Educational Robotics for Inclusive Design

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Abstract. This research stems from the need to prepare future teachers to design digital inclusive teaching. The contribution thus presents a distance training course on Coding and Educational Robotics (ER) for pre-service support teachers (PSSTs). The aim was not only to enhance PSSTs' digital skills but mainly to foster their ability to design for all, using technologies in an inclusive perspective. Trainers supported them without offering predefined work packages. They stimulated PPSTs to become experimenters and researchers to identify functional paths for the introduction of coding-ER in their future curricular teaching. We investigated the evolution of PSSTs' basic knowledge and self-confidence on coding-ER tools and methodologies and their beliefs on their introduction to PSSTs' education. We finally detected their satisfaction with this training course. From the results, the training proved to be effective, despite the distance implementation and the lack of an embodied approach. The PSSTs showed a greater self-confidence and a higher awareness about the benefits of ER. They also demonstrated a conscious use of tools and a focus on inclusiveness in the design of learning paths. We can identify the following as success factors: the strong interaction between participants supported by the course structure; the continuous feedback from both peers and trainers; the possibility to experiment in groups and share successes and failures. These positive results have also led to a greater awareness of the role of support teachers in the complexity of classroom life.

Keywords: Educational robotics · Pre-service teachers · Teacher training · Inclusive didactic · Kindergarten

1 Introduction

This research stems from the need to prepare future teachers to design digital inclusive teaching. The use of robots can enable the structuring of play activities accessible to all, aimed at learning and cognitive, affective and social development, even for pupils with different types of disabilities [1]. The contribution thus presents a distance training course on Coding and Educational Robotics (ER) for pre-service support teachers

This paper stems from the collaborative work of the authors. Specifically, Francesca Gratani is the author of paragraphs 2 and 3; Lorella Giannandrea is the author of paragraph 1; Alessandra Ranieri is the author of paragraph 4. Abstract, conclusions and references have been written collaboratively.

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(PSSTs). Our aim was not only to enhance PSSTs' digital skills, gaining new tools and methodologies but mainly to foster their ability to design for all. Specifically, we wanted to promote an autonomous and critical attitude in designing teaching activities using technology. Participants experienced an active training mode. Trainers supported them without offering predefined work packages. They stimulated PPSTs to become experimenters and researchers to identify functional paths for the introduction of coding and ER in their future curricular teaching. Robotics activities, indeed, are not limited to a "passive" use of the technological tool; instead, they could be a process of "production" of technology, a task that requires a conscious and critical attitude [2]. Moreover, the Covid-19 emergency led us to face the additional challenge of training teachers on these issues fully online. This has opened up research topics such as new ways of collaborating remotely and being familiar with tools that generally require an embodied/in-person approach.

We investigated the evolution of PSSTs' basic knowledge and self-confidence on coding-ER tools and methodologies and their beliefs on their introduction to PSSTs' education. We finally detected their satisfaction with the training course.

The following paragraphs will present the theoretical framework (par. 2), the methodological design (par. 3), the results (par. 4), and the conclusions (par. 5).

2 Theoretical Framework

Besides the common benefits of other ICT tools, ER is particularly well suited to create the conditions for an inclusive learning environment [3]. The variety of activities made possible by ER allows teachers to design learning opportunities for all. The inclusive force of such activities lies in the possibility of individualizing learning, implementing a path from simple to complex. The student is at the center of the learning process and can work according to its abilities, preferences, and attitudes. Coding and ER can foster problem-solving skills; attentional system and working memory; playfulness; multisensory and multilevel strategies; 'intrinsic' feedback ('low impact' regulation) [4]. In this regard, the "Istituto Tecnologie Didattiche" (ITD-CNR) has carried out several experiences in schools that show how robotics supports the development of students' computational thinking and cognition in playful contexts, through personal design, sharing and discussion [5–7]. Therefore, ER becomes a facilitator and mediator for social, emotional, and imitation skills; cognitive, visual-perceptual, and motor skills; social acceptability; attention and motivation; less stressful approach to the task in a collaborative climate; experience of self-efficacy and self-control [8, 9, 10]. Furthermore, the ability to "customize" robots can be beneficial for a genuinely inclusive approach to educational support [11].

Despite these acknowledged benefits, ER is often introduced in education from a narrow perspective due to the misconception that it is suitable only for science and technology majors and gifted children [12] and the teachers' lack of expertise and self-confidence in ICT [13]. Thus, if curricular teachers must be usually trained to use ICT effectively, there are even stronger reasons and needs to train PSSTs [3]. The aim of teacher training is primarily to enable teachers to build on the educational benefits of ER for providing a learning landscape that fosters curiosity, critical thinking, problem-solving and creativity for learners [14]. Moreover, it is essential to make the support teachers aware of the possibility of easily integrating any ER project designed for special-needs students into a project suitable for the entire class to promote collaboration between them and curricular teachers [3]. Teachers are indeed requested to design and implement activities characterized by multimodality, multidisciplinary and inclusion of students with different abilities or linguistic and cultural difficulties. Therefore, teachers need not only technical support in using robotic tools and software, but also didactic support to design activities that move away from traditional classroom teaching.

3 Methodological Design

The course was part of a specialization course to qualify as a kindergarten support teacher, provided by the University of Macerata. Specifically, it was introduced as a module within the Technology Laboratory that required compulsory attendance.

The next sub-paragraphs will provide a detailed description of the participants (Sect. 3.1), the course activities (Sect. 3.2), and the assessment instruments (Sect. 3.3).

3.1 Participants

During the course's first meeting, we administered an entry questionnaire to collect personal (gender, age) and professional information (educational qualification, employment situation, educational stage and type of teaching, previous training on the topics). The course involved 47 students, predominantly female (97.87%). Almost all of them were more than 30 years old (95.74%) and currently employed, mainly in the educational field (80.85%). The majority were teaching at kindergarten (71.05%), and 44.74% were already working as support teachers, consistent with their chosen specialization address. Data concerning personal and professional information about the sample are summarized in Table 1.

Table 1. Summary of data describing the sample.

Features	Index	Values (%)
Gender	F	97.87
	M	2.13
Age	20–25	2.13
	26–30	2.13
	31–40	25.53
	> 40	70.21
Educational qualification	Diploma Bachelor's degree Master's degree PhD	63.83 6.38 29.79 –

(*continued*)

Table 1. (*continued*)

Features	Index	Values (%)
Currently working	No Yes, in the educational field Yes, in other fields	8.51 80.85 10.64
Teaching educational stage	Nursery Kindergarten Primary school Lower Secondary school Upper Secondary School Other	- 71.05 21.05 - 2.63 5.26
Support teachers	Yes No	44.74 55.26

Finally, 74.47% of PSSTs reported that they had no previous training on the topics. The others stated that they had attended training courses lasting more than 5 h (6.38%), participated in basic experiences lasting less than 5 h (6.38%), or carried out individual training (books, magazines, podcasts, etc.) (10.64%). One participant reported both last two options (2.13%).

3.2 Course Description

The training course was held between March 2021 and April 2021 in fully online mode due to the Covid-19 emergency. It lasted four weeks and consisted of five synchronous meetings for a total of 23 h. We used two platforms adopted by the University: the Microsoft Teams platform for all the meetings and the OLAT LMS platform for all the asynchronous interactions (sharing of materials, notices, and tasks). Every meeting has been recorded, and every material has been shared to create a repository always accessible by participants. Considering the needs and characteristics of the sample, we decided to set the course mainly on group exercises and activities conducted during the meetings. Indeed, participants were primarily student-workers who also engaged in the weekend to attend the specialization course. Furthermore, data from the entry questionnaire showed a low level of knowledge and training related to the topics, which prompted us to provide synchronous support and promote teamwork. The group activities took place in different virtual rooms created in the Teams platform, where trainers could freely access to monitor the process and interact with the participants. Restitution then followed the teamwork in the general room. Table 2 shows the training course schedule.

The course was composed of two phases. The first phase aimed to present and familiarize with some coding and ER tools and methodologies, focusing on kindergarten. In particular, we introduced students to Cody Roby [15], Cody Feet [16], and Cody Color [17], to the Bee-Bot emulator platform [18] and Blue-Bot app, and finally to the ScratchJr software (available both in-app and desktop version) [19]. For each tool, we have shown distinctive features, potentiality, difficulties, and possible learning activities. Regarding the Cody cards, participants had to compose or apply short paths on a grid to solve the task starting from some guide-tracks. We proposed a collective exercise-guide about the Bee-Bot platform and the ScratchJr software usage in the following meetings. Then, we assigned a task to be done individually/in groups. Specifically, using the Bee-Bot simulator, they had to: choose the background (of the grid); create a short story; build a code to make Bee-Bot go through the various stages of the story; take a screenshot that includes the grid and the code; briefly describe the story created. Instead, using the ScratchJr application (from tablet or PC), we required to: customize the character; choose a background; write their name above the background; decide what to make the character do; create a script consisting of (at least) one command per color that makes the character act; take a screenshot that includes the entire ScratchJr window; describe briefly what the character must do. Finally, assignments were uploaded onto OLAT, where we subsequently provided feedback.

The second phase was then dedicated to designing an inclusive learning path for kindergarten pupils based on coding and/or ER. As a preparatory activity, we proposed the creation of a shared database of designs. Each group had to collect examples of instructional designs/activities which used coding and/or ER tools across the various fields of experience. They filled out a table with the following guide-fields: link to the video or resource; section/age of pupils (if indicated); duration; field(s) of experience; type of disability; coding and/or ER tools; annotations (why you chose it, strengths/weaknesses, etc.). Tables were uploaded onto the OLAT platform. Then, we shared the evaluation criteria and provided supporting guidelines for the design of the learning paths. Specifically, participants had to: define the context, the type(s) of disability, the competence(s), the goals and the fields of experience; explain the path highlighting the work phases, what teacher and children do, and the possible strategies, mediator, and evaluation methods; clearly explain the inclusion strategies and the coding and/or ER tools used, describing their characteristics, the reason for the choice and their use. The last meeting then focused on the restitution and evaluation of the projects.

Table 2. The training course schedule.

Meeting	Duration	Activities
I	3 h	*Preliminary Test;* Introduction to *Coding* and *ER;* Presentation of *Cody Roby, Cody Feet, Cody Color*
II	5 h	Individual exercises; Presentation of *Bee-Bot* and *Blue-Bot;* Individual exercises and group activities
III	5 h	Presentation of *Scratch Jr*; Group activities
IV	10 h	Group activity – creation of a *shared database*; Group activity – planning of a *learning path*
V	5 h	Restitution and evaluation, peer and self-evaluation; *Final Test*

3.3 Assessment Instruments

We decided to assess the evolution of three main areas: PSSTs' basic knowledge (K) and self-confidence (SC) on coding-ER tools and methodologies, and their beliefs (B) on the relevance of such training during their education, on the possible introduction of these topics in schools and the importance in terms of inclusiveness. We thus administered two questionnaires, before-course (BC) and post-course (PC), inspired by the work of Scaradozzi and colleagues [20] and reported in [21].

The basic knowledge test (Test K) uses six multiple-choice questions with three answers: correct, partially correct, and incorrect. For each type of answer, we assigned a score: 2-correct, 1-partially correct, 0-incorrect. Four questions are related to Coding, and two questions are related to ER.

The other two areas (SC and B) presented questions structured according to a 10-point Likert scale. Some of them offered an open-ended question to explore the reasons behind the given answer.

The PC questionnaire also detected PSSTs' satisfaction (SAT) with the course organization and schedule, structured like the SC and B questionnaires. We administered the test and the questionnaires through Google Form.

To assess the designed learning paths, we prepared a rubric shared in advance with the participants. This rubric focused on the following descriptors: age pertinence; time pertinence; originality; correct use of tools; conscious use of tools; inclusiveness; internal consistency. Those criteria were shared in advance with the participants. We reported the descriptors on a Google form with 5-point Likert scale questions. This form was used during the restitution meeting by the trainers and the participants themselves. In this way, we collect an "external evaluation" (made by trainers and the participants that evaluated the learning paths made by other groups) and an "internal evaluation" (each group self-evaluated its learning path).

4 Results

4.1 Course Results

Data from K-Test and SC-B BC and PC questionnaires were recorded, and statistical analysis was carried out using RStudio (v 1.4.1103).

As we reported in [21], the answers of each participant in the K-BC and K-PC tests were classified into three classes: basic (zero/one correct answer), medium (few correct answers) and advanced (all correct answers). For SC (BC-PC) and B (BC-PC), since SC and B are more complex constructs, we discretized and divided data into five classes (levels): very low level (class I), low level (II), medium level (III), good level (IV), very good level (V). We tested the difference between BC and PC to verify the training effectiveness. We decided to verify the differences by separating Coding and ER questions to analyze the improvements better.

We tested the difference between BC and PC to verify the training effectiveness, using the McNemar-Bowker test (H0: no correlation between variables, rejected with p-value < 0.05).

This procedure reported a statistically significant difference from all BC-PC questionnaires (p-value $< 0{,}001$ for each test) (Fig. 1).

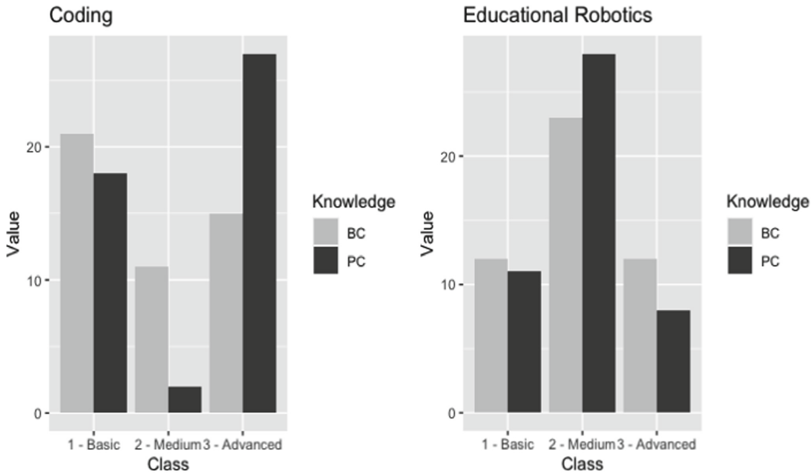

Fig. 1. Histogram reporting data from tests K-BC (light grey) and K-PC (dark grey) related to Coding and Educational Robotics.

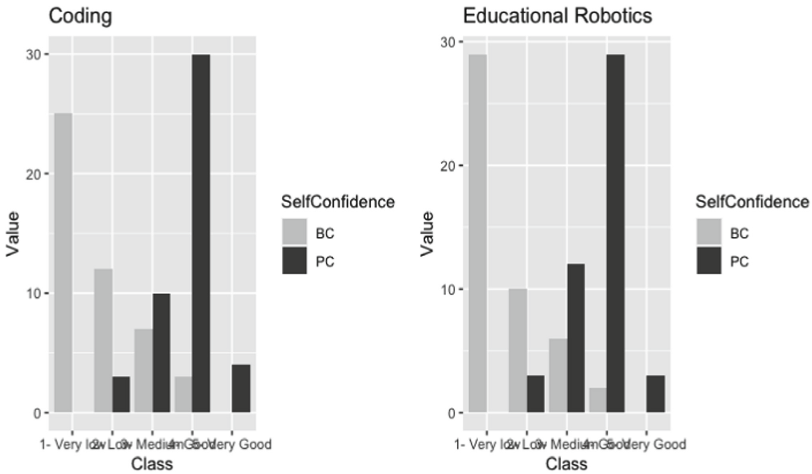

Fig. 2. Histogram reporting data from questionnaires SC-BC (light grey) and SC-PC (dark grey) related to Coding and Educational Robotics.

Unfortunately, we cannot confirm the statistically significant difference between all pairs of classes except between class I and class IV in SC-ER (BC-PC) and SC-C (BC-PC) ($p < 0,000274$) (Fig. 2).

In B1-BC (Fig. 3), almost all PSSTs highlighted the benefits of this kind of training during PSSTs' education (91.49%). The majority motivated the importance of setting up educational, challenging, future-oriented activities for students (36.17%) and staying updated (21.28%); only 6.38% talked about inclusiveness. In B1-PC, almost all PSSTs

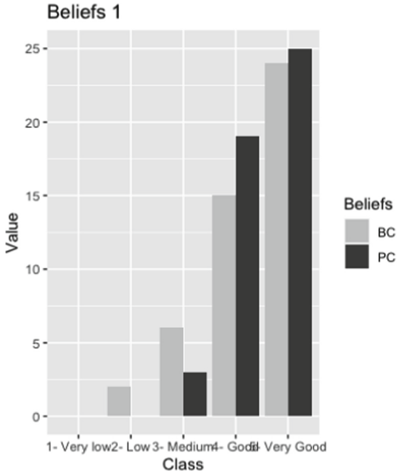

Fig. 3. Histogram reporting data from questionnaires B1-BC (light grey) and B1-PC (dark grey) related to the relevance of this kind of training during PSSTs' education.

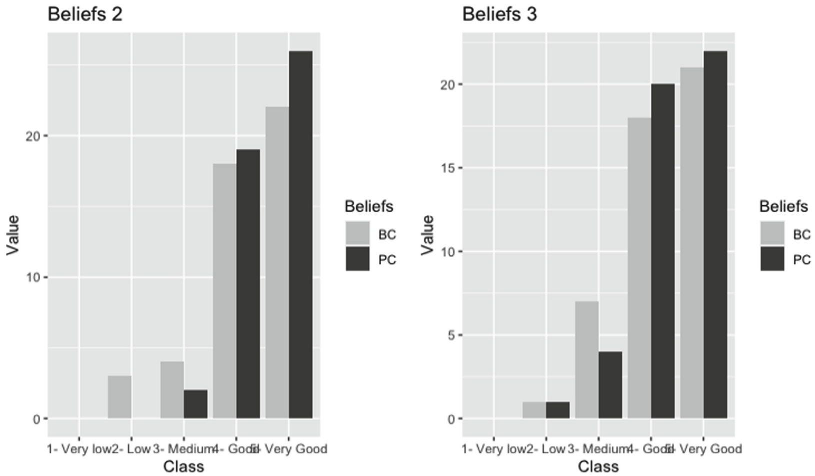

Fig. 4. Histograms reporting data from questionnaires B2-BC (light grey) and B2-PC (dark grey) related to the relevance of the possible introduction of these topics in schools and from questionnaires B3-BC (light grey) and B3-PC (dark grey) related to the relevance of these topics in schools in terms of inclusiveness.

spoke about the benefits. There was more perception of the inclusive value of these activities (19.15%).

In B3-BC (Fig. 4), PSSTs motivated the relevance by referring to coding and ER as facilitative, compensatory, and alternative tools (36.17%) or as tools accessible to all (10.64%). Only 4.25% stated that these activities support cooperative work. On the contrary, in B3-PC, 31.95% of PSSTs emphasized the importance of cooperative peer activities, and 23.40% highlighted the opportunity to learn by doing and playing.

The SAT-PC questionnaires show overall high satisfaction with the course. In particular, in SAT-Organization (Fig. 5), we detected PSSTs' satisfaction with working remotely in groups. We found that 55.32% of participants did not experience difficulty. The others mainly reported two reasons: little immediacy/direct contact or experience (27.66%) and connection/network problems (12.77%). Then, in SAT-Schedule (Fig. 6), 95.75% of PSSTs reported that it is possible to train remotely on these topics and emphasized as main favorable factors the clarity of content, materials, and organization (25,53%), team working and sharing (14.89%), and the opportunity to experiment (14.89%). However, 21.28% of PSSTs stated that in presence, it could have been even more effective.

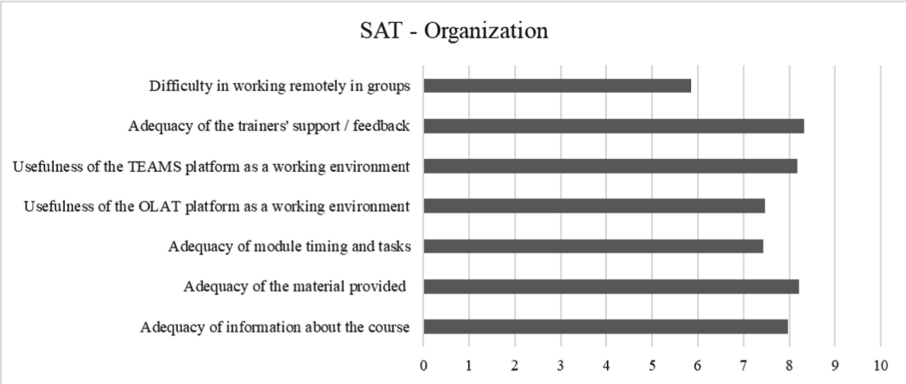

Fig. 5. Histogram reporting data from questionnaires SAT-PC-Organization.

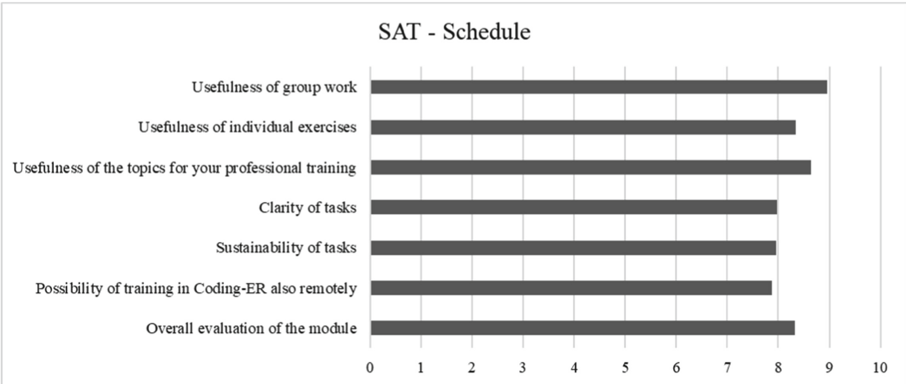

Fig. 6. Histogram reporting data from questionnaires SAT-PC-Schedule.

Finally, most of the designed learning paths proved to be original, inclusive, and consistent. Specifically, we identified as strengths the adoption of collaborative strategies to foster inclusion (e.g. peer tutoring, team working) and the promotion of authentic experiences or role-playing activities. Besides that, we suggested some areas of improvement: a more balanced use of tools in terms of quantity and time and a more conscious way of transition between the different tools.

4.2 Course Results

To assess the designed learning paths, we focus on two of the seven descriptors: inclusiveness and conscious use of tools.

Table 3. Inclusiveness.

Group	Self-evaluation	Peer-evaluation	Trainers' evaluation
G1	4.5	4.5	5
G2	4.3	4.1	4
G3	4.4	3.8	3.5
G4	4	4.1	3/3.5
G5	5	4.3	5
G6	4.5	4	3.5
G7	4.8	4.5	5
G8	4.5	4.1	5
G9	4.2	3.4	4.5
G10	4.3	3.7	4

Looking at Table 3, we can underline that there is a general consistency among the three evaluations. We can say that almost all groups have taken care of the aspect of inclusiveness. In fact, seven out of ten groups get an average score of 4/5. Specifically, we can see a higher self-evaluation for groups G3 and G6 than the peer and trainer evaluation, while we have a lower peer evaluation for G5, G8, and G9.

Table 4. Conscious use of tools.

Group	Self-evaluation	Peer-evaluation	Trainers' evaluation
G1	4.3	4.4	5
G2	4.1	4.3	4
G3	4.7	4	4
G4	4	4.2	4

(*continued*)

Table 4. (*continued*)

Group	Self-evaluation	Peer-evaluation	Trainers' evaluation
G5	5	4.15	4.5
G6	4.3	3.9	3/3.5
G7	4.6	4.2	5
G8	4.5	4.1	4
G9	4.3	3.5	4
G10	4	3.7	4

From Table 4, we can say that there was a good average level in the conscious use of the tools. We also note more minor discrepancy between the three evaluations than we saw in Table 3.

5 Conclusions

This paper describes a training proposal for PSSTs aimed at improving their digital skills and especially the ability to design for all. The course, indeed, responded to the increased current need to familiarize all teachers with technologies in an inclusive perspective. It focused the teachers' attention on the need to design in an inclusive way for the benefit of the whole section. Many of the participants were initially wary and reluctant to use technology in kindergarten. Familiarization with the proposed tools and activities changed this initial attitude and allowed PSSTs to imagine the potential of robotics in the inclusion of pupils with disabilities. The study has some limitations, such as the small sample size and the duration of the course. However, the training proved to be effective from the results of the K-test, SC, B and SAT questionnaires, despite the distance implementation and the lack of an embodied approach. We can identify the following as success factors: the strong interaction between participants supported by the course organization/structure; the continuous feedback from both peers and trainers; the possibility to experiment in groups and to share successes and failures. While the improvement of knowledge can be considered an expected and usual outcome of a training course, the improvement of self-confidence is undoubtedly less predictable. This construct is regarded as one of the main limiting factors in introducing coding-ER activities and methodologies in schools [21]. Similar results emerged in [3]. Furthermore, concerning beliefs, all questions presented show a shift from lower to higher levels of awareness. The PSSTs showed, indeed, a heightened awareness of training on these issues during university/professional education and introducing these tools at school, also in terms of inclusiveness. Almost all groups then gave centrality to inclusiveness in the planning phase of a learning pathway. Finally, the increased self-confidence gained by PSSTs is linked to a greater possibility of adopting technology in their daily teaching and learning practices. Indeed, the training has led to a greater awareness of the role of support teachers in the complexity of classroom life.

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