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INTEGRATING COMPUTATIONAL THINKING IN SCHOOL
STEM EDUCATION: BARRIERS, STRATEGIES AND FUTURE
DIRECTIONS

Ritu Singh

(Junior Research Fellow)

Faculty of Education, B.H.U., Varanasi, Uttar Pradesh, India

Email: ritubhmed19@gmail.com

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Keywords

Computational Thinking,
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Abstract

The current educational scenario needs to replace traditional, isolated subjects learning approach to an integrated subjects learning approach so that students can be prepared for a complex, technology-oriented, innovation driven, real-world scenario. The concept of computational thinking (CT) is derived from computer science. It is a set of skills that help to solve problems and offers a powerful framework for the integration of STEM. This paper explores the practical implementation of integrating computational thinking (CT) into a STEM (Science, Technology, Engineering, Arts, and Mathematics) educational framework to encourage multidimensional learning in school education. The integration of CT with project-based and interdisciplinary STEM framework, acts as a powerful tool and it has a positive impact on the development of creativity, critical thinking, collaboration and self-reflection of students. This paper first



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develops a theoretical framework for STEAM-CT integration, and argues that CT provides a systematic way for solving the open-ended, real-world challenges ingrained in STEM projects. This paper also highlights the major barriers in implementation of this integrated STEAM-CT approach in school education. These major obstacles are untrained teachers, rigid curricula, limited resources, poor infrastructure, lack of administrative policies, cultural resistance, and lack of authentic tools for the assessment of CT. At last, this paper concludes a range of solutions for overcoming the above challenges which includes creating sufficient opportunities for redefining teacher professional development programs, developing flexible curricula, ensuring fair access to resources in under-resourced schools, and developing real assessment frameworks. By overcoming these obstacles, schools can harness the combined strengths of CT and STEAM to nurture a new generation of learners who are not only digitally literate but also creative, resilient, and ready to navigate and shape their futures.

1. INTRODUCTION

The modern era of education demands for a paradigm shift from traditional, isolated subjects learning approach to an integrated subjects learning approach that prepares students for a complex, technology-driven real-world scenario (Kristanto, 2020). Computational Thinking (CT) is a set of problem-solving skills and techniques that is derived from computer science which offers a powerful framework for integration of STEM (Cansu & Cansu, 2019; Wing, 2006). Computational Thinking (CT) is a way of problem solving and presently it is considered as a 21st century skill (NEP, 2020; NCFSE, 2023). The interdisciplinary education, particularly integration of Science, Mathematics, Engineering, and Technology (STEM) enhances conceptual understanding, students' engagement, and real-world application of knowledge. The various Indian policies and frameworks like National Education Policy (NEP) 2020, National Curriculum Framework for School Education (NCFSE) 2023 and the Next Generation Science Standards (NGSS) promote integrated pedagogies at all school levels. However, in many classrooms, science and mathematics are taught as isolated subjects in school education.

STEM education provide learners knowledge different fields simultaneously and leads to the development of critical thinking and creative skills which helps them to deal with real-world problem (Land, 2013). The STEM approach support development of the critical thinking and creative skills through project-based learning based on real-world problems which through which students can learn to find solutions of the problems, along with designing and creating products (Lu et al., 2022; Shatunova et al., 2019). In project-based approach students create products that helps them to develop their creativity and problem-solving skills. Wilson et al. (2021) stated that implementation of STEM education in elementary and middle school has a positive impact on the critical and creative thinking skills of students. Along with this, several other studies have discovered related



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results, that represents STEM approach can help students develop critical and creative thinking skills (Alkhabra et al., 2023; Anggraeni & Suratno, 2021; Engelman et al., 2017; Priantari et al., 2020). The problem-solving, which is a central activity in STEM support the development of computational thinking (CT) dimensions: decomposition, pattern recognition, abstraction, and algorithm (Barr & Stephenson, 2011). Decomposition is the process of breaking down a complex problem into smaller problems in order to make the problem easier to understand, handle, or manage. The search for similarities between different problems is referred to as pattern recognition. Focusing on important information while ignoring irrelevant details is what abstraction entails. The final dimension, algorithm, refers to the process of creating steps or rules to solve problems. The four CT dimensions can be embedded in STEM learning activities (Barr & Stephenson, 2011). CT integrated teaching and learning is often carried out using computers, especially programming (Wang et al., 2022), and also programming support critical tasks related to CT (Grover & Pea, 2013). The programming activities are often integrated into STEM education using Scratch (Tan et al., 2020) and Lego Mindstorm (Ding et al., 2019). CT integrated teaching and learning can also be implemented without the use of a computer. This strategy is suitable to implement in schools with limited access to technology (Brackmann et al., 2017). Thus, the combination of CT and STEM education, which hereinafter we refer to as STEM-CT, holds strong potential for large-scale implementation.

The combination of CT and STEM education provides a realistic and impactful environment for the multi-dimensional learning. This integrated approach facilitates the development of critical and creative thinking, collaboration, and self-reflection (Mariana & Kristanto, 2023).

CT at its core, mainly focusses on breaking complicated problems into interrelated components and processes. Similarly, STEM education is the integration of academic disciplines like Science, Mathematics, Engineering and Technology to produce a deeper and more impactful understanding. This powerful integrated model has a shared commitment of removing the barriers between disciplines and encouraging interdisciplinary learning that prepares students for multifaceted and evolving landscapes of future.

This research paper seeks to address that despite the several benefits of integrated STEM-CT approach, fully integrating Computational Thinking into STEM education faces major obstacles. These challenges are related to the education system, educational policies, and educational institutions. A multi-faceted approach and appropriate strategies are required to overcome these barriers or obstacles.

2. METHODOLOGY

The review technique used in this paper is the Integrative Review technique, which allowed for the integration of diverse findings—from definitions and conceptual frameworks to pedagogical



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challenges and innovative assessment tools—to provide a holistic and well-supported analysis of STEM-CT integration.

3. BARRIERS TO EFFECTIVE STEAM-CT INTEGRATION

Despite the several benefits of the STEM-CT approach, fully integrating Computational Thinking into STEM education faces major obstacles. These challenges are related to the education system, educational policies, and educational institutions. A multi-faceted approach and appropriate strategies are required to overcome these barriers or obstacles.

3.1 Inadequate Teacher Training Opportunities

One of the major obstacles in the implementation of the STEM-CT approach in school education is the lack of teachers' knowledge about integrated STEM activities for teaching and learning. They also don't have proper training in computer science or a similar area. They may find it hard to integrate the abstract concepts of CT in the present curriculum. One of the biggest misconceptions about CT that it is only related to coding is also a barrier. In the absence of proper training for teachers, they lack necessary skills to create and lead integrated STEM-CT activities. Current in-service teachers' training programs usually do not provide long-term support, mentoring, or chances for teachers to work together. These programs are crucial for real changes in teaching methods of school teachers for an effective STEM-CT approach. (Angeli & Giannakos, 2020; Boice et al., 2024; Correia et al., 2024)

3.2 Rigid and Overloaded Curriculum

School curricula often have a very rigid previously defined structure which is already overloaded with various curricular and co-curricular activities, so there is a very space for interdisciplinary project-based learning. Introducing a new integrated STEM-CT teaching learning in the curriculum can feel like an extra burden on an already defined curriculum. Curriculum developers may face difficulties in including the STEM and CT integrated activities or projects..(Angeli & Giannakos, 2020; Correia et al., 2024)

3.3 Inadequate Resource and Poor Infrastructure

The CT plugged activities are mostly dependent on computers and other technological equipments and most of the Indian schools lack the basic infrastructure and schools in rural areas are having very limited resources which are not sufficient for the implementation of STEM-CT approach of teaching learning. (Correia et al., 2024)

3.4 Administrative Barriers and Cultural Resistance

Implementing a new educational model and changing deep rooted teaching practices is very difficult. It has to face several obstacles at various administrative level and cultural opposition because it requires a shift in administrative culture and philosophy. School leaders, administrators, and even



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parents may refuse to move away from traditional, subject-specific teaching methods and accept the new activity-based teaching learning approach. It might be a fear that the focus on the integrated STEM-CT approach may reduce the importance of core subjects and can affect the students' final achievement. (Angeli & Giannakos, 2020; Correia et al., 2024)

3.5 Barriers to Effective Assessment and Evaluation

Traditional methods of assessment, like quizzes and exams, are often effective in measuring the improvement in different CT skills. The evaluation of a student's ability to decompose a problem, recognize a pattern, abstraction or develop algorithm requires a more nuanced approach. The evaluation of CT skills may involve observing their problem-solving process, analyzing their project work, and gathering peer feedback. The absence of strong, scalable assessment tools for CT makes it difficult for teachers to observe or monitor students' progress, give targeted feedback, and demonstrate the effectiveness of integrated STEM-CT programs to administrators and policymakers (Angeli & Giannakos, 2020)

4. STRATEGIES, SOLUTIONS AND RECOMMENDATIONS

The challenges described above can be addressed through a well-rounded strategy that targets policy, teaching methods, and practices.

4.1 Redefining Teacher Professional Development

To empower teachers, in-service training programs should be improved, and professional development must move beyond one-time workshops. Professional Learning Communities (PLCs) should be created in which teachers from various disciplines, such as science and math, can work together to design and implement integrated STEM-CT activities. There should be experts and mentors in these PLCs to guide training program. The pre-service teacher education programs should also include knowledge of CT, which will be effective in long term. It will ensure that the upcoming teachers have proper training in CT skills and enter the profession with these skills. (Angeli & Giannakos, 2020; Boice et al., 2024; Correia et al., 2024)

4.2 Developing Flexible and Integrated Curricula

It is necessary to develop a curriculum which should not treat CT as a separate subject or discipline; instead, it should be integrated with different STEM subjects. For example, in a biology class, complex datasets can be analyzed by the used of CT, an art class could apply it to generative art projects, and an engineering class could use it to program a prototype. The focus of the curriculum should be on project-based learning that requires the application of CT skills by students. Furthermore, collaboration among teachers should be encouraged, and assessments should evaluate both subject knowledge and the use of CT skills in projects. (Angeli & Giannakos, 2020; Correia et al., 2024)



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4.3 Equitable Resource Allocation

The digital divide needs to be addressed through collective policy effort. The Governments and educational organizations should give priority to under-resourced schools and provide funding for technology and infrastructure. This includes hardware, software, and the technical support needed to use the technology effectively. Schools can use open-source software, and free online coding platforms. Robotics kits made from available materials can also be used. These are all cost-effective or free solutions which can be easily available (Sun & Saleh, 2024).

4.4 Developing Authentic Assessment Frameworks

Schools should adopt a portfolio-based approach to evaluation to replace traditional methods of assessment. Student portfolios could include various aspects of their personality and performance, for example, digital artifacts from projects, documentation of their problem-solving process, reflections on their learning, and peer reviews. The various aspects or skills related to CT, such as breaking down a problem or algorithm design to the solution of the problem, can also be assessed through Rubric development (Tang et al., 2020; Mariana & Kristanto, 2023). These methods of assessment offer a more holistic and reliable view of student growth and enable teachers to give goal-oriented and impactful feedback. For the creation of such frameworks of assessment, collaboration between researchers, teachers, and policymakers is required.

5. CONCLUSION

The integration of computational thinking in a STEM framework for multi-dimensional learning represents a strong, combined approach to modern education. This paper has argued that CT gives a new, basic way of thinking for problem-solving. At the same time, STEM provides the creative and interdisciplinary framework required for the application of CT in real situations. The STEM-CT integrated approach creates a supportive and engaging environment for the all-round development of students. It promotes critical thinking, creativity, and a sense of social responsibility.

The embedding of computational thinking components within the STEM framework is a highly effective teaching method for empowering students to handle the challenges of the 21st century. It is not only focused on the development of digital skills but also promotes a mindset of systematic problem-solving, creativity, and resilience. Despite the several benefits of the STEM-CT approach, fully integrating Computational Thinking into STEM education faces major obstacles such as untrained teachers, rigid curricula, limited resources, poor infrastructure, lack of administrative policies, cultural resistance, and lack of authentic tools for the assessment of CT. But these challenges can be overcome by redefining teacher professional development, developing flexible curricula, ensuring fair access to resources in under-resourced schools, and developing real assessment frameworks. By implementing these reforms, schools can create a learning environment where students are not just users of technology but also contribute to the product creation. The



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development of our students and society in the future depends on our ability to accept and adopt this combined approach and make the necessary modifications that are required. There is an urgent need to make necessary changes in the curricula and replace a fragmented education model with an educational model that truly supports multidimensional and lifelong learning. This journey of curricula change and adoption of the new educational model may be tough, but the aim of an education system that enables every student to reach full potential is attainable.

6. AUTHOR(S) CONTRIBUTION

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7. CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

8. PLAGIARISM POLICY

All authors declare that any kind of violation of plagiarism, copyright and ethical matters will take care by all authors. Journal and editors are not liable for aforesaid matters.

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10. REFERENCES

- Alkhabra, Y. A., Ibrahem, U. M., & Alkhabra, S. A. (2023). Augmented reality technology in enhancing learning retention and critical thinking according to STEAM program. *Humanities and Social Sciences Communications*, 10(1). <https://doi.org/10.1057/s41599-023-01650-w>
- Angeli, C., & Giannakos, M. (2020). Computational thinking education: Issues and challenges. In *Computers in Human Behavior* (Vol. 105). Elsevier Ltd. <https://doi.org/10.1016/j.chb.2019.106185>
- Anggraeni, R. E., & Suratno. (2021). The analysis of the development of the 5E-STEAM learning model to improve critical thinking skills in natural science lesson. *Journal of Physics: Conference Series*, 1832(1). <https://doi.org/10.1088/1742-6596/1832/1/012050>
- Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community? *ACM Inroads*, 2(1), 48–54. <https://doi.org/10.1145/1929887.1929905>



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Boice, K. L., Alemdar, M., Jackson, J. R., Kessler, T. C., Choi, J., Grossman, S., & Usselman, M. (2024). Exploring teachers' understanding and implementation of STEAM: one size does not fit all. *Frontiers in Education*, 9. <https://doi.org/10.3389/educ.2024.1401191>

Brackmann, C. P., Moreno-León, J., Román-González, M., Casali, A., Robles, G., & Barone, D. (2017). Development of computational thinking skills through unplugged activities in primary school. *ACM International Conference Proceeding Series*, 65–72. <https://doi.org/10.1145/3137065.3137069>

Cansu, F. K., & Cansu, S. K. (2019). An Overview of Computational Thinking. *International Journal of Computer Science Education in Schools*, 3(1), 17–30. <https://doi.org/10.21585/ijcses.v3i1.53>

Correia, M., Ribeirinha, T., Beirante, D., Santos, R., Ramos, L., Dias, I. S., Luís, H., Catela, D., Galinha, S., Arrais, A., Portelada, A., Pinto, P., Simões, V., Ferreira, R., Franco, S., & Martins, M. C. (2024). Outdoor STEAM Education: Opportunities and Challenges. *Education Sciences*, 14(7). <https://doi.org/10.3390/educsci14070688>

Ding, F., Cai, M., & Chen, S. (2019). *Application of STEAM Theory in Robot Teaching*.

Engelman, S., Magerko, B., McKlin, T., Miller, M., Edwards, D., & Freeman, J. (2017). Creativity in authentic STEAM education with Earsketch. *Proceedings of the Conference on Integrating Technology into Computer Science Education, ITiCSE*, 183–188. <https://doi.org/10.1145/3017680.3017763>

Grover, S., & Pea, R. (2013). Computational Thinking in K-12: A Review of the State of the Field. In *Educational Researcher* (Vol. 42, Issue 1, pp. 38–43). <https://doi.org/10.3102/0013189X12463051>

Kristanto, Y. D. (2020). *Upaya peningkatan kualitas pembelajaran matematika melalui flipped classroom dan gamifikasi: suatu kajian pustaka*. <https://www.researchgate.net/publication/339927323>

Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science*, 20, 547–552. <https://doi.org/10.1016/j.procs.2013.09.3>

Lu, S. Y., Lo, C. C., & Syu, J. Y. (2022). Project-based Learning Oriented STEAM: the case of micro-bit paper-cutting lamp. *International Journal of Technology and Design Education*, 32(5), 2553–2575. <https://doi.org/10.1007/s10798-021-09714-1>

Mariana, E. P., & Kristanto, Y. D. (2023). Integrating STEAM education and computational thinking: Analysis of students' critical and creative thinking skills in an innovative teaching and learning. *Southeast Asia Mathematics Education Journal*, 13(1), 1–18. <https://eric.ed.gov/?id=ED629819>



Ritu Singh (2026). *Integrating Computational Thinking in School STEM Education: Barriers, Strategies and Future Directions*. International Journal of Multidisciplinary Research & Reviews. 5(4). 363-371.

Ministry of Education. (2020). *National Education Policy 2020*. Government of India. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

National Council of Educational Research and Training. (2023). *National Curriculum Framework for School Education 2023*. Ministry of Education, Government of India. https://www.education.gov.in/sites/upload_files/mhrd/files/infocus_slider/NCF-School-Education-Pre-Draft.pdf

Priantari, I., Prafitasari, A. N., Kusumawardhani, D. R., & Susanti, S. (2020). Improving Students Critical Thinking through STEAM-PjBL Learning. *Bioeducation Journal*, 4(2), 94–102. <https://doi.org/10.24036/bioedu.v4i2.283>

Shatunova, O., Anisimova, T., Sabirova, F., & Kalimullina, O. (2019). STEAM as an Innovative Educational Technology. *Journal of Social Studies Education Research*, 10, 131-144. <https://jsser.org/index.php/jsser/article/view/916>

Sun, N., & Saleh, S. (2024). The challenges and strategies for promoting equity in STEAM education activities by kindergarten in China. *International Journal of Chinese Education*, 13(2). <https://doi.org/10.1177/2212585X241273986>

Tan, W.-L., Samsudin, M. A., Ismail, M. E., & Ahmad, N. J. (2020). Gender differences in students' achievements in learning concepts of electricity via steam integrated approach utilizing scratch. *Problems of Education in the 21st Century*, 78(3), 423–448. <https://doi.org/10.33225/pec/20.78.423>

Tang, X., Yin, Y., Lin, Q., Hadad, R., & Zhai, X. (2020). Assessing computational thinking: A systematic review of empirical studies. *Computers and Education*, 148, 1-22. <https://doi.org/10.1016/j.compedu.2019.103798>

Wang, C., Shen, J., & Chao, J. (2022). Integrating Computational Thinking in STEM Education: A Literature Review. *International Journal of Science and Mathematics Education*, 20(8), 1949–1972. <https://doi.org/10.1007/s10763-021-10227-5>

Wilson, H. E., Song, H., Johnson, J., Presley, L., & Olson, K. (2021). Effects of transdisciplinary STEAM lessons on student critical and creative thinking. *The Journal of Educational Research*, 114(5), 445–457. <https://doi.org/10.1080/00220671.2021.1975090>

Wing, J. M. (2006). Computational thinking. In *Communications of the ACM*, 49(3), pp. 33–35. Association for Computing Machinery. <https://doi.org/10.1145/1118178.1118215>

