still feel unprepared to implement STEM education effectively, highlighting the need for ongoing support and training in this area. This gap suggests that while awareness is crucial, practical experience and institutional support are equally important for the successful implementation of STEM education.

Limitations of the study

The study assessed Pre-service teachers' STEM awareness, accounting for their demographic variables and their influence on overall scores. It didn't address the implementation of STEM in real-world classroom settings. It didn't provide any intervention to increase participants' STEM awareness. It didn't capture their practical aspects, such as designing and modeling capabilities in STEM teaching and learning. It focused solely on using the Buyruk and Korkmaz (2016) standardized STEM Awareness Scale (SAS) to evaluate pre-service teachers' STEM awareness in the Indian context, so we can design STEM awareness programs for further development. It is suggested that further studies conduct a one-group pre-test-post-test experimental design with intervention programs to enhance STEM awareness among pre-service teachers in the Indian context.

CONCLUSION

The present study aimed to examine the level of STEM awareness among pre-service teachers and to determine whether differences exist based on gender, year of study, programme, and

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locality. The study's findings indicate that pre-service teachers generally demonstrate a high level of awareness of STEM education. This suggests that most participants recognize the importance of integrating science, technology, engineering, and mathematics into modern teaching and learning. However, the results also revealed that STEM awareness varied across certain demographic factors. Significant differences were observed by gender and locality, suggesting that background and learning experiences may influence how pre-service teachers perceive and understand STEM education. On the other hand, no significant differences were found between the year of study and programme, suggesting that STEM awareness among participants remains relatively consistent across different stages of teacher preparation within the institution. These findings highlight an important consideration for teacher education programmes. While the participants show encouraging levels of awareness about STEM education, awareness alone may not automatically translate into effective classroom practice. Teacher education institutions, therefore, have an important role in providing meaningful opportunities for pre-service teachers to engage with STEM-oriented teaching approaches, interdisciplinary learning activities, and practical classroom applications. From a broader perspective, this study contributes to the growing body of research on STEM education within teacher preparation contexts, particularly in the Indian educational setting, where empirical studies on STEM awareness are still emerging. Future research may further explore how STEM awareness influences teaching readiness and how teacher education programmes can better support the development of practical STEM teaching competencies among future educators.

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Ethical Consideration

Informed consent was obtained from all participants prior to data collection. Participation was voluntary, and confidentiality of responses was ensured.

Conflict of Interest

The authors declare no conflict of interest

Author Contribution

Prawnya V contributed to the conceptualization, methodology, data collection, formal analysis, and manuscript drafting. Kapilas P. and P. Rajasekaran contributed to the statistical review and editing. Narmada Devi G assisted in data curation and literature review. P.S. Sreedevi and Chun-Yen Chang provided supervision, validation, and critical revision of the manuscript. Also contributed to academic review and manuscript refinement. All authors have read and approved the final version of the manuscript.

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