education sciences

MDPI

Article

Training Education Professionals in Educational Robotics: Findings from the sfera.BOT Project in Italian Schools

Caio Carvalho [1] and Carla Morais [2,*]

[1] Eletrotécnica, Instituto Federal do Norte de Minas Gerais, Porteirinha 39520-000, Brazil; caio.carvalho@ifnmg.edu.br
[2] CIQUP—IMS, Science Teaching Unit, Faculty of Science, University of Porto, 4169-007 Porto, Portugal
* Correspondence: cmorais@fc.up.pt

Abstract

Educational robotics is increasingly recognized as a promising tool for innovation in teaching and learning. However, its successful integration in schools often depends on the availability of targeted professional development programs that support educators with no prior experience in this field. This study addresses this gap by presenting and evaluating the development and implementation of a training program specifically designed to equip educators with the knowledge, skills, and confidence to integrate robotics into early and primary education. The program, sfera.BOT, was designed as part of a regional educational initiative in Basilicata, Italy, and was conceived within T.I. Abilito, a national initiative that promotes educational inclusion; within this broader framework, however, the training pathway examined here was addressed to educators working with all children in mainstream early childhood and primary classrooms, rather than exclusively with children with disabilities. It followed a blended learning model and was grounded in hands-on exploration, collaborative planning, and weekly mentoring sessions. The research employed a qualitative approach to explore the experiences of four female educators from diverse backgrounds who completed the training. Data was collected through semi-structured interviews, a knowledge assessment questionnaire, and field observations. The findings reveal that participants acquired significant technical and pedagogical competencies, shifted from initial insecurity to confident implementation, and began to see themselves as potential trainers and change agents within their schools. Given the small, purposefully selected sample and the specific regional context, these findings are context-rich rather than statistically generalizable. The study underscores how well-structured, practical, and context-aware training can foster continuing professional development in the field of educational robotics.

Keywords: educational robotics; teacher professional development; technology integration; pedagogical innovation; Italian education system

Check for updates

Academic Editor: Mike Joy

Received: 17 April 2026
Revised: 3 August 2026
Accepted: 5 August 2026
Published: 18 August 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

Educational robotics (ER) has progressively evolved from experimental classroom activities to a consolidated field of practice and research. Initially shaped by constructionist perspectives, which emphasize learning through active creation and tangible artifacts (Papert, 1980), ER gained strength with the democratization of programmable kits and low-cost digital technologies. Research consistently shows its potential to promote problem solving, creativity, collaboration, and interdisciplinary connections between science,

technology, engineering, and mathematics (STEM) and other curricular areas (Benitti, 2012; Eguchi, 2016). This versatility extends across educational levels: recent work shows that robotics-based approaches can also support conceptual understanding in tertiary mathematics education, for instance through the construction and visualization of trochoid curves with LEGO-based robots (Körei et al., 2024; Szilágyi et al., 2025).

Beyond technical abilities, ER has been linked to critical thinking, adaptability, and innovation, aligning with the competencies expected for 21st-century learners. Recent reviews and bibliometric studies indicate a sharp rise in ER research after 2018, with growing interest in human–robot interaction, early childhood robotics, and sustainable development goals (Lu et al., 2025).

Despite this potential, the integration of ER into schools remains challenging. Many educators report limited technical knowledge, insecurity about programming, and the absence of pedagogical models that go beyond mechanical assembly or predesigned tasks. Organizational barriers such as scarce resources, insufficient time for experimentation, and weak institutional support also persist (Tondeur et al., 2017; Darling-Hammond et al., 2017). Without adequate and continuous professional development, robotics initiatives often remain superficial or isolated, with little impact on long-term teaching practices.

More recent investigations confirm these barriers: in science and mathematics contexts, educators' self-efficacy frequently remains low despite exposure to robotics (De la Hoz et al., 2026), and large-scale surveys of preschool and primary educators show enthusiasm but also uncertainty about how to embed robotics meaningfully into curricula (Gavrilas et al., 2024).

Professional development (PD) is therefore recognized as essential for the successful adoption of ER. Effective programs tend to combine hands-on experimentation, collaborative design of activities, mentoring, and structured reflection (Desimone, 2009; Darling-Hammond et al., 2017). In ER contexts, successful initiatives often scaffold learning from unplugged activities to robot-based programming, include peer support networks, and adapt content to local contexts and educators' prior experience. Emerging trends also point to the integration of new technologies, such as augmented reality, to enhance robotics-based learning (Pasalidou et al., 2025). These approaches help professionals not only gain technical confidence but also develop pedagogical strategies that make robotics meaningful for diverse classrooms.

In Italy, ER has grown steadily as both a research field and a policy priority. Studies such as those by Agatolio et al. (2017) highlight the enthusiasm of primary-level educators but also their struggles in translating robotics into everyday practice. Menegatti and Moro (2019) examined pilot training programs and underscored the importance of sustained mentoring and collaborative lesson planning. Reports from INDIRE (2020) point to unequal access to robotics resources and professional support across Italian regions, while acknowledging its potential to drive pedagogical innovation. These national developments align with broader European strategies, such as the Digital Education Action Plan 2021–2027 (European Commission, 2020, and Italy's Piano Nazionale Scuola Digitale (MIUR, 2018), which encourage digital transformation and active learning methodologies in schools.

It is within this Italian educational and policy landscape that the sfera.BOT project was developed. The program was conceived within T.I. Abilito, a national initiative in Italy aimed at promoting educational inclusion for children with intellectual disabilities and developmental disorders in contexts affected by educational poverty. Within this broader inclusion-oriented framework, sfera.BOT was designed to integrate educational robotics into mainstream and inclusive classrooms: the specific training pathway examined in this study addressed educators working with all children in early childhood and primary education—often with little or no previous experience in robotics—rather than educators

working exclusively with children with disabilities. It followed a blended learning model combining asynchronous online modules, in-person workshops, collaborative activity planning, and weekly mentoring to support practical implementation in real classrooms. By analyzing the experiences of the educators who completed this program, the present study aims to understand how targeted, practice-oriented, and context-aware professional development can foster both technical and pedagogical growth, strengthen confidence and autonomy, and support the sustainable adoption of robotics in schools.

Beyond this specific training pathway, educational robotics more broadly has an established record as a resource for inclusive and special education: recent scoping evidence indicates its potential to support the participation of autistic students by building on their individual strengths rather than a deficit-oriented approach (Nanou & Karampatzakis, 2023), and targeted interventions using educational robots have shown promising effects on social skills, emotion recognition, and theory of mind in children with neurodevelopmental difficulties (De la Hoz et al., 2026).

Specifically, the research is guided by three main questions:

(1) How does the sfera.BOT training program influence educators' technical and pedagogical competencies in educational robotics?
(2) How does it affect their confidence and autonomy when integrating robotics into classroom practices? and
(3) How do educators perceive the effectiveness and relevance of the program and its digital resources for their professional growth.

To achieve these aims, the study seeks to describe the design and implementation of the sfera.BOT training program, assess the development of educators' technical and pedagogical competencies, evaluate changes in their confidence and autonomy in using robotics, and explore their perceptions of the program's effectiveness and relevance.

2. Materials and Methods

2.1. Research Design

This study employed a qualitative research design to explore the experiences of educators participating in the sfera.BOT training program. A qualitative approach was chosen to gain in-depth understanding of the educators' perceptions, challenges, and successes in integrating educational robotics into their teaching practices. The research design is interpretivist, focusing on the subjective meanings and interpretations that participants bring to their experiences.

2.2. Participants

The participants in this study were four female educators working in early childhood and primary education settings in the Basilicata region, Italy. They were selected from a broader group of twenty professionals who initially took part in the general sfera.BOT training phase. This study adopted an in-depth qualitative design focused on a small number of cases to capture detailed accounts of how training was appropriated and translated into classroom practice across different school contexts. Participant selection was purposeful and based on three criteria: willingness to implement robotics activities in real classrooms, sustained commitment to the training pathway, and availability for follow-up interviews and observations.

This strategy enabled closer documentation of professional learning processes through multiple sources of evidence, including interviews, field observations, and training-related artifacts. At the same time, it may have introduced a positive-selection bias, as participants who were more available and more motivated to implement the project may also have been more likely to report constructive experiences and persist through initial difficulties.

Therefore, the findings are not intended to be statistically generalizable, but rather to provide context-rich insight into the early professional development trajectories of educators with no previous experience in educational robotics. Participant profiles are summarized in Table 1.

Table 1. Participant Profile Overview.

Participant	Age	Academic Background	Professional Role	Experience
A	31	Degree in Psychology; Scientific secondary school with Informatics focus	School psychologist; Works on the project	5–7 years
B	32	Degree in Psychology; Licensed Psychotherapist; Specialized in School and Sports Psychology	School psychologist; Works on the project	6–8 years
C	35	Degree in Literature; Enrolled in Master's program	Home-care assistant; Works only on the project	2–3 years
D	41	Undergraduate degree in Geological Sciences; Currently studying Primary Education	Future primary teacher; Works only on the project	2–3 years

Notes: Participants are identified as A–D to preserve confidentiality. Ages and years of experience are self-reported. Academic backgrounds and roles are summarized from interview and project records.

2.3. Context and the sfera.BOT Training Program

The sfera.BOT was conceived within T.I. Abilito, a national initiative in Italy aimed at promoting educational inclusion for children with intellectual disabilities and developmental disorders in contexts affected by educational poverty. Within this broader framework, sfera.BOT was designed to integrate educational robotics into mainstream and inclusive classrooms through a blended training pathway.

The training program combined in-person meetings, synchronous online sessions, and asynchronous materials. It was organized around four main training sessions and continuous classroom application between them, allowing educators to implement weekly activities and return to subsequent meetings with concrete experiences to discuss and refine. To contextualize the intervention, the sfera.BOT professional development pathway was organized into a sequence of training sessions combining in-person and synchronous online formats. The timeline, formats, and main pedagogical focus of each session are presented in Table 2.

Table 2. Training Sessions Overview.

Date	Format	Focus	Participants/Duration
September 2024	In-person	Intro to robotics and body-based programming	20 professionals/6 h
November 2024	Online (sync)	Project structure and use of official website	4 selected educators/2 h
January 2025	Online (sync + async)	Integration of robotics tools	Same 4 educators/2 h + videos (~1 h)
February 2025	Online (sync)	Storytelling activities with robotics	Same 4 educators/2 h

Notes: Session dates are reported by month/year. "Sync" = synchronous online meeting; "async" = asynchronous materials (e.g., videos/resources). Total duration refers to the training session time and does not include classroom implementation time.

Through implementation, the four educators worked across five schools and seven classrooms, reaching 101 students. Although student learning was part of the process, the analytic focus of this study is on educators' experiences and professional development.

2.4. Digital Platform, Weekly Modules, and Robot Allocation

A central component of sfera.BOT was its official website, which acted as the organizational backbone of the training. Updated weekly, the platform provided downloadable worksheets, activity plans, video tutorials, and a gallery of classroom documentation. It also hosted evaluation forms and FAQs, enabling educators to revisit instructions and troubleshoot independently between synchronous meetings.

The pedagogical trajectory was organized into four phases: (1) six weeks of body-based programming (unplugged activities); (2) three weeks introducing robot-specific operation and basic programming; (3) two weeks introducing storytelling concepts; and (4) seven weeks dedicated to storytelling through robotics, where students coded short narratives using the assigned robot and supporting materials.

Five educational robots were used in the project, distributed by grade level according to developmental appropriateness and interface complexity. Robot allocation is summarized in Table 3, followed by a brief technical-pedagogical description of each platform.

Table 3. Robot Allocation by Class.

Grade Level	Assigned Robot	Main Interaction Mode (Summary)
Infanzia (3–5 years)	Sphero Indi	Screen-free color tiles for directional sequencing
Prima Primaria (6 years)	mTiny	Tap-pen + physical coding cards; maps and thematic boards
Seconda Primaria (7 years)	Tale-Bot	On-body buttons + voice/sound features for sequencing and storytelling
Terza Primaria (8 years)	KaiBot	Physical tiles and/or block-based programming via Kai's Clan
Quarta Primaria (9 years)	VinciBot	Scratch-like programming via mBlock; sensors, LEDs, sound; advanced logic
Pluriclasse (Terza + Quarta)	KaiBot	Flexible use across mixed ages; tactile and digital options

Notes: Grade levels refer to the Italian school system (Infanzia and Primary). Robot allocation reflects the project design; classrooms used the assigned robot as the main device for the weekly activities.

2.5. Data Collection Instruments

To capture educators' experiences comprehensively and to strengthen analytic credibility through triangulation, three complementary instruments were used: (i) unstructured observations recorded as field notes throughout the implementation; (ii) semi-structured interviews conducted after the implementation phase; and (iii) a post-course knowledge assessment questionnaire focusing on tool-specific technical understanding.

2.5.1. Unstructured Observations and Field Notes

Unstructured observations were conducted during training sessions and school-based implementation activities. Field notes were written without a predefined template, aiming to document spontaneous events, classroom dynamics, educators' decision-making, and adaptation strategies. Following guidance for ethnographic-style field documentation, notes captured both descriptive elements (e.g., organization of groups, robot usage patterns) and analytic memos (e.g., emerging interpretations, tensions, and questions). This instrument was particularly useful for identifying how educators' confidence evolved in real time and how they negotiated constraints such as time, space, device sharing, and technical failures.

2.5.2. Semi-Structured Interviews

Individual semi-structured interviews were conducted with the four educators in March 2025 after completion of the classroom modules. The interview protocol explored participants' initial expectations, perceived learning trajectory, confidence and problem-solving experiences, evaluation of the training structure and digital resources, perceived student engagement, and future intentions to continue robotics practices. All interviews were audio-recorded with consent and transcribed verbatim for analysis.

2.5.3. Knowledge Assessment Questionnaire

A short knowledge assessment questionnaire was administered after the interviews to evaluate educators' technical understanding of the robotic tools used in the project. The instrument included ten multiple-choice and true/false questions organized by robot type (KaiBot, VinciBot, Sphero Indi, mTiny, and Tale-Bot). Items assessed three domains: (a) basic robot functioning, (b) programming concepts and command execution, and (c) practical classroom applications. Participants completed the questionnaire individually (estimated 25–30 min). The objective was not statistical generalization, but a structured complement to qualitative evidence regarding technical learning. The questionnaire was developed by the project team specifically for this study and was not subjected to a formal psychometric validation process (e.g., expert panel review, pilot testing, or reliability analysis); this is addressed as a limitation in Section 4.5.

2.6. Data Analysis

Interview transcripts and observational field notes were analyzed using a category-based thematic approach (Elo & Kyngäs, 2008; Emerson et al., 2011; Nowell et al., 2017). The analysis combined deductive alignment with the research questions, which served as initial main categories, with inductive coding that allowed unanticipated themes to emerge from the data. The analytic process followed six iterative stages: familiarization with the full dataset; initial coding; grouping of codes into candidate themes; review and refinement of themes across sources; definition and naming of themes; and synthesis of interpretive findings.

Coding was conducted by the first author, who worked across interview transcripts and field notes in parallel to preserve connections between reported experiences and observed practices. To support analytic transparency and consistency, a categorization matrix was developed for interviews and for observations, presented in Tables 4 and 5 respectively. These matrices functioned as coding guides, mapping main categories, subcategories, and typical indicators. Throughout the process, repeated readings, constant comparison across participants and data sources, and analytic memos were used to refine category boundaries and avoid overreliance on isolated statements.

Questionnaire responses were analyzed descriptively, summarizing performance across domains to identify strengths and gaps. Trustworthiness was strengthened through triangulation across interviews, classroom observations, and questionnaire results. In addition, selected excerpts and emerging interpretations were discussed with a second researcher during the analysis process, allowing for critical review and refinement of category definitions. Reflexive notes were also maintained during data collection and analysis to document emerging assumptions, interpretive decisions, and possible sources of researcher influence. Because this was a small-scale qualitative study centered on contextual understanding, the aim of the analysis was not statistical generalization, but the production of credible, well-supported interpretations grounded in converging evidence from multiple sources.

Table 4. Categorization Matrix for Semi-Structured Interviews.

Main Category	Subcategories	Examples of Indicators in the Data
A. Knowledge and Skills Acquired	A.1. Technical knowledge; A.2. Pedagogical adaptation	Ability to operate robots; use of coding concepts; activity design by age group
B. Confidence and Problem-Solving	B.1. Confidence growth; B.2. Handling technical challenges; B.3. Pedagogical flexibility	Self-assurance; troubleshooting; adapting plans under constraints
C. Evaluation of Training Structure	C.1. Perceived strengths; C.2. Platform/resources; C.3. Suggestions	Feedback on sessions; usability of website/materials; requests for support
D. Plans and Goals	D.1. Immediate implementation; D.2. Long-term aspirations	Intent to continue robotics; intention to train others; collaboration plans
E. Emerging Themes	E.1. Child engagement; E.2. Professional identity; E.3. Inclusion; E.4. Unforeseen challenges	Surprise at student reactions; identity shift; equity/access; new teaching reflections

Notes: The interview matrix combines categories derived from the research questions with inductive subcategories refined during coding.

Table 5. Categorization Matrix for Observational Data (Field Notes).

Category	Examples of Indicators in Field Notes
A. Autonomy and Confidence	Independent robot operation; initiative in activity design; self-directed troubleshooting
B. Peer Collaboration	Mutual support; strategy sharing during mentoring; collaborative planning
C. Pedagogical Adaptation	Adjustments to age level; inclusion-oriented modifications; pacing decisions
D. Child Engagement	High participation; spontaneous interaction; collaborative problem solving
E. Reflective Practice	Educator insights about learning; links to broader teaching goals; reflective dialogue

Notes: Observational categories supported triangulation by linking real-time classroom evidence to interview themes.

3. Results

3.1. Results from Post-Course Interviews

Interview data provides a detailed account of how educators interpreted the training experience, how they developed confidence in classroom implementation, and how their professional perspectives shifted throughout the project. Across participants, educational robotics was initially framed as unfamiliar territory, but also as a motivating opportunity for growth. Participant A described it as "a totally new world for me" and emphasized that, despite a general interest in technology, educational robotics had been "a completely unknown topic" before the project. Participant D similarly stated that the training was very positive because she "didn't know the world of educational robotics" and had essentially started "from scratch" (Participants A and D, personal communication, March 2025).

A central theme in the interviews was the importance of hands-on exploration during training. Participants repeatedly stressed that physically handling the robots was more effective than theory alone in helping them understand how the tools worked and what they could do pedagogically. Participant A considered in-person use of the robots "perhaps the most effective way to learn," while Participant D emphasized the importance of being able to "touch with my own hands the various robots" to discover their functioning and potential. Participant B further linked this learning to pedagogical reasoning, noting that

understanding coding helped her see that the robot only becomes educationally meaningful when the educator gives it goals and structure, rather than treating it as a mere toy.

The interviews also revealed a clear confidence trajectory from insecurity to growing autonomy. Participant C explicitly described herself as "a more insecure person" and admitted being "a little scared" at the beginning, especially when asked to implement robotics activities in school after a short initial training period. Over time, however, she reported feeling "much more confident" and able to work more fluently. Participant A echoed this progression, explaining that she initially felt intimidated when returning to the robots after training, but later came to feel "very confident" and "knowledgeable on the subject." This shift was also associated with a better understanding of how to prepare activities rather than simply operate the devices.

Participants described technical and pedagogical challenges not as reasons for abandoning the activities, but as situations that gradually became manageable through experience. Participant C, for example, recounted an episode in which VinciBots appeared to malfunction because they were discharged even though they still turned on; she also described connection problems when multiple robots paired with the wrong tablets. Importantly, she explained that, after encountering these issues, she and the students developed routines that made classroom management easier. Participant D, in turn, emphasized that the main challenges were often not the robots themselves, but conflicts among children during group work, especially when collaboration and turn-taking were required. These accounts suggest that autonomy develops not only through technical familiarization, but also through repeated pedagogical decision-making in real classroom conditions.

Another recurring theme was that participants increasingly saw robotics as a pedagogical resource capable of integrating multiple domains of learning. Participant D argued that robotics made it possible to work simultaneously on laterality, colors, and shapes "with a single activity," while Participant B highlighted its inclusive value, noting that robotic activities could place children with and without disabilities on a more equal footing because everyone began by exploring something new. In this sense, educational robotics was not described merely as an engaging tool, but as a flexible pedagogical environment that supported cognitive, social, and inclusive learning goals.

Participants repeatedly mentioned the usefulness of weekly materials and visual scaffolds. Participant C described a practical challenge that illustrates the role of scaffolding: "The cards helped, but the moment you add the tablet, it gets more complicated. . . it took more time" (Participant C, personal communication, March 2025). In general, educators valued the predictability of weekly modules, the availability of tutorial videos, and the ability to revisit instructions on the platform when doubts emerged.

Beyond implementation, interviewees expressed intentions to continue ER activities and to share practices with colleagues. For several participants, the project was framed as a professional turning point that expanded what they believed they could do in school contexts, including the possibility of leading future training or supporting other educators.

3.2. Results from Observational Data (Field Notes)

Observational field notes provided in situ evidence of how educators progressively translated training into classroom action. In line with the observational categorization matrix (Table 5), the notes documented changes in autonomy and confidence, peer collaboration, pedagogical adaptation, child engagement, and reflective practice across the implementation period.

The first recurrent pattern was the visible transformation from initial insecurity to greater confidence and autonomy. Across visits conducted between December 2024 and February 2025, field notes indicated that educators became increasingly able to manage ac-

tivities independently, respond to classroom unpredictability, and solve practical problems without interrupting the pedagogical flow. In the primary school classes led by Participant C, for example, observations recorded her effective adaptation when VinciBot presented difficulties, a pattern that aligned with the broader impression of growing technical autonomy across the project.

A second important pattern concerned pedagogical adaptation and inclusion. The observations showed that educators did not apply activities in a rigid way; rather, they adjusted them to the developmental characteristics of each class and to the specific needs of individual students. In Participant C's classes, children with autism spectrum conditions and behavioral difficulties showed notable engagement during robotics sessions, and creative solutions were identified to support participation. In Participant D's early childhood group, body-based activities before robot programming proved especially effective in helping children understand sequences and follow instructions. In the classes observed with Participant A and Participant B, field notes highlighted creative adjustments designed to include all learners and strong classroom management during group tasks.

Child engagement was one of the most consistent findings across the field notes. Students showed marked enthusiasm for robotics activities, sustained attention, and collaborative involvement during group work. In the primary school visits, the notes emphasized a collaborative atmosphere among students, as well as visible progress in spatial understanding and sequencing-related concepts. In the early childhood context, children initially focused on the visual appeal of the robots but quickly moved toward more structured participation when the activities were scaffolded through movement and simplified instructions. These patterns suggest that engagement was not limited to novelty effects but was sustained through meaningful participation in age-appropriate tasks.

The observations also documented the emergence of a broader community of practice around the activities. Regular teachers, who at first often remained more distant, gradually became more curious and participatory, asking questions about how robotics could be connected to other curricular areas or joining the sessions more actively. This was particularly visible in the primary school contexts, where regular and assistant teachers increasingly supported the sessions and showed interest in how robotics might be used beyond the project itself.

Finally, field notes suggested that classroom implementation generated reflective professional learning rather than mere task completion. Through the observation period, educators demonstrated increasing capacity to adapt storytelling to their specific groups, transfer strategies between contexts, and develop innovative pedagogical uses for robotics. In the storytelling phase, all four educators were able to tailor narrative work to their classes: Participant A integrated digital narrative elements, Participant B used psychologically informed approaches in story construction, Participant C found ways to include nonverbal children, and Participant D adapted stories to work with mathematical concepts in early childhood education. Taken together, these observations reinforce the interpretation that sfera.BOT supported not only technical familiarization, but also the development of context-sensitive pedagogical judgment.

3.3. Results from the Knowledge Assessment Questionnaire

The post-course knowledge assessment questionnaire provided a structured complement to the interview and observational data by capturing participants' technical understanding after the implementation phase. Across the three domains, Participant A achieved 100% accuracy, Participants B and C achieved 90% overall, and Participant D achieved 80% overall. Performance was strongest in basic functionality and practical applications, while relatively greater variability emerged in programming and command-related items,

consistent with qualitative evidence that abstraction increases when moving from tactile interfaces to block-based environments. Results are summarized in Table 6.

Table 6. Knowledge Assessment Questionnaire Results.

Domain	A	B	C	D
Basic functionality	100	90	100	80
Programming & commands	100	80	90	80
Practical applications	100	90	100	80
Overall	100	90	90	80

Notes: Values are percentages of correct answers. "Overall" corresponds to the mean score across the listed domains for each participant. The questionnaire was administered after the implementation phase.

These results should be interpreted cautiously due to the very small number of participants and the descriptive purpose of the instrument. Rather than serving as a basis for statistical comparison, the questionnaire was used to support triangulation with the qualitative findings. In this respect, the results are broadly consistent with interview accounts indicating increased familiarity with robot functions, improved ability to plan and conduct activities, and continued demand for deeper preparation in programming-related aspects. For example, Participant A and Participant D both expressed interest in receiving more training on programming logic and block-based coding, while Participant B emphasized that understanding coding was central to seeing the robot as a pedagogical tool rather than a mere device.

Taken together, the questionnaire findings reinforce the interpretation that the sfera.BOT pathway supported the acquisition of foundational technical knowledge across participants, while also indicating that programming concepts may require more extended treatment in future iterations of the training.

4. Discussion

4.1. Knowledge and Pedagogical Development Through Educational Robotics

The results indicate that sfera.BOT supported educators' progression from initial technical familiarization to pedagogical use of ER. Rather than treating device operation as an end in itself, participants increasingly framed robotics to support learning goals and classroom narratives. This trajectory aligns with constructionist perspectives emphasizing learning through the creation and manipulation of meaningful artifacts (Papert, 1980) and reinforces evidence that robotics is most effective when embedded in purposeful instructional design (Benitti, 2012).

A notable feature of the program was the staged progression: unplugged sequencing and embodied activities were used to establish the logic of commands before robot interaction, and storytelling was later introduced to broaden robotics beyond STEM-only positioning. This pedagogical choice aligns with approaches that value creative and interdisciplinary connections as a means of fostering more meaningful engagement with scientific and educational content (Araújo et al., 2015; Morais et al., 2019). In practice, educators described planning story elements first and then selecting robot behaviors to enact them, which helped avoid superficial "demo" sessions and supported continuity across weekly modules.

4.2. Autonomy, Confidence, and Problem-Solving in Classroom Implementation

Interview and observational findings converge on a strong trajectory of growing confidence and autonomy. At the beginning of the project, several participants described fear, insecurity, or uncertainty when asked to transfer recent training into real classroom

situations. Participant A stated that she was initially "a little scared" when resuming the robots after the training period, while Participant C described herself as generally insecure when approaching something new and reported being afraid she would not be able to manage the activities effectively in school contexts. Over time, however, both participants described a clear shift toward confidence, fluency, and a greater sense of preparedness.

This development appears to have been supported not only by repeated contact with the robots, but also by the training design itself. Participants repeatedly emphasized that being invited to explore the robots directly, before receiving full explanations, helped them become less dependent on rigid instructions and more able to deal with unexpected situations. Participant B, for example, explained that having the robots "in our hands without telling us anything, just to explore them" helped her later when facing technical difficulties in practice. This is consistent with professional development research showing that confidence tends to grow when learning is sustained, practice-based, and connected to creative and authentic implementation rather than restricted to isolated workshops (Desimone, 2009; Darling-Hammond et al., 2017).

Problem-solving also emerged as an important dimension of autonomy. In the interviews, Participant C described concrete classroom difficulties such as VinciBots that appeared to malfunction because they were discharged despite still turning on, as well as connection problems when multiple robots paired with the wrong tablets. Importantly, these experiences did not lead to withdrawal; instead, they contributed to the development of new classroom routines, such as turning on and pairing robots one group at a time. Observational notes similarly documented increasing technical independence across the implementation period and a visible transformation from initial insecurity to confidence and autonomy.

At the same time, the findings suggest that confidence did not mean complete control over every classroom variable. Participant D, for instance, distinguished clearly between understanding how the robots worked and managing interpersonal conflicts among children, especially in group work. This distinction is analytically important because it shows that robotics implementation in school settings depends not only on technical competence, but also on broader pedagogical judgment, classroom management, and the ability to respond flexibly to social dynamics. In this sense, autonomy in sfera.BOT was not simply technical mastery; it was the gradual development of a professional stance capable of integrating technical knowledge, planning, troubleshooting, and facilitation.

4.3. Pedagogical Adaptation, Inclusion, and Reflective Practice

The findings indicate that pedagogical adaptation and inclusion were central dimensions of implementation rather than secondary outcomes. Across interviews and field observations, educators described and demonstrated continuous efforts to tailor activities to the developmental characteristics of their groups, to behavioral and communication differences among children, and to the practical conditions of each classroom. This was visible in the use of body-based sequencing activities before programming, visual supports, differentiated pacing, and modifications in how storytelling tasks were organized.

Inclusion was especially salient in participants' reflections on children with specific support needs. Participant C reported that the storytelling preparation phase could be more limiting for a non-verbal autistic child, since the writing and story invention stages did not afford the same forms of participation as robot interaction. At the same time, she emphasized that the team continually tried to find alternative ways for all children to contribute. Observational notes reinforce this interpretation by documenting creative adaptations for inclusion, strong engagement among children with autism spectrum conditions

and behavioral difficulties, and the use of alternative forms of participation in both primary and early childhood settings.

The data also suggests that participants increasingly understood robotics as a flexible pedagogical environment rather than a fixed technological script. Participant D, for example, stressed that robotics allowed children to work simultaneously on laterality, colors, shapes, and logic through a single activity, while Participant B emphasized that the educator's role is to define the goal and pedagogical meaning of the robot's actions. This shift is significant because it suggests movement beyond instrumental use of the devices toward more intentional pedagogical design, in line with the idea that robotics become educationally powerful when integrated into broader meaning-making processes (Di Battista et al., 2020; Agatolio et al., 2017). Such an interpretation is also consistent with previous evidence indicating that meaningful and participatory educational experiences may contribute to stronger student engagement and more positive attitudes toward science-related learning (Araújo et al., 2021).

A related outcome was the emergence of reflective practice. Field notes documented educators' growing ability to explain why certain adaptations worked, how group organization affected participation, and how the same robotics tool could be redesigned for different ages and needs. During the storytelling phase, each educator appeared to appropriate the proposal differently: Participant A integrated digital narrative elements, Participant B drew on psychologically informed approaches, Participant C sought ways to include non-verbal children, and Participant D adapted stories to support mathematical concepts in early childhood education. These patterns suggest that the program fostered not only adoption of robotics activities, but also reflective pedagogical judgment about how to adapt them meaningfully in context.

4.4. Perceptions of the Training Design and Digital Tools

Participants' evaluations highlight the importance of a training design that reduced entry barriers for novices while maintaining continuity between training and classroom action. Across interviews, educators valued not only the content of the program, but also the way it was organized: the combination of in-person exploration, synchronous discussion, weekly online modules, and access to a structured website created a support system that helped them move from uncertainty to implementation.

Hands-on exploration emerged as the most valued training feature. Participant A and Participant D both emphasized that physically using the robots was more effective than theory alone for understanding their potential, and Participant B similarly explained that exploratory contact with the devices helped her later when she had to solve technical difficulties independently. At the same time, participants did not reduce the value of the program to the robots themselves. Participant B, for instance, stressed that the weekly discussion moments were fundamental because they allowed participants to share critical issues and reflect collectively on the implementation process.

The digital platform was evaluated positively as a just-in-time support resource. Participant D described the website as something that "practically saved" her when she was initially unsure how to begin, and Participant A characterized the modules as intuitive and easy to follow. These perceptions are important because they indicate that the platform functioned as an accessible organizational backbone rather than as a passive repository of materials. It allowed educators to revisit instructions, recover pacing, and maintain continuity between meetings and classroom sessions (Castro et al., 2018; de Oliveira et al., 2023; Ronsivalle et al., 2019).

However, the interviews also suggest that digital resources worked best when complemented by human support and practical experimentation. Some participants felt that

more time could have been devoted to certain robots or to programming concepts, especially block-based logic and algorithmic thinking. This suggests that the strength of the sfera.BOT design lay not in the blended format alone, but in how asynchronous resources, synchronous meetings, mentoring, and hands-on experimentation worked together. In that sense, the platform did not replace interaction with trainers and peers; rather, it extended the learning environment and helped sustain educators' engagement between formal sessions (Paiva et al., 2017; Redecker & Punie, 2017).

4.5. Limitations and Future Research

This study should be interpreted considering several limitations. First, it is based on an in-depth qualitative exploration of only four educators, purposefully selected from a larger trained group. Although this design enabled close documentation of professional learning processes and classroom implementation, it may also have overrepresented participants who were more available, more motivated, and more willing to persist through challenges. As a result, the findings should be understood as context-rich and exploration rather than broadly generalizable.

Second, the study is situated within a specific regional initiative in Basilicata, Italy, and within a particular support structure that included mentoring, weekly modules, and access to shared digital resources. These contextual conditions may have influenced both the implementation process and participants' perceptions, limiting direct transferability to settings with different institutional support, time availability, or resource access.

Third, the analysis relied primarily on educators' interviews, observational field notes, and a post-course knowledge assessment questionnaire. While triangulation across these sources strengthened the credibility of the findings, the study did not include standardized pre- and post-measures, a comparison group, or long-term follow-up data on sustainability. The knowledge assessment questionnaire, in particular, was developed for this study and has not undergone formal psychometric validation; its results should therefore be read as a descriptive complement to the qualitative evidence rather than as a validated measure of technical competence. Likewise, although student engagement and participation were observed, the design was not intended to measure student learning outcomes systematically.

Future research could extend this work by including larger and more diverse samples, following participants over longer periods, and combining qualitative approaches with more structured measures of technical competence, pedagogical change, and student-level outcomes. Comparative or mixed-method designs could also help clarify which aspects of robotics professional development—such as mentoring, hands-on exploration, digital platforms, or storytelling integration—are most influential in supporting sustainable adoption in school contexts.

5. Conclusions

This study examined how a structured blended training program supported early childhood and primary education professionals in adopting educational robotics as a pedagogical tool. Across interviews, field observations, and a post-course knowledge assessment, results indicate that educators acquired core technical and pedagogical competencies, developed confidence and problem-solving routines for real classroom constraints, and perceived the program's structure and resources as highly supportive.

Regarding the first research question, educators improved their ability to operate multiple robotic platforms and to design developmentally appropriate activities, progressively moving from simple sequencing toward expressive storytelling tasks. Regarding the second research question, participants reported a clear confidence shift: initial insecurity gave way to greater autonomy, with educators reframing technical failures as learning

opportunities and adopting a facilitator role in classroom exploration. Regarding the third research question, educators evaluated the blended structure, mentoring cycle, and digital platform as effective support for continued professional growth, and several expressed intentions to sustain robotics practices and to support colleagues in future implementations.

Overall, the sfera.BOT experience suggests that educational robotics training can function as a catalyst for pedagogical innovation when it is contextualized, hands-on, aligned with educators' realities, and supported by accessible resources that enable continuous practice between training sessions.

Author Contributions: Conceptualization, C.C. and C.M.; methodology, C.C. and C.M.; formal analysis, C.C.; investigation, C.C.; data curation, C.C.; writing—original draft preparation, C.C.; writing—review and editing, C.C. and C.M.; visualization, C.C.; supervision, C.M.; project administration, C.C. and C.M. All authors have read and agreed to the published version of the manuscript.

Funding: The study was supported by national funds through FCT—Fundação para a Ciência e a Tecnologia, I. P., under the projects of the Chemistry Research Center of the University of Porto (CIQUP) (UID/00081/2025, UID/PRR/00081/2025 and UID/PRR2/00081/2025), IMS (Institute of Molecular Sciences) (LA/P/0056/2020) and IFIMUP (UID/04968/2025).

Institutional Review Board Statement: Ethical review and approval were waived for this study because it involved minimal risk educational research with adult participants, with no collection of sensitive personal data beyond professional experiences, and with all data anonymized prior to analysis. The study was conducted in accordance with the Declaration of Helsinki and applicable data protection regulations.

Informed Consent Statement: Written informed consent was obtained from all subjects involved in the study. Participants consented to audio recording of interviews and to the use of anonymized quotations in publications. No identifiable information about participants or schools is reported.

Data Availability Statement: The datasets generated and analyzed during the current study are not publicly available due to privacy and confidentiality restrictions, as they include interview recordings/transcripts and field notes from a limited number of participants in identifiable institutional contexts. De-identified aggregated data and supporting materials (e.g., coding framework excerpts or anonymized excerpts) may be made available from the corresponding author upon reasonable request, subject to ethical and data protection constraints.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

ER	Educational Robotics
PD	Professional Development
ICT	Information and Communication Technologies
STEM	Science, Technology, Engineering and Mathematics
SDGs	Sustainable Development Goals

References

Agatolio, F., Pivetti, M., Di Battista, S., Menegatti, E., & Moro, M. (2017). A training course in educational robotics for learning support teachers. In D. Alimisis, M. Moro, & E. Menegatti (Eds.), *Educational robotics in the context of the maker movement* (pp. 3–14). Springer. [CrossRef]

Araújo, J. L., Morais, C., & Paiva, J. C. (2015). Poetry and alkali metals: Building bridges to the study of atomic radius and ionization energy. *Chemistry Education Research and Practice*, *16*(4), 893–900. [CrossRef]

Araújo, J. L., Morais, C., & Paiva, J. C. (2021). Students' attitudes towards science: The contribution of a citizen science project for monitoring coastal water quality and (micro)plastics. *Journal of Baltic Science Education*, *20*(6), 881–893. [CrossRef]

Benitti, F. B. V. (2012). Exploring the educational potential of robotics in schools: A systematic review. *Computers & Education*, *58*, 978–988. [CrossRef]

Castro, E., Cecchi, F., Salvini, P., Valente, M., Buselli, E., Menichetti, L., Calvani, A., & Dario, P. (2018). Design and impact of a teacher training course, and attitude change concerning educational robotics. *International Journal of Social Robotics*, *10*, 669–685. [CrossRef]

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Learning Policy Institute.

De la Hoz, A., Ceballos, E., & Cubero, J. (2026). Therapeutic effect of educational robotics on neurocognitive and social skills in two case studies of children with neurodevelopmental difficulties. *Disabilities*, *6*, 13. [CrossRef]

de Oliveira, D. S., Garcia, L. T. S., & Gonçalves, L. M. G. (2023). A Systematic review on continuing education of teachers for educational robotics. *Journal of Intelligent & Robotic Systems*, *107*, 24. [CrossRef]

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181–199. [CrossRef]

Di Battista, S., Pivetti, M., Moro, M., & Menegatti, E. (2020). Teachers' opinions towards educational robotics for special needs students: An exploratory italian study. *Robotics*, *9*, 72. [CrossRef]

Eguchi, A. (2016). RoboCupJunior for promoting STEM education, 21st century skills, and technological advancement through robotics competition. *Robotics and Autonomous Systems*, *75*, 692–699. [CrossRef]

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*, 107–115. [CrossRef] [PubMed]

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (2011). *Writing ethnographic fieldnotes* (2nd ed.). University of Chicago Press.

European Commission. (2020). *Digital education action plan 2021–2027: Resetting education and training for the digital age* [COM(2020) 624 Final]. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0624 (accessed on 13 February 2026).

Gavrilas, L., Kotsis, K. T., & Papanikolaou, M.-S. (2024). Exploration of the prospective utilization of educational robotics by preschool and primary education teachers. *Pedagogical Research*, *9*(1), em0181. [CrossRef] [PubMed]

INDIRE. (2020). *Coding e robotica*. Istituto Nazionale di Documentazione, Innovazione e Ricerca Educativa.

Körei, A., Szilágyi, S., & Vaičiulytė, I. (2024). An educational robotics approach to drawing and studying central trochoids at the university level. *Sustainability*, *16*, 9684. [CrossRef]

Lu, S., Nuryana, Z., Ni, X., Xu, W., & Alias, M. N. (2025). A decade of educational robotics: Trends and SDG contributions. *Humanities and Social Sciences Communications*, *12*, 1356. [CrossRef]

Menegatti, E., & Moro, M. (2019). *Robotica educativa 2019: Corso di apprendimento permanente per insegnanti*. Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Padova.

Ministero dell'Istruzione, dell'Università e della Ricerca (MIUR). (2018). *Piano nazionale scuola digitale: Azioni per l'innovazione didattica e digitale*. MIUR.

Morais, C., Araújo, J. L., & Saúde, I. (2019). Awakening to chemistry through storytelling and practical activities: Middle school students interacting with pre-school children. *Chemistry Education Research and Practice*, *20*(1), 302–315. [CrossRef]

Nanou, A., & Karampatzakis, D. (2023). The participation of students with autism in educational robotics: A scoping review. *Social Sciences*, *12*, 675. [CrossRef]

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, *16*, 1609406917733847. [CrossRef]

Paiva, J., Morais, C., & Moreira, L. (2017). Activities with parents on the computer: An ecological framework. *Journal of Educational Technology & Society*, *20*.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. Basic Books.

Pasalidou, C., Lytridis, C., Tsinakos, A., & Fachantidis, N. (2025). Augmented reality and robotics in education: A systematic literature review. *Computers in Human Behavior: Artificial Humans*, *4*, 100157. [CrossRef]

Redecker, C., & Punie, Y. (2017). *European framework for the digital competence of educators: DigCompEdu*. Publications Office of the European Union.

Ronsivalle, G. B., Boldi, A., Gusella, V., Inama, C., & Carta, S. (2019). How to implement educational robotics' programs in Italian schools: A brief guideline according to an instructional design point of view. *Technology, Knowledge and Learning*, *24*, 227–245. [CrossRef]

Szilágyi, S., Körei, A., & Vaičiulytė, I. (2025). Teaching and learning trochoid curves: The importance of LEGO drawing robots and educational robotics in tertiary mathematics education. *Education Sciences*, *15*, 1472. [CrossRef]

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Educational Technology Research and Development*, *65*(3), 555–575. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.