Collaborative Approaches for Effective and Sustainable Integration of Computational Thinking Educational Strategies

Giulia Paludo
Alberto Montresor
University of Trento
Trento, Italy

CCS CONCEPTS

• **Social and professional topics** → **K-12 education**; **Computational thinking**.

KEYWORDS

Computational Thinking Education

ACM Reference Format:
Giulia Paludo and Alberto Montresor. 2024. Collaborative Approaches for Effective and Sustainable Integration of Computational Thinking Educational Strategies. In *The 19th WiPSCE Conference on Primary and Secondary Computing Education Research (WiPSCE '24), September 16–18, 2024, Munich, Germany*. ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3677619.3678129

1 INTRODUCTION

Despite the availability of resources, schools struggle at integrating educational technology and both Computer Science (CS) and Computational Thinking (CT) education in an effective and sustainable way. The two-year "*Coding and Storytelling*" program aims as addressing this issue by proposing a strategic interweaving of teacher training, sessions of CS and CT [6] activities design and their implementation in class with trained facilitators. The project exploits the theoretical framework of the "*Will, Skill and Tool Model*" [5] with a holistic approach to competency and affective aspects in both students and educators. It involves addressing harmoniously aspects of attitudes, and both technical competency and accessibility. We conducted an exploratory study at the end of the first year, addressing the following research questions:

- How does our program impact the integration of CT activities and approaches into the educational setting?
- Which are the factors involved in the process of integration of CT educational strategies with the program?

According to the concept of "*Technology Integration*" of the Sustainable Development Goals [8], the education system needs to equip next generations with relevant skills such as CT, CS literacy and proplem solving [4]. The integration and the scalability of such tools in the educational system has not been addressed properly, leading to challenges in the sustainability of technology and CS/CT education. As stated by Çoklar et al. "*teachers are important providers of educational sustainability*" [10]: with this project we proposed a comprehensive solution targeted on teacher training, aided implementation and cooperative improvement.

The "*Coding and Storytelling*" project stems from previous experiences in teacher training for CS and it is set to run for two years. The program includes monthly training sessions for the co-design of plugged and unplugged CT activities, and classroom activities supported by trained facilitators. We opted for mixing plugged and unplugged activities, given their efficacy in conveying the concepts as well as the pedagogical relevance, inclusivity, skills transfer and benefits to the creativity domain[4, 7]. The program aims at introducing CS and CT activities as a transversal learning environment to enhance the learning process and the experience of other subjects [6, 9].

2 METHODS

The project was conducted in a primary school (K5) with 10 classes and involved all the 29 teachers (28 females, 1 male), whose participation was mandatory for professional training, while the participation in the study was voluntary. The average experience was 21.7 years (SD = 10.88), ranging from new to the job to approaching retirement. The data collection consisted of:

- *Ethnographic Observations* were conducted during three classroom sessions facilitated by trained personnel: two 2nd grade with unplugged activities and one 4th grade with plugged activities. The observation focused on the classroom dynamics and the teachers involvement.
- *Semi-structured interviews* were conducted with 10 teachers (N=10) chosen by self-selection sampling. They covered personal experience with the project, faced challenges, employed strategies for integration and significant episodes encountered during the implementation.
- A *survey* (N=20) included demographic information and questions on their involvement in the project. Teachers were also asked to reflect on students' dynamics and share relevant episodes. Items were open and close-ended with multiple choice and a 5-point Likert scale. Qualitative data were analyzed with thematic analysis [1] according to the framework of Grounded Theory [3], while for quantitative data we obtained both descriptive and inferential statistics using Wilcoxon tests for Likert's scale items.

3 RESULTS

Data reported a significantly positive outcome of the initiative with positive attitudes towards the introduction of the mentioned approaches ($p < 0.001$). Teachers reported feeling more competent

WiPSCE '24, September 16–18, 2024, Munich, Germany

ACM ISBN 979-8-4007-1005-6/24/09
https://doi.org/10.1145/3677619.3678129

in CT teaching skills after the training, increasing from a mean of 1.9 (SD = 0.73) to 3.1 (SD = 0.56) on a 5 point Likert scale. 80% of the participants would recommend it to a colleague: the most appreciated aspects for integrating CT activities in their practice and existing curriculum were the expert-guided training, the support from the facilitators and the unplugged activities.

Thematic analysis [1] of the interviews and open ended questions allowed the detection of the following key themes:

Learning alliance with students. Complex activities such as Scratch programming might require co-teaching when engaging with special needs students: this it is not always possible. To tackle this challenge teachers and students formed learning alliances, switching roles in a seamless way. This approach stimulated proactive and collaborative behaviors, and it allowed teachers to introduce the activities even if they did not feel entirely comfortable with them.

Lack of communication between colleagues from different classes. Activities developed by single teachers and class teams are often not shared with other colleagues. This lack of communication further hindered the implementation of activities by more reluctant teachers, who could have benefited from adopting already tested strategies. In future iterations, fostering collaboration across grade levels could mitigate this issue, enhancing the effectiveness and acceptance of new educational activities.

Higher Perceived Effectiveness of Unplugged Activities. Unplugged activities were perceived as the most effective way to introduce CT knowledge across various subjects, facilitating their integration. While Scratch programming was highly appreciated by students in the 4^{th} and 5^{th} grades, its integration was often limited by time constraints. These activities provided a more accessible entry point for CT for classes where time was a significant limiting factor [7].

Boost to autonomy and self management. CT activities positively contributed to stimulating students' autonomy. These proposals provided a great opportunity to foster autonomy, group work and self-management in the learning process especially for 2^{nd} graders. Students exhibited greater resilience, curiosity, and a willingness to experiment in a collaborative learning environment.

Inclusion. Teachers observed frequent instances of peer tutoring and collaboration among students throughout the activities. Children with special needs did not experience the usual frustration associated with mistakes, while gifted students never became bored: they either helped classmates or explored autonomously greater complexity in the proposed tasks.

4 DISCUSSION AND FURTHER DIRECTIONS

Despite the overall positive impact, teachers highlighted the need for improved communication and engagement to avoid missing opportunities and unnecessary efforts. In response to this concerns, we developed a *documentation repository* to collect materials with practical advice to bridge the gap between differently experienced teachers. This will set the basis for a sustainable integration of CT education in the current practice.

While addressing practical needs, we also worked in creating a tool for meta-reflection and to provide a rich, functional description of the activity through a structured template, inspired by the AEIOU method by Burnett and Evans [2] and the checklist developed by the ASPHI Onlus Foundation (https://www.percontare.it/). The template (in the supplemental materials) is organized as follows:

- *Objectives*: scope and purpose of the activity
- *Activities*: instructions, materials and any other resources to perform the activity.
- *Environment*: location's requirements and alternatives.
- *Interactions*: social setting and behaviours to be expected from the students.
- *Users*: knowledge for the teacher.

The template contains also information for tasks' completion, introduction and exploration of different concepts and skills, and how to consolidate them. The documentation repository will facilitate ongoing data collection; during the next school year, we will evaluate its effectiveness in enhancing collaboration.

5 CONCLUSIONS

The "*Coding and Storytelling*" project represents a promising initiative for tackling the challenges of effectively and sustainably integrating CT in the educational practice of primary schools. Preliminary findings from the first year show a positive impact on the integration and the teachers perceptions of CT activities and approaches into the educational setting. The topic of "*Alliance with Students*" has been highlighted by thematic analysis: the adoption of the "*be the learner*" strategy in the classroom is a significant result, reflecting a pedagogical shift towards a new teacher-student alliance that we aspire to see in the future of CT education.

The activities resulted in enhanced autonomy and collaboration between students, with improvements in peer-tutoring, resiliency, and curiosity. This enhanced the teachers' willingness to continue experimenting with these approaches during the next year. Findings also emphasized a positive contribution of CT in promoting an inclusive learning environment for everyone. The document repository is currently being tested as a tool to enhance coordination, communication, and community engagement among teachers and as a research method for the systematic documentation of educational activities.

Acknowledgements. This research was supported by the project PRIN 2022 "Learning Informatics" (20222BP7K3).

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