Teacher education is a deeply pedagogical process rooted in values, ethics, and the social purpose of schooling. Globally, it sits at the core of educational quality and fairness, as research in comparative and international education demonstrates: the training of teachers directly influences students' learning chances, social inclusion, and the democratic aims of schools. Teachers are not simply transmitters of curricula, but active professionals whose convictions, reflective skills, and ability to manage the complexities of classroom life give shape and substance to the educational experience itself.
The pedagogical dimension of teacher education frames teaching as a relational, context-aware, and ethically grounded profession rather than just a set of procedural skills. From a research perspective, this demands robust research methodologies that can critically examine the complex realities of schools and inform evidence-based policies. Equally important is the connection between theory and practice, which helps to bridge the persistent gap between universities and schools.
The contributions gathered in this volume reflect the richness and diversity of experiences showcased during the ATEE Spring Conference 2024, held at the University of Bergamo from May 29 to June 1, 2024. The volume presents 70 selected papers out of more than 300 presented by researchers representing over 40 countries.
This broad spectrum of studies highlights promising directions that can inspire renewed inquiry and concrete proposals aimed at improving contemporary educational systems.

FRANCESCO MAGNI is an Associate Professor of General and Social Pedagogy (PAED-01/A) at the Department of Human and Social Sciences, University of Bergamo, Italy. He is a member of the board and Deputy Director of CQIIA (Center for the Quality of Teaching, Didactic Innovation, and Learning). He is also a member of the ATEE – Association for Teacher Education in Europe.

NICOLE BIANQUIN is an Associate Professor of Didactics and Special Education (PAED-02/A) at the Department of Human and Social Sciences, University of the Aosta Valley, Aosta, Italy. She is a member of the ATEE – Association for Teacher Education in Europe.

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ATEE Spring Conference 2024

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Teacher education research in Europe: trends, challenges, practices and perspectives

May 29th – June 1st, 2024
S. Agostino, Bergamo

Edited by Nicole Bianquin and Francesco Magni

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BOOK OF PROCEEDINGS

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POSTER SESSION

The contributions published in this book of proceedings have been evaluated through a double-blind peer review process. We would like to thank the members of the Scientific Committee, as well as the many other professors, researchers and experts who agreed to act as reviewers.

Exploring Coding and Educational Robotics in Primary Schools.
Results and Perspectives from an Action Research Approach to Teaching Innovation

Federica Pelizzari, *Università Cattolica del Sacro Cuore,* federica.pelizzari@unicatt.it
Simona Ferrari, *Università Cattolica del Sacro Cuore,* simona.ferrari@unicatt.it

Abstract

This study explores the integration of coding and innovative teaching methods in primary education through an action research approach. Pre- and post-training surveys and teacher logbooks were used to assess changes in perceptions, practices, and student outcomes. Findings show shifts in teacher attitudes, greater collaboration, and improved student critical thinking. Coding fostered creativity, problem-solving, and digital skills. Challenges included time limits and the need for tailored training. The study outlines implications for teacher education and future research, emphasizing innovation's role in preparing students and educators for 21st-century learning.

Keywords: coding; innovative teaching; educational robotics; teacher training; action research.

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1. Introduction[1]

The increasing presence of digital tools in education calls for innovative and student-centered methodologies. Coding and educational robotics are recognized for fostering 21st-century skills such as computational thinking (CT), critical thinking, creativity, and collaboration (Grover & Pea, 2013; Shute et al., 2017; Resnick, 2018; Bers, 2020).

To integrate these tools effectively, pedagogical approaches must support experiential and iterative learning. The Situated Learning Episodes (EAS) model (Rivoltella, 2013), structured in anticipation, production, and reflection phases, offers a flexible framework that complements coding and robotics, particularly in primary education.

This paper presents an action-research study evaluating a teacher training program based on EAS and coding. The project aimed to equip teachers with innovative strategies for integrating digital tools into everyday teaching. Through mixed methods, the study explores how these practices impact teacher attitudes, instructional approaches, and student engagement.

2. Theoretical Framework

This study is grounded in three interrelated domains—Computational Thinking (CT), coding, and educational robotics—which together frame a broader pedagogical vision oriented towards 21st-century skills such as creativity, collaboration, and problem-solving (Grover & Pea, 2013; Shute et al., 2017; Bers, 2020).

Computational Thinking (CT) refers to a set of cognitive processes for analyzing and solving problems in systematic and innovative ways (Wing, 2006). CT CT bridges technical and transversal competences, forming a key educational literacy (Denning & Tedre, 2021). CT can be fostered from early years through unplugged activities—hands-on, screen-free experiences that model computational logic in accessible formats (Brackmann et al., 2017; Rücker & Pinkwart, 2017). These activities allow learners to internalize core CT principles even before engaging with digital tools, thus supporting inclusive and progressive curricular implementation. CT promotes critical thinking, adaptability, and metacognition (Pelizzari et al., 2023b), supporting students in reflecting on their learning strategies.

Coding concretizes CT by offering interactive and creative problem-solving tasks. It enables learners to engage in real-world problems through experimentation and logical reasoning (Lye & Koh, 2014; Grover & Basu, 2023). Coding is also a vehicle for imagination and play (Hennessy, 2016), especially when implemented through block-based platforms like Scratch (Resnick et al., 2009; Brennan & Resnick, 2012). These tools democratize access to programming and foster agency and confidence among young learners (Moraiti et al., 2022). In addition, coding offers strong cross-curricular potential, allowing integration with disciplinary content in mathematics, science, art, and language education.

Educational robotics adds a tangible and collaborative layer to coding. It brings together engineering, programming, and design-based learning, enhancing both cognitive and socio-emotional skills (Atmatzidou & Demetriadis, 2016; Angeli & Valanides, 2020). Robotics aligns with Resnick’s (2018) Creative Learning Spiral—imagine, create, play, share, reflect—which integrates constructionist and iterative learning cycles. Robotics encourages resilience and teamwork, particularly in group problem-solving tasks (Rusk et al., 2008; Sullivan & Bers, 2016; Yu et al., 2024).

The interplay among CT, coding, and robotics fosters not only technical literacy but also transversal competences such as collaboration, empathy, and ethical thinking (Chevalier et al., 2021). These methodologies support learners in navigating complexity and transferring knowledge across domains (Sengupta et al., 2013).

From a teacher training perspective, effective integration of these tools requires targeted professional development. Educators need both technical skills and pedagogical vision, aligned with

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[1] This article was collaboratively developed by the authors. F.P. contributed to Section 1, "Introduction", 3. "Research Design", 4. "Results", 5. "Discussion" and 6. "Conclusions"; S.F. authored Section 2, "Theoretical Framework".

holistic competence models such as Le Boterf's (2011) slider of competence. Experiential, collaborative training programs, supported by mentoring and peer exchange, are essential to develop confidence and didactic creativity (Di Battista et al., 2020; Fagerlund et al., 2021).

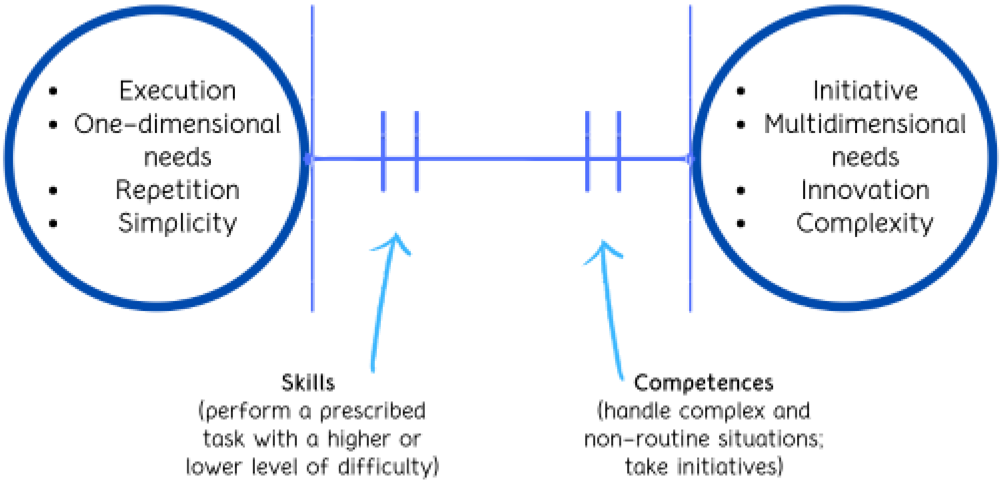


Figure 1: Le Boterf's Slider of Competence (2011).

3. Research Design

This study adopts an action research approach (Kemmis & McTaggart, 2005) to address the need—identified by a primary school in Iseo (Brescia, Italy)—to integrate digital skills and coding into teaching practices. Action research offers a responsive and participatory method, enabling iterative improvements through cycles of planning, action, observation, and reflection.

3.1 Research Methodology

The intervention centered on a teacher training program combining theoretical input, hands-on experimentation, and classroom application. The study explored how coding and the EAS model influence teaching practices and teacher perceptions. The training is aimed to:

1. Foster innovative teaching experimentation.
2. Assess the applicability of EAS and coding.
3. Understand teachers' pedagogical shifts following the coding-based intervention.

Three research questions guided the inquiry:

RQ1: How does the training foster innovation in teaching?
RQ2: What are teachers' views on integrating EAS and coding?
RQ3: How do teachers experience the impact of coding on their practice?

A data alignment table matched each question with relevant sources (e.g., surveys, logbooks, classroom observations) to ensure coherence.
To ensure alignment between data and research questions, the following mapping was applied:

Research Question	**Data Sources**
RQ1	Classroom observations; post-training surveys
RQ2	Pre/post surveys; teacher reflections in logbooks
RQ3	Logbook content; survey items on practice change

Table 1 - Alignment between data and research questions

3.2 Design Model for the Classroom: EAS & Coding

The EAS model (Rivoltella, 2013) structures lessons in three phases—anticipation, production, reflection—promoting active, student-centered learning. Its iterative and contextual nature aligns well with coding's logic, supporting both skill development and metacognitive awareness.

EAS activities begin with a motivating prompt (anticipation), continue with hands-on problem-solving (production), and end with critical reflection. This model enables interdisciplinary integration of coding in the classroom, fostering creativity, problem-solving, and resilience.

The EAS model offers several advantages in the integration of digital tools in primary education. First, it structures the learning process in a way that supports student agency and teacher flexibility, allowing educators to adapt activities to diverse learning contexts. Second, it emphasizes the iterative and circular nature of learning, particularly well-suited to the logic of coding and robotics, where testing, debugging, and refining are intrinsic to the process.

Within this study, the EAS framework provided a pedagogical backbone for designing interdisciplinary learning units that combine curricular content with digital creativity. It allowed teachers to scaffold coding experiences in a meaningful and structured way, making them accessible even to students with no prior exposure to digital technologies. The model also helped teachers manage classroom time, support differentiated instruction, and introduce reflective practices that extended beyond technical skills.

Anticipate

Activate a first appropriation of the contents

- Problem solving: advance hypotheses and have a first access to the contents.
- Stimulus: the student is confronted with a new topic that has not yet been addressed in class.

Reflect

Fix the key elements

- Return to the path, regain possession of contents and experiences.
- The student must be guided to reflect, even presenting his work aloud
- Development of critical sense. Different debriefing techniques

Produce

Work on constructs

- Organize individual and/or work group.
- Delivery must be clear and precise.

Figure 2: EAS model (Rivoltella, 2013).

3.3 Training Intervention Design

The training intervention was structured into five sequential phases. It began with two online meetings focused on the theoretical foundations of coding and the Situated Learning Episodes (EAS) model. This was followed by an in-person session dedicated to hands-on exploration of educational technologies, including unplugged activities, Scratch, and educational robotics. Subsequently, teachers participated in design workshops aimed at co-constructing interdisciplinary learning units based on the EAS model, integrating coding into meaningful curricular contexts. During the implementation phase, teachers implemented the planned activities with tutoring support. Finally, each participant completed a structured logbook documenting the key elements of the learning experience, aligned with the three phases of the EAS model: anticipation, production, and reflection.

Online plenary (introduction to the method, introduction to coding and definition of the course) for all teachers;

12 hours in-presence presentation of coding as a teaching methodology, implemented in the EAS and the technical tools that can be used (unplugged coding, Bee Bot and Lego Spike);

9 hours of in-presence workshops for the construction of an EAS (interdisciplinary, in small groups) to be experimented later in the classroom, accompanied by asynchronous coaching;

Online plenary on the EAS produced and experimentation. This provided continuous feedback and made it possible to evaluate the effectiveness of the training intervention

Figure 3 - Training Intervention Design.

3.4 Data Collection Tools

The study adopted a mixed-methods approach (Creswell & Plano Clark, 2017), integrating quantitative and qualitative tools to ensure effective data triangulation and a comprehensive understanding of the phenomena investigated.

1. Pre-/Post-Surveys were administered to assess teachers' prior knowledge, expectations, and perceptions of coding and educational robotics before and after the training. The questionnaires included both closed-ended items using Likert scales, allowing for statistical analysis, and open-ended questions to collect qualitative reflections. Quantitative data were used to identify significant variations in self-reported competencies and perceptions, while qualitative responses offered insights into teachers' personal experiences and beliefs.
2. Reflective Logbooks were compiled during the classroom implementation phase. Teachers documented the structure and execution of the learning activities, student reactions, and their own reflections. These logbooks provided rich qualitative data, revealing challenges, adaptive strategies, and the practical application of coding and the EAS model. Thematic analysis was conducted to identify recurring patterns and meaningful narratives across cases.
3. Classroom Observations were carried out during the implementation to assess the integration of coding and robotics in real educational settings. Observations followed a structured protocol focusing on key indicators such as teacher-student interaction, peer collaboration, and engagement in problem-solving tasks. These direct observations enriched the qualitative dataset by capturing classroom dynamics and contextual factors not always evident in self-reports.

The combination of these tools enabled methodological triangulation, increasing the validity and reliability of the findings. The integration of quantitative measures with narrative accounts provided a holistic view of the training's impact, highlighting both measurable changes in teacher competencies and more nuanced shifts in pedagogical practice and innovative attitudes.

3.5 Participants

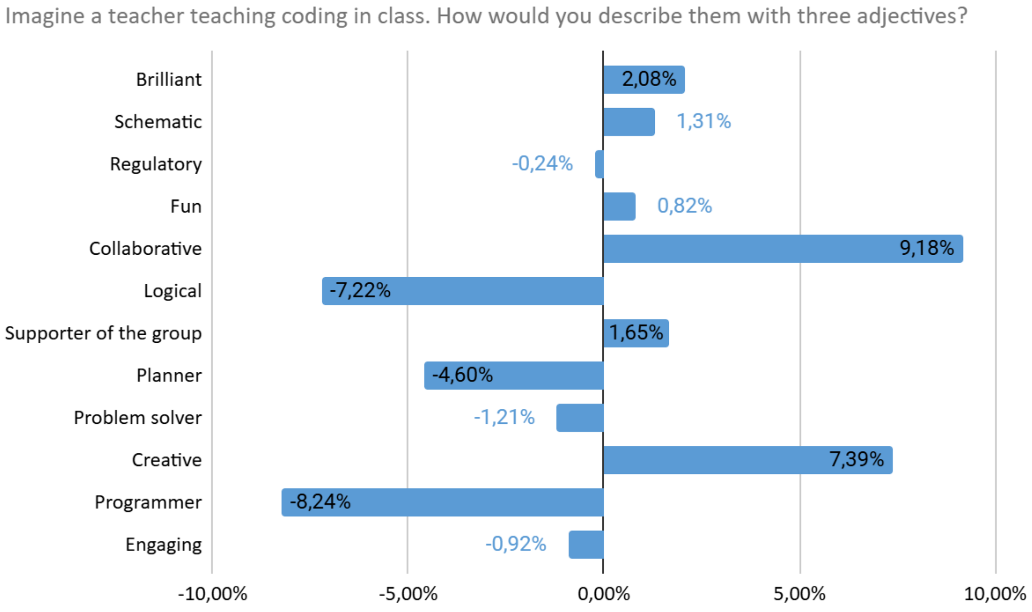
The study involved 43 women primary school teachers, who participated in a coding training program. The participants were diverse in terms of age, teaching experience, prior exposure to coding, and technological proficiency. Among them, 46% were aged between 40 and 60 years, while 37% were between 21 and 39 years. In terms of teaching experience, 37% had been teaching for more than 10 years, 34% had between 3 and 10 years of experience, and 23% had been teaching for only 1 to 3 years. Their specializations were similarly varied, with 35% teaching in the mathematical-scientific-technological field and 33% in the linguistic field.

Participants were selected based on their voluntary enrollment in the training program, which aimed to explore the integration of coding and digital skills into pedagogical practices. To respect international standards, all teacher comments and reflections originally written in Italian were translated into English during analysis and in the final reporting of findings.

4. Results

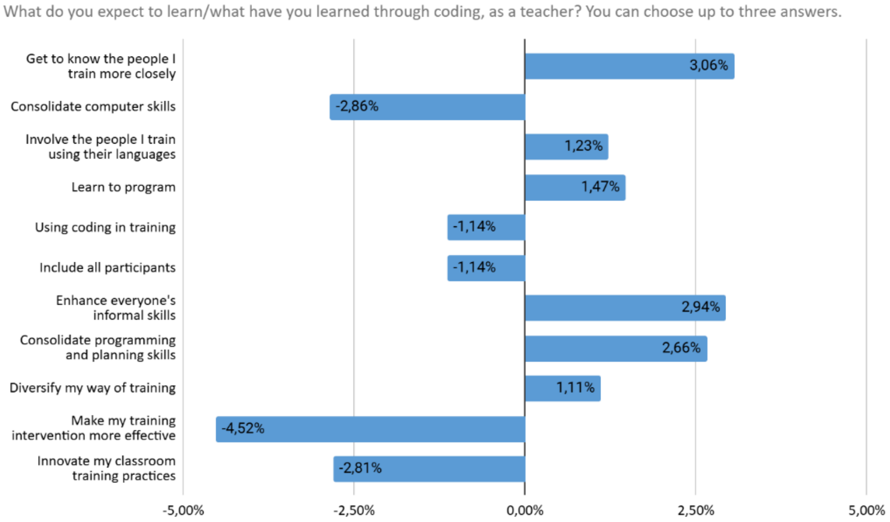
This section presents findings based on the three research questions. Quantitative and qualitative data are integrated to provide a comprehensive understanding of the impact of the training program.

4.1 Survey (RQ2, RQ3)



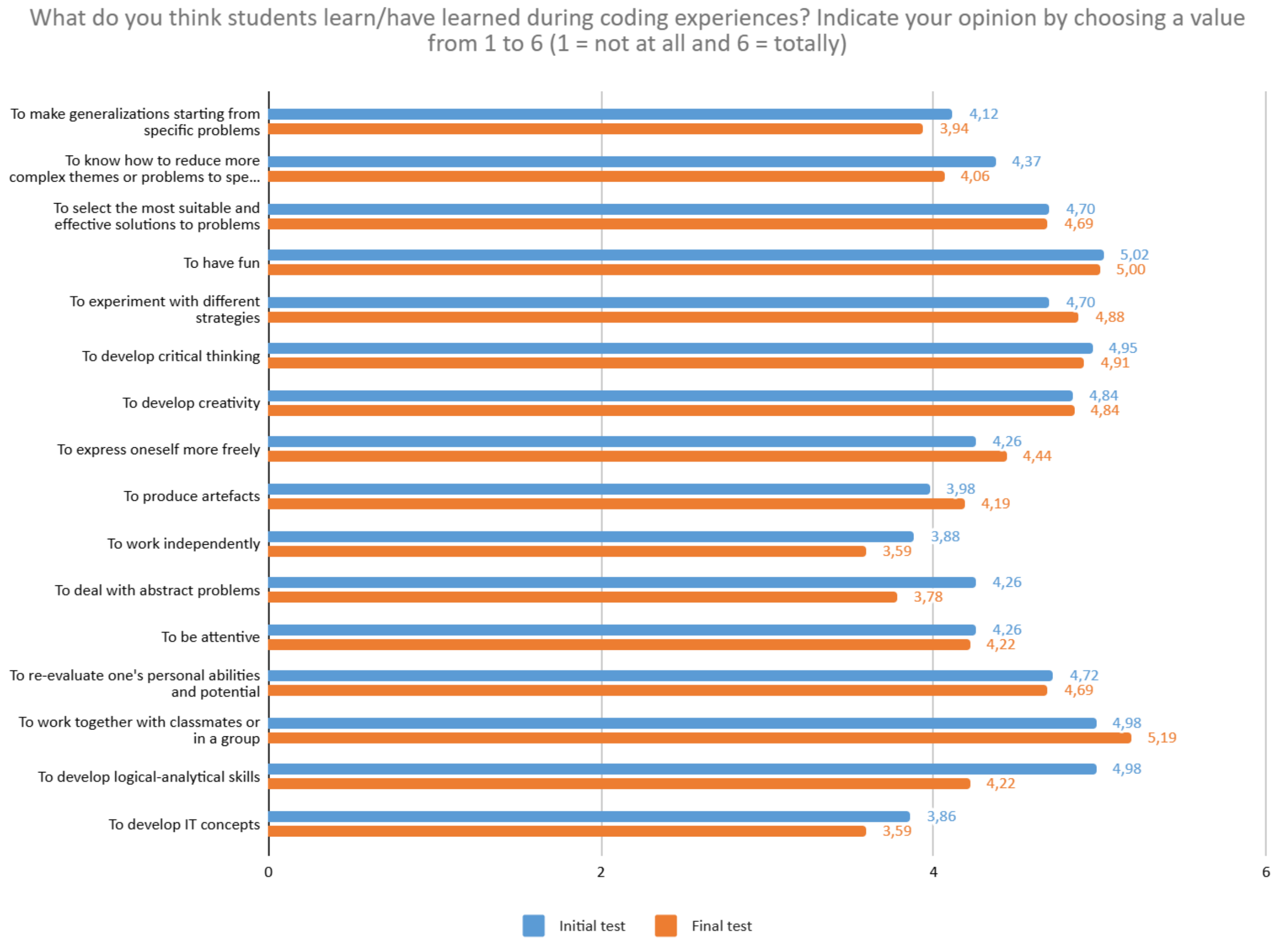
Graphic 1: Adjectives used to describe a coding teacher (pre/post).

When asked to describe a teacher who uses coding, participants' perceptions shifted notably after the training. Initially, "engaging" was the most frequent adjective, but "creative" became dominant post-intervention (19.79%). The term "programmer" declined sharply (from 12.4% to 4.17%), while collaborative" more than doubled (from 8.53% to 17.71%). These changes reflect a shift from a technical view of coding toward a more creative and collaborative pedagogical perspective.



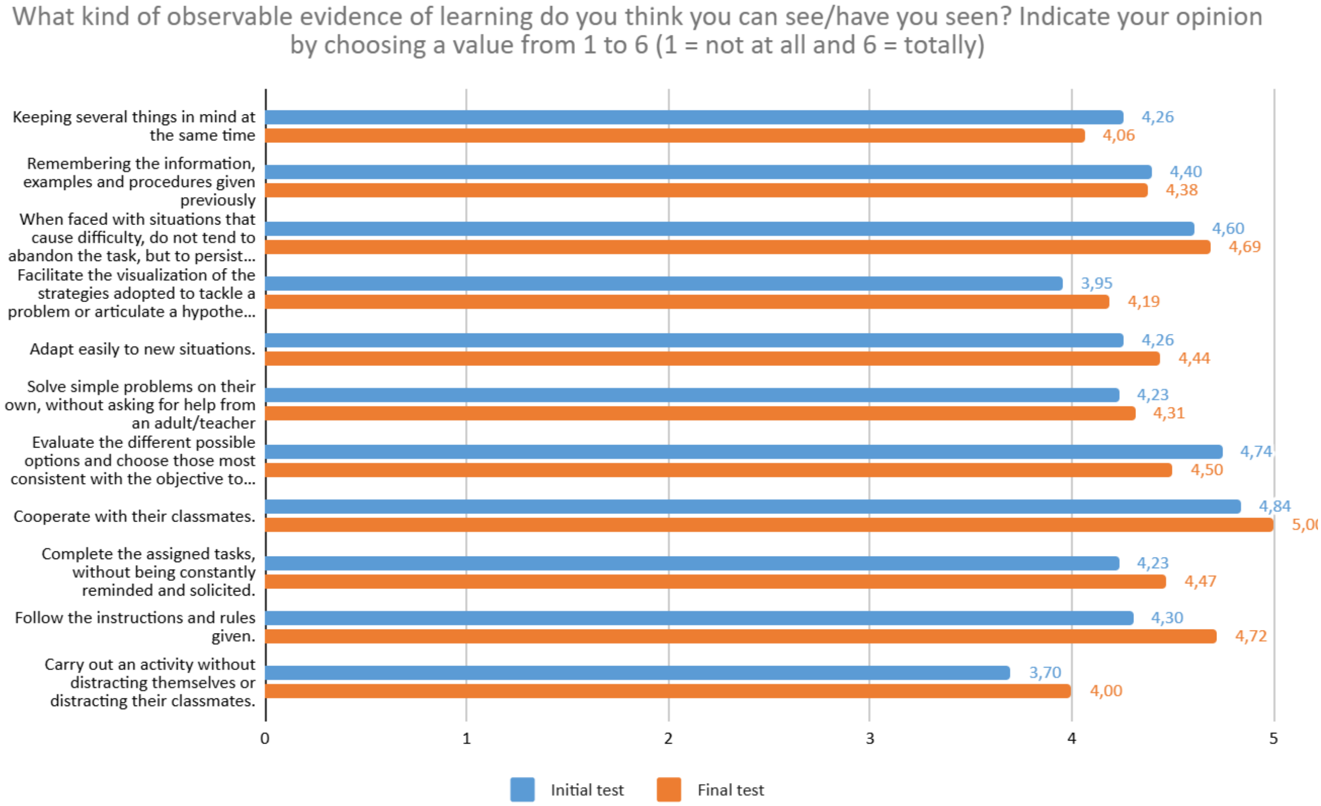
Graphic 2: What teachers expected vs. what they learned through coding.

When comparing their expectations with what they learned, teachers confirmed the anticipated value of innovation (20.16% pre vs. 17.35% post), while perceived improvements in teaching effectiveness (−4.53%) and technical skill consolidation (−2.86%) declined. Notably, social aspects gained unexpected relevance: 3.06% of teachers highlighted collaboration as an emerging outcome, a theme absent in initial expectations. These findings reveal a partial alignment between expectations and outcomes, with innovation validated but technical gains perceived as limited, and a growing appreciation of the social dimension of coding and robotics.



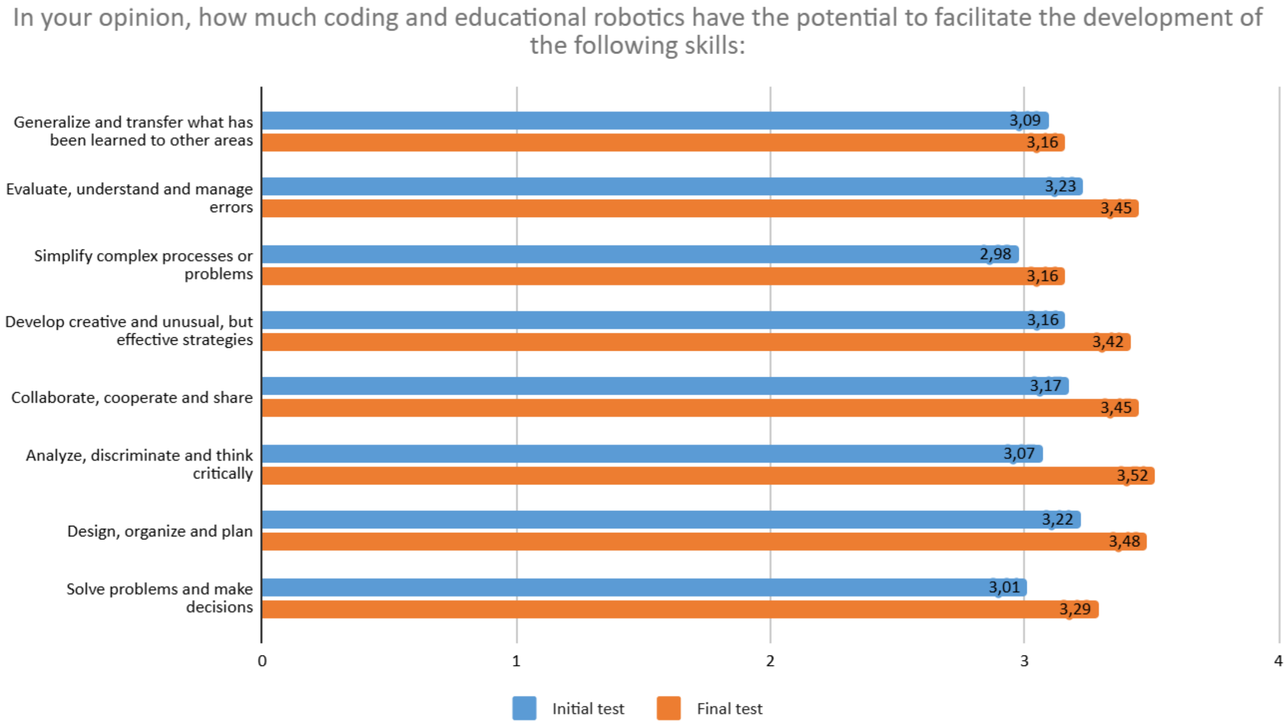
Graphic 3 : Perceived student learning outcomes.

The questionnaire assessing students' perceived learning during the coding experimentation showed stable overall scores, but certain items recorded notable declines. Logical-analytical skills decreased by 15% (from 4.98 to 4.22), and the ability to deal with abstract problems dropped by 11% (from 4.26 to 3.78). Smaller declines were observed in developing IT concepts, working independently, and simplifying complex problems (each around –7%). These results suggest that while the experience offered valuable learning opportunities, some skills—particularly those related to abstract reasoning—were either less reinforced or more difficult for students to recognize. Contributing factors may include task complexity, misaligned expectations, or a more critical self-assessment after the intervention.



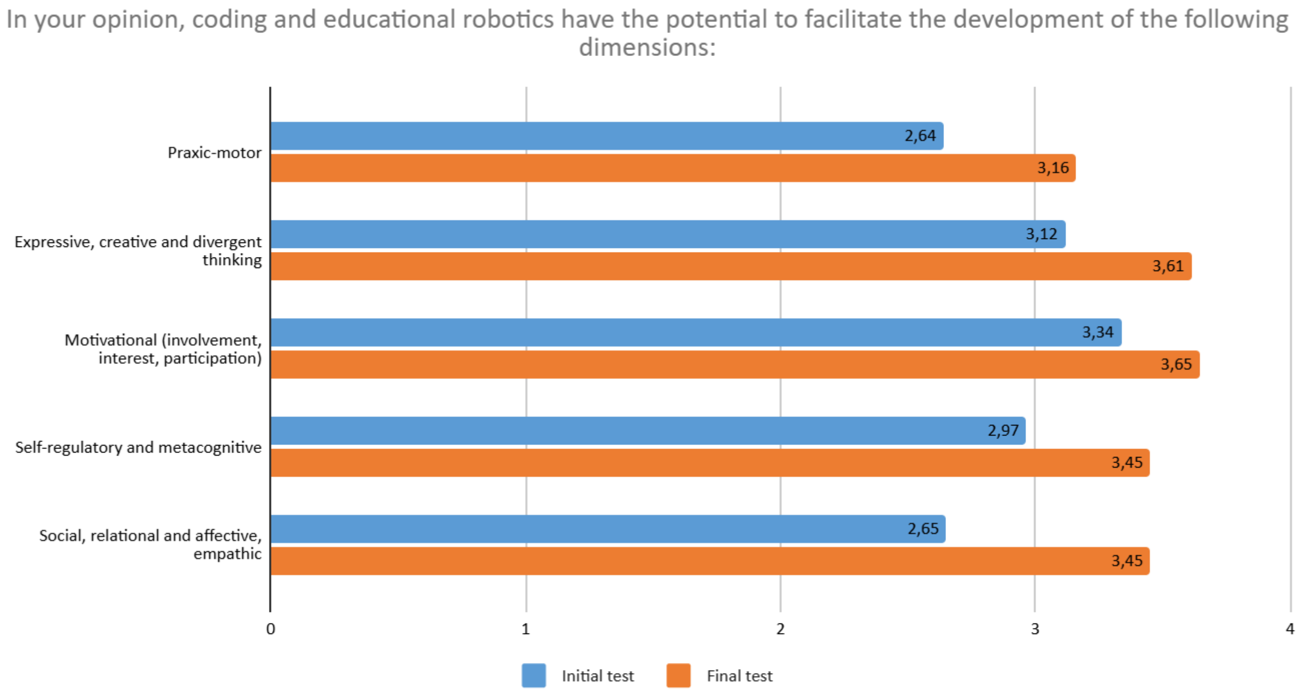
Graphic 4: Observable student behaviors.

Among the observed indicators, four items showed significant changes. Adaptability and perseverance both increased by 12%, suggesting that coding activities helped students better face new situations and persist through challenges. Conversely, multitasking ability (–14%) and independent task completion (–9%) declined, possibly due to cognitive overload or the need for greater structure in unfamiliar contexts. These results reflect the experiment’s dual impact: it fostered resilience while revealing areas—such as autonomy—that may require further scaffolding in future implementations.



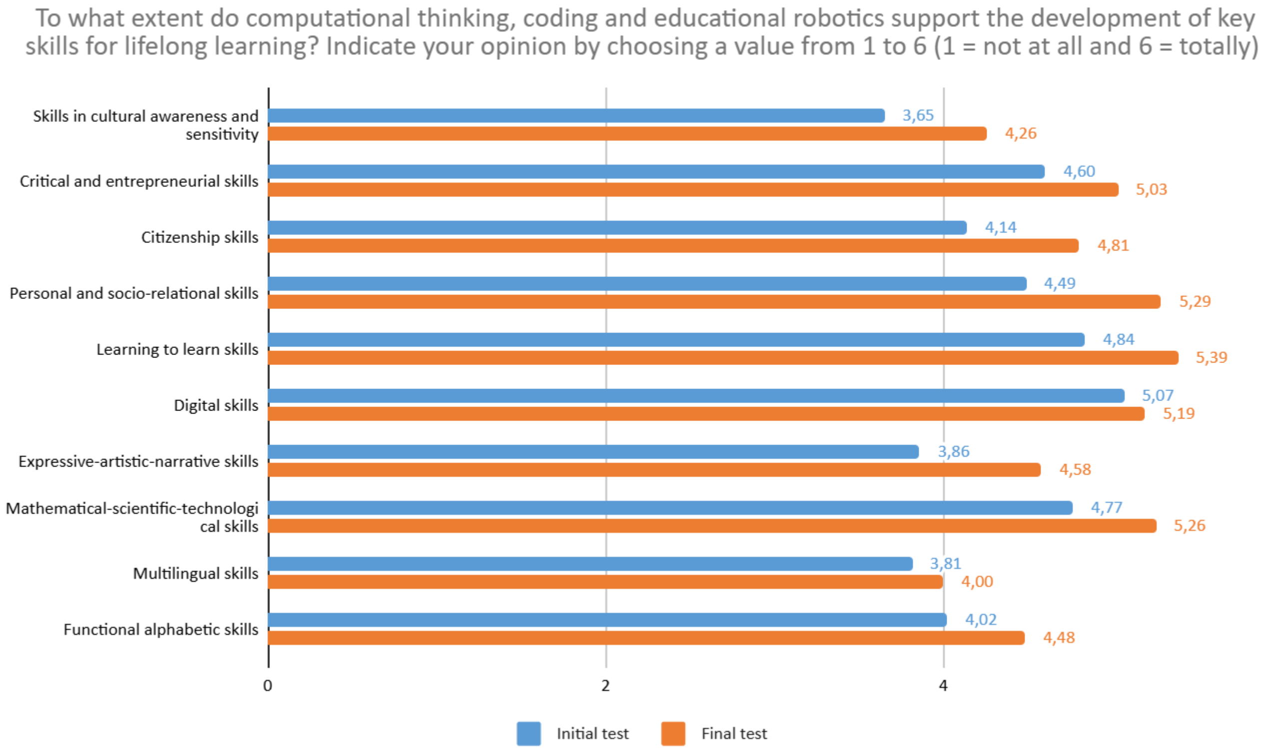
Graphic 5: Skills supported by coding and robotics.

Teachers reported overall improvements across all assessed skills, reinforcing their confidence in the educational value of coding and robotics. The most significant gain concerned critical thinking (from 3.07 to 3.52), highlighting their perceived impact on higher-order cognitive skills. The smallest increase was observed in the ability to generalize and transfer learning (from 3.09 to 3.16), suggesting that broader knowledge transfer may require more targeted support. The overall average score rose from 3.12 to 3.37, reflecting a positive shift in teachers' perceptions, while also pointing to areas—like generalization—that future interventions could strengthen through more explicit real-world connections.



Graphic 6: Developed dimensions.

Teachers reported increased scores across all personal dimensions assessed, confirming the perceived positive impact of coding and robotics. The most significant gain was in the social, relational, and empathic domain (from 2.65 to 3.45), followed by praxic-motor skills (from 2.64 to 3.16). The overall average rose from 2.94 to 3.46. These results suggest that beyond cognitive benefits, coding and robotics also support interpersonal development and hands-on coordination, reinforcing their value in promoting holistic student growth.



Graphic 7: Key competences for lifelong learning.

Teachers confirmed that coding and robotics can enhance lifelong learning skills, with all indicators improving post-intervention. The strongest gain was in expressive-artistic-narrative skills (from 3.86 to 4.58), showing the creative potential of these tools. Socio-relational skills also rose significantly (from 4.49 to 5.29), highlighting benefits in empathy and collaboration. Digital skills improved only slightly (from 5.07 to 5.19), likely due to already high pre-existing confidence. Correlation analyses (Pearson and Spearman) showed that older teachers rated coding and robotics more highly for developing citizenship and cultural awareness. Overall, the intervention supported diverse and often underexplored skill areas, especially creativity and interpersonal growth.

4.2 Logbook (RQ1, RQ3)

The qualitative analysis of teachers' logbooks provided valuable insights into the implementation of the EAS model and coding activities. Five key thematic areas emerged: successes, group dynamics, assessment, challenges, and suggestions for improvement.

1. Success: Teachers consistently reported high student engagement and enthusiasm across all EAS phases. Activities involving tablets, group work, and narrative tasks were particularly effective. Despite some technical challenges (e.g., with Lego Spike), students demonstrated autonomy, curiosity, and collaboration, validating the educational potential of the intervention.

> «The students showed enthusiasm in all phases of the work: story completion, use of the tablet with Wordwall, group work on the grid to arrange the stones to reach Hansel and Gretel's house, and finally the sharing of the work» (1_III_Mathematical-scientific-technological field).

2. Group Dynamics: Effective collaboration was observed, supported by clear role distribution, and structured tasks. Students displayed initiative, leadership, and self-regulation. While occasional conflicts required teacher mediation, the overall cooperative climate facilitated the successful execution of activities.

> «The students, organized in islands, worked while respecting time, roles, and instructions. The class often practices cooperation, which certainly benefited the proposed activity» (6_III_Linguistic field).

3. Assessment: Tools such as checklists and peer/self-assessment strategies were appreciated for supporting observation and reflection. However, several teachers noted their time-consuming nature, suggesting a need for more agile evaluative formats that maintain rigor without overburdening the process.

> «Using the checklists was a valuable support for observation during the various phases» (14_IV_Expressive field).

4. Challenges: The most frequently cited difficulties included time constraints and limited familiarity with some tools. Adapting to these obstacles required flexibility and on-the-spot adjustments, which many teachers managed, though highlighting the need for more planning and training.

> «The biggest challenges were related to using the tool, due to limited knowledge both on my part and the students'» (20_V_Mathematical-scientific-technological field).

5. Future Improvements: Suggestions included diversifying tools to boost engagement, refining the planning phase with clearer instructions and times, and better aligning activities with students' prior knowledge. Several participants stressed the importance of matching tools to student readiness levels and of revisiting the intervention timing across the school year.

> «In future projects, I will aim to propose activities using multiple tools, as I observed this increases students' enthusiasm and participation» (24_IV_Expressive field).

In summary, the EAS model provided a robust pedagogical framework that enhanced engagement and structure. However, its efficacy was closely tied to the teachers' planning capacity and familiarity with the technological tools, indicating the need for sustained support and reflective iteration in future implementations.

5. Discussion

The integration of coding and the EAS methodology revealed valuable insights into teacher development and classroom practice. Teachers increasingly perceived coding not as a technical skill but as a creative and collaborative pedagogical tool, shifting their language from "programmer" to "creative" and "collaborative." This reflects broader research emphasizing coding's role in fostering critical thinking, adaptability, and peer learning (Resnick et al., 2009; Shute et al., 2017).

The training promoted a stronger sense of professional identity and community among teachers, who valued peer support, shared reflection, and increased confidence in implementing innovative strategies. Logbooks confirmed high student engagement, especially during the "production" phase, with notable gains in social and relational skills—aligned with the Spiral of Creative Learning (Resnick, 2018).

Despite evidence of skill transfer, especially in problem-solving, connections to real-world issues were limited. Teachers also reported lower perceived impact on logical-analytical and abstract thinking, indicating a need to better align task complexity with cognitive demands. However, positive group dynamics, mutual support, and students' ability to manage conflict suggest strong potential for coding to support inclusive, empathetic learning.

Challenges included time constraints, technical tool mastery (e.g., Lego Spike), and the burden of assessment tools, which were appreciated but often demanding. Simplified, integrated assessment practices are needed to support teachers without compromising depth.

The study's limitations—small, all-female sample; short intervention duration; limited longitudinal data—suggest cautious interpretation. Yet the findings offer clear implications: coding and EAS can nurture creative, collaborative, and reflective competencies if supported by sustained, practical teacher training. Key recommendations include:

- Expanding hands-on modules and tool practice;
- Providing ready-to-use materials and tutorials;
- Streamlining assessment tools for daily use;
- Encouraging interdisciplinary co-design;
- Framing coding as a pedagogical, not just technical, resource.

Ultimately, successful integration requires not only tools, but a cultural shift toward reflective, collaborative, and creative teaching practices.

6. Conclusions

This study confirms the transformative potential of coding and educational robotics in primary education, particularly when integrated with structured pedagogical models such as EAS. Teachers shifted their perception of coding—from a technical task to a creative, collaborative, and inclusive strategy—and reported greater confidence in experimenting with digital tools. Students showed increased engagement, resilience, and socio-emotional growth, especially in collaborative settings.

However, the findings also point to persistent challenges: time constraints, unfamiliarity with tools, and difficulties in connecting coding to disciplinary and real-world contexts. Addressing these issues requires more structured professional development that moves beyond technical instruction to include pedagogical planning, classroom management, and reflective practices. Equally important is the development of simplified and integrated teaching and assessment tools that ease teachers' workload while maintaining quality standards.

To fully harness the potential of coding in education, three key directions should guide future efforts:

1. Reinforce professional development through blended programs combining theory, hands-on practice, and continuous support;
2. Expand research on interdisciplinary skill transfer and real-world application;
3. Experiment with emerging technologies to increase accessibility and engagement.

The success of such initiatives depends on a systemic approach involving all educational stakeholders. Teachers need ongoing training and institutional support; students should engage actively in creative, reflective learning; and educational communities—families, policymakers, school leaders—must foster an innovation-oriented culture. Coding and robotics should be understood not merely as technical skills, but as pedagogical tools for nurturing critical thinking, creativity, and lifelong learning habits.

Future research should explore long-term impacts, more diverse samples, and direct assessments of student learning outcomes. Framing coding within a broader educational vision will help equip learners with the skills to thrive as creative and critical thinkers in a rapidly evolving world.

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