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Investigating pre-service teachers' awareness on integrating computational thinking skills into classroom practices

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Abstract
Computational Thinking (CT) has become a vital 21st-century skill, expanding beyond computer science to disciplines such as mathematics, science, and social sciences. In science education, CT enhances scientific inquiry by improving data modeling, problem-solving, and analytical reasoning. Integrating CT into science education is essential at all educational levels to develop students' ability to think systematically and approach scientific problems effectively. Pre-service teachers play a crucial role in this integration, as their understanding and pedagogical skills in CT will shape how future generations engage with science. This study aims to assess pre-service teachers' awareness of CT integration in science education, exploring variations based on teacher education programs and gender. Using a descriptive survey method, data were collected from pre-service teachers enrolled in four-year integrated and two-year B.Ed. programs. A self-developed awareness tool was administered through Google Forms, providing insights into the current state of CT integration in teacher education. The study findings revealed that pre service teachers have awareness on integration of computational thinking skills in science education as high level, partially medium level, low level 5.6 %,70.5%,23.9% respectively. Additionally, there was no significant difference between the four year and two-year B.Ed. teacher programs and also there is no significant difference between male and female pre service teachers on awareness of integrating CT in science education. Though NEP 2020 emphasize on integration of CT across all the disciplines the study proved that pre service teachers have very less awareness. Thus, there is a need to focus on awareness of Integrating CT skills as it is 21st century skill for the benefit of the learners.

Keywords: Computational thinking, awareness, integration of CT, pre-service teachers

Introduction

Computational thinking has become as essential skill in the 21st century where every child need to acquire for problem-solving, extending beyond its roots in computer science to fields such as mathematics, science, and social sciences. CT enables individuals to break down complex problems, recognize patterns, develop algorithms, and apply logical reasoning to find solutions. In science education, CT supports scientific inquiry by fostering analytical thinking, data modeling, and simulation-based experimentation. As science becomes increasingly data-driven, integrating CT into science curricula is crucial for enhancing students' ability to analyze and interpret data, formulate hypotheses, and develop models. Recognizing its importance, several educational policies and frameworks advocate for embedding CT within science education to prepare students for a technology-driven world. The National Research Council and Next Generation Science Standards emphasize that CT should be a core component of science learning to develop critical and systematic thinking skills among students (National Research Council, 2012; NGSS, 2013; Weintrop *et al*., 2016) [17, 18, 22].

Despite the growing emphasis on CT, its successful integration into science education largely depends on teachers' understanding and ability to incorporate CT-based pedagogical practices. Pre-service teachers, in particular, play a crucial role in this transformation, as their preparedness and awareness of CT will shape how they design and implement science lessons. Research indicates that teachers with strong CT pedagogical knowledge can effectively integrate computational strategies such as data visualization, simulations, and modeling into science instruction (Grover & Pea, 2013; Yadav *et al*., 2014; Wang *et al*., 2018) [11, 21, 25]. However, a significant challenge remains in equipping pre-service teachers with the necessary CT competencies, as many teacher training programs still lack structured approaches to embedding CT in science education (Hurt *et al*., 2023; Ye *et al*., 2023) [13, 26]. Understanding pre-service teachers' awareness and preparedness in integrating CT into science classrooms is therefore critical to ensuring the effective adoption of computational strategies in teaching and learning.

The role of CT in science education has gained further recognition with the rise of interdisciplinary learning approaches that integrate STEM disciplines. Computational tools and methods are increasingly used in scientific research, emphasizing the need for future science educators to be proficient in CT-based instructional strategies (Weintrop *et al*., 2016; Association for Computing Machinery, 2016) [3, 22]. Studies suggest that students exposed to CT-enhanced science instruction show improved problem-solving abilities, critical thinking skills, and engagement in scientific practices (Astrachan *et al*., 2011; Guzdial, 2008; Groff & Bryant, 2019) [4, 5, 12]. However, without adequate awareness and training, pre-service teachers may struggle to implement these strategies effectively, leading to gaps in CT integration at the classroom level (Chen & diSessa, 2018; Wang *et al*., 2018) [9, 21].

In India, national education policies have also recognized the importance of CT in science education. The National Education Policy (NEP, 2020) highlights the need to

incorporate computational skills into school curricula to develop students' analytical and problem-solving abilities. This aligns with global efforts to prepare students for an increasingly digital world where scientific exploration often relies on computational techniques (Ministry of Education, 2020) [16]. However, there is limited research on the extent to which pre-service teachers in India are aware of and prepared to integrate CT into their teaching practices. Addressing this gap is essential for designing effective teacher education programs that equip future educators with the skills needed to foster computationally enriched science learning experiences (Sumarna *et al*., 2017; Wing, 2006; Weintrop *et al*., 2016) [20, 22, 23].

This study aims to investigate pre-service teachers' awareness of the integration of CT skills in science education. Specifically, it seeks to assess their level of awareness, compare awareness levels across different teacher education programs, and examine gender-based differences in CT awareness. A descriptive survey method was used to collect data from pre-service teachers enrolled in four-year integrated and two-year B.Ed. programs. By analyzing their perceptions and preparedness, this study contributes to understanding how teacher education programs can better integrate CT training to enhance science education. The findings will provide valuable insights into improving CT-based pedagogical strategies in teacher preparation programs, ensuring that future science educators are well-equipped to integrate computational thinking into their teaching practices (Astrachan *et al*., 2011; Guzdial, 2008; National Research Council, 2012; Yadav *et al*., 2014) [4, 5, 12, 17, 25].

1. The evaluation and significance of computational thinking

The term computational thinking (CT) was first introduced by Seymour Papert, an American computer scientist and mathematician, in the context of computer science. Papert is renowned for creating child-friendly learning activities through computer programming languages. The term CT appeared in his book Mindstorms (1980, p. 182) without extensive explanation. However, in 1996, Papert elaborated on computational thinking in his paper An Exploration in the Space of Mathematics and Science Education. He emphasized that CT is essential for developing mathematical ideas through operations, representations, and structured thinking. He illustrated this concept using Turtle Geometry and Logo Programming (Ramanujam, 2022).

Despite its early introduction, computational thinking did not gain widespread recognition in education for several decades. The shift occurred when Jeannette Wing brought CT into mainstream discussion through her 2006 article in the Communications of the Association for Computing Machinery (Wing, 2006) [23]. Wing (2006, 2008) [23] described computational thinking as a fundamental skill for everyone, not just computer scientists. She characterized it as a "set of attitudes and skills" that anyone can learn, encompassing problem-solving, system design, and understanding human behavior through core concepts of computer science.

Although computational thinking is rooted in computer science, its applicability extends far beyond. Researchers have explored its relevance in life sciences (Arık & Topçu, 2022) [1], music (Bell & Bell, 2018) [7], science and mathematics (Weintrop *et al*., 2016; Benakli *et al*., 2017) [8, 22], robotics (Jaipal Amani & Angeli, 2017; Yi Wu & Sheng Su, 2021) [14], and even interdisciplinary fields combining sciences and arts (Lin *et al*., 2020) [15]. This expansion highlights the versatility of computational thinking in various domains (Subramaniam *et al*., 2022). Papert (1996) also noted that while computers serve as valuable tools for problem-solving, the computational representation of concepts across disciplines enhances clarity, creativity, and innovation, ultimately refining children's cognitive development. Computational thinking involves a broad spectrum of cognitive skills, including problem decomposition, abstraction, pattern recognition, algorithmic thinking, iterative reasoning, transformation, error prevention, and intuitive reasoning. These skills are crucial for problem-solving and align closely with mathematical thinking. Given its significance, computational thinking is increasingly recognized as an essential 21st-century skill, comparable to reading, writing, and mathematics (Liu *et al*., 2022). Many researchers and educators advocate for computational thinking as a mandatory skill that extends beyond computer science and should be mastered by all learners (So *et al*., 2020; Subramaniam *et al*., 2022).

2. Integration of CT in education

The integration of computational thinking (CT) into science education has gained significant momentum following the introduction of the Next Generation Science Standards (NGSS) and the National Research Council's (NGSS, 2012 & NRC, 2013) framework in the United States. These standards emphasize the importance of incorporating science, technology, engineering, and mathematics (STEM) practices such as formulating investigative questions, developing data-driven explanations, modeling phenomena, applying computational methods, and designing engineering solutions into educational curricula. Among these practices, computational thinking has received considerable attention and investment, reflecting its potential to enhance scientific inquiry and problem-solving skills (Astrachan *et al*., 2011; Guzdial, 2008; NRC, 2011a, b; Wilson *et al*., 2010) [4, 5, 12, 24]. This emphasis aligns with educators' recognition of CT's role in fostering deeper comprehension, improving problem-solving abilities, and enabling more creative applications across various disciplines.

Recent research underscores the multifaceted benefits of integrating CT into science education. For instance, a systematic review highlighted that embedding computational thinking within science classrooms not only enhances students' critical thinking but also promotes interdisciplinary learning by connecting computational skills with scientific concepts (Grover & Pea, 2013) [11]. Moreover, the development of frameworks, such as the Computational Thinking for Science (CT-S) framework, provides educators with structured approaches to effectively incorporate CT into science curricula, thereby enriching students' learning experiences and better preparing them for complex scientific endeavors (Weintrop *et al*., 2016) [22]. These advancements reflect a growing consensus on the value of CT in cultivating a more profound and integrated understanding of science among students.

3. Need and Significance of the study

Computational thinking also helps to improve problem solving skills and critical thinking skills and will help to solve scientific problems systematically and develop

creative solutions. Next Generation Science standards (NGSS) also emphasis on scientific practices (NGSS Lead States, 2013) [18]. Even National Education policy (NEP,2020) emphasis clearly recognizes the importance of integrating computational thinking skills into science education. By integrating CT across science education to prepare students with critical thinking, problem solving skills, data analysis.it also pointed out that there is need to encourage collaboration between educators, researcher and technology experts to develop innovative resources and strategies for effective CT integrating in science education. Even National Education policy (NEP, 2020) emphasis clearly recognizes the importance of integrating computational thinking skills into science education. By integrating CT across science education to prepare students with critical thinking, problem solving skills, data analysis.it also pointed out that there is need to encourage collaboration between educators, researcher and technology experts to develop innovative resources and strategies for effective CT integrating in science education. Based on recommendations of the national education policy (NEP, 2020) there is a need to explore and understand the current level of the awareness on integrating computational thinking skills in science education inters of general understanding about computational thinking and its core dimensions which helps different stake holders.

4. Statement of the Problem

Investigating Pre-Service Teachers' awareness on Integrating Computational Thinking skills into Classroom Practices.

5. Objectives

1. To determine the level of awareness of pre service teachers in integrating computational thinking skills in science education.
2. To compare the awareness level of pre service teachers in integrating computational thinking skills in science education with respect to different teacher education programme.
3. To compare the awareness level of pre service teachers in integrating computational thinking skills in science education with respect to gender.

6. Hypotheses

There is no significant difference between in the awareness level of re service teachers in integrating computational thinking skill in science education among four-year integrated courses and Two-year B.Ed. course.

1. There is no significant difference between in the awareness level of pre service teachers in integrating computational thinking skill in science education among Male and Female.

2. Methodology of the study

The study is conducted to identify the level of awareness of pre service teachers who are studying teacher education programme in integrating computational thinking skills in science education. In order to achieve the objective of the study the investigator adopted the descriptive survey method.

3. Sample

The sample of the study is all the student teachers studying pedagogy of mathematics in four-year and six-year teacher education programs are considered.

4. Delimitations of the study

The present study was delimited to the fourth-year integrated course of four-year and six-year and Two-year B.Ed. pre service teachers of the Regional Institute of Education - Mysore Karnataka India.

5. Tool and techniques, data collection

The investigator developed a tool titled "Awareness on Integration of Computational Thinking Skills." The tool comprises six dimensions: General Understanding of CT, the Four Dimensions of CT (Decomposition, Pattern Recognition, Abstraction, and Algorithmic Thinking), and Perception and Challenges Related to CT. It includes 30 items, with each dimension represented by 5 items. Each item carries one mark, and the scores reflect the degree of awareness within each respective dimension. Data were collected through a Google Form, then transferred to SPSS for analysis in line with the study's objectives and research hypotheses. Descriptive statistics, frequency distributions, and independent sample t-tests were employed for data analysis.

Results

Objective 1: To determine the level of awareness of pre service teachers in integrating computational thinking skills in science education.

In order to attain the first objective of the study namely" To determine the level of attainment of the pedagogical competencies in mathematics" A test was administered through google form to the 3rd and 4th year BSc. Ed, MSc. Ed and Two-year B.Ed. student teachers of RIE Mysuru and scores were recorded. The results are indicated in the following table:

Table 1: Descriptive statistics of pre serviced teachers' awareness of CT in science education

Statistic	Value
Mean	13.70
Median	14.00
Mode	17
Std. Deviation	4.128
Skewness	-.179
Kurtosis	-.775

The results from Table 1 indicate the mean, median, and mode values of the total score of student-teacher awareness level in integration of computational thinking skills in science education are 13.70, 14, and 17 respectively. The standard deviation value is 4.128 which shows that the total achievement scores are relatively packed within the distribution from the mean. The skewness value is - 0.179, which indicates a slightly negatively skewed distribution. The kurtosis value is -0.775, which indicates a slightly platykurtic distribution. That means it shows that pre service teachers not aware of the computational thinking skills though it is one of the major skills in the present century which help individual to develop their thought process and become a creative problem solver therefore, there is need to

focus on awareness of computational thinking skills in integration with science education in a comprehensive manner. Figure-1 represents the distribution of awareness level scores of student-teachers in integrating computational thinking skills in science education slightly away from the normal distribution. Hence most of the student teachers are not aware of how to integrate computational thinking skills in science education which need to focus on that as student teacher are the future teachers of the nation to provide quality education.

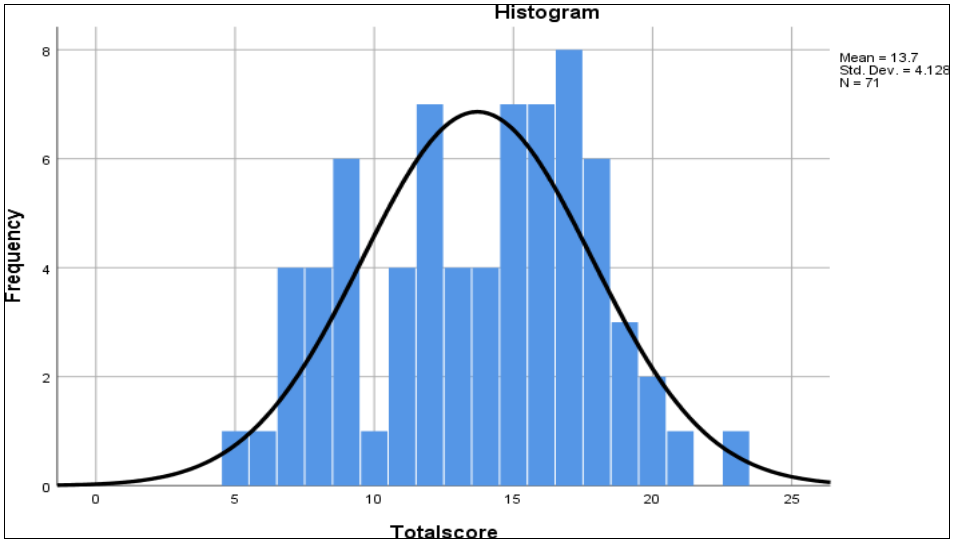

Fig 1: Descriptive statistics of awareness level on integration of computational thinking skills in science education

Table 2: Frequency and Percentage of awareness level of student-teacher in integrating computational thinking in science education

Awareness level	Frequency	Percentage (%)
High Level	04	5.6
Medium Level	50	70.5
Low Level	17	23.9

The results from the table 2 indicate that there are 71 participants in the sample. It is evident that only 5.6 % of the student teachers are have high level awareness in integrating computational thinking in science education which shows very less student teachers are aware than the mean value (13.70) while 70.5 % of the student teachers are partially have awareness in integrating computational thinking skills in science education. It shows that average attainment than the mean value and 23.9% of the student teachers are have very less awareness which indicates that they are not aware about computational thinking skills.

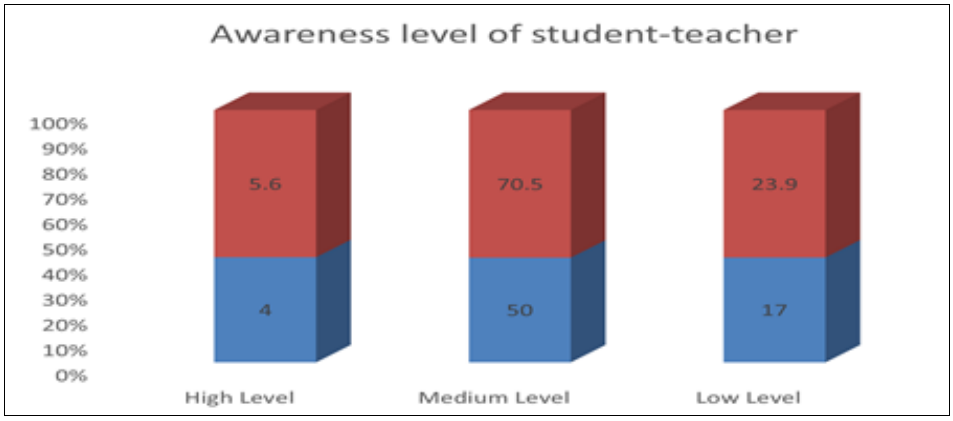

Fig 2: Awareness level of student-teacher in integrating CT In education

Objective 02: To compare the awareness level of pre service teachers in integrating computational thinking skills in science education with respect to different teacher education programme.

To find the whether there is a significant difference in the levels of awareness of student teachers' in integrating computational thinking skills in science education with respect to different teacher education programs. In order to achieve the second objective of the study namely "To compare the awareness level of pre service teachers in integrating computational thinking skills in science education with respect to different teacher education program" The following hypothesis is formulated for testing.

Hypothesis 01:

H0: There is no significant difference between in the awareness level of pre service teachers in integrating computational thinking skill in science education among BSc. Ed and Two-year B.Ed. course. The above hypothesis is tested by using t-test. The summary of the test result is given in Table3.

Table 3: Descriptive statistics- level of awareness of integrating CT skills in science education (Course)

Course Programme	N	Mean	Std. Deviation	t-Test
BSc. Ed	22	16.90	5.54	0.001^{ns}
B.Ed.	16	23.06	4.39	

The obtained value 0.001 is less than the table value of 1.96 at 0.05 level of significant. Therefore, the null hypothesis accepted, and it is concluded that there is no significant mean score difference between four-year course pre service teachers and two-year course pre service teachers in their awareness level of integrating computational thinking skills in science education. Thus, there is no evidence in this study to show that the various teacher education programs can cause a significant difference in their awareness in integrating computational thinking skills in science education.

Objective 03:

To compare the awareness level of pre service teachers in integrating computational thinking skills in science education with respect to gender.

To find the whether there is a significant difference in the levels of awareness of student teachers' in integrating computational thinking skills in science education with respect to ender. In order to achieve the third objective of the study namely "To compare the awareness level of pre service teachers in integrating computational thinking skills in science education with respect to gender" The following hypothesis is formulated for testing.

Hypothesis 02: There is no significant difference between in the awareness level of pre service teachers in integrating computational thinking skill in science education among Male and Female. The above hypothesis is tested by using t-test. The summary of the test result is given in Table 4.

Table 4: Level of awareness of integrating computational thinking skills in science education with respect to gender

Gender	N	Mean	Std. Deviation	t-Test
Male	25	20.22	5.09	0.327^{ns}
Female	46	18.79	6.16	

The obtained value 0.327 is less than the table value of 1.96 at 0.05 level of significant. Therefore, the null hypothesis accepted, and it is concluded that there is no significant mean score difference between male and female pre service teachers in their awareness level of integrating computational thinking skills in science education. Thus, there is no evidence in this study to show that male and female pre service teachers can cause a significant difference in their awareness in integrating computational thinking skills in science education.

Major Findings of the study

The major findings of the study were

- The overall observation of pre service teachers' awareness on integrating computational thinking skills in science education percentages obtained by the student teachers revealed that only 5.6 % of the student teachers have high level awareness,70.5% of the student teachers have partially awareness and 23.9% of the student teachers have low level awareness on integrating computational thinking skills in science education.
- The mean scores of the four-year course (BSc. Ed) is 16.90 which is less than the that of Two-year course (B.Ed.) is 23.06. Results indicate that two-year course student teachers have higher awareness of integrating computational thinking skills in science education than the Four-year integrated course. Thus, there are other factors causing to
- Increase the awareness level though they are getting training in similar college and similar training by equally qualified faculty.
- There is no significant mean score difference between four-year course pre service teachers and two-year course pre service teachers in their awareness level of integrating computational thinking skills in science education at 5% significance level.
- The mean scores of male pre service teachers are 20.22 which is higher than the that of female pre service teachers are 18.79. Results indicate that male student teachers have higher awareness of integrating computational thinking skills in science education than the Female pre service teachers. Thus, there are other factors causing to increase the awareness level though they are getting training in similar college and similar training by equally qualified faculty.
- There is no significant mean score difference between male pre service teachers and female pre service teachers in their awareness level of integrating computational thinking skills in science education at 5% significance level.

Discussions of the findings

There has been an increasing demand in research area in the present 21st century around the world about computational thinking particularly inculcating computational thinking skills such as decomposition, abstraction, identifying pattern recognition, creating algorithms across all the disciplines especially with STEM subjects which helps to enhance the ability to analyze data skills, build models and to investigate complex scientific concepts in more comprehended way (Yadav *et al*., 2014; NRC, 2012) [25]. Computational thinking also helps to improve problem solving skills and critical thinking skills and will help to solve scientific problems systematically and develop creative solutions. Next Generation Science standards (NGSS) also emphasis on scientific practices (NGSS, 2013) [18]. National Education policy (NEP, 2020) emphasis clearly recognizes the importance of integrating computational thinking skills into science education. By integrating CT across science education to prepare students with critical thinking, problem solving skills, data analysis.it also pointed out that there is need to encourage collaboration between educators, researcher and technology experts to develop innovative resources and strategies for effective CT integrating in science education. Therefore, the present study explores the level of awareness in integrating computational thinking skills in science education of pre service teachers of various teacher education programs. This study results reveled that most of the student teachers are partially have awareness on integration of computational thinking skills in science education and there is no significant difference between the four year and two year and boys and girls in terms of their awareness on computational thinking skills. This study also

supports the National educational policy 2020 recommendations where educators, teachers, technical experts have to work collaborate to inculcate, to foster, to develop computational thinking skills in science education.

Conclusion

Computational thinking skills are increasing demand in inculcating across various disciplines and making them essential skills in developing problem-solving skills, critical thinking skills etc. awareness on integrating CT in science education can help students to become a better student in demand of the present 21st century for work force. Exploring awareness on integration of computational thinking skills in science education will helps teachers and teacher educators to understand current level of the awareness of the computational thinking will play a major impact for the benefit of all stake holders such as pupils, teachers etc. National Educational policy (NEP, 2020) also, emphasize that the integration of computational thinking skills in science education though out several section and points. Such as at foundational stage introducing mathematical and computational thinking through various or multiples activities such as puzzles, games, coding, giving much focus on developing reasoning problems solving and data analysis skills which are relevant to science exploration. Especially at middle stage and secondary stage introducing coding activities to foster mathematical thinking and algorithmic thinking, solve real world problems and inculcating with multiples disciplines such as physics, chemistry, mathematics etc. (NEP, 2020) also emphasize that need for teachers and future teachers to be equipped with CT skills themselves to effectively integrate them into science classrooms. Though this study researcher identified that in general pre service teachers are aware of integrating computational thinking skills moderately or partially not extreme level. But research also show that very less pre service teachers are aware of computational thinking and integration of computational thinking in various dimensions in science education. Thus, there is a need to discuss or conduct various workshops, collaborative discussions at various or multiple forums with experts especially for future teachers and present Inservice teachers regarding integrating computational thinking skills in different disciplines and across other subjects also.

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