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Coding and robotics to support *linguistic and non-verbal interactional practices* in Italian preschools: the powerful effect of small group situations

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The research started in 2020-2021 and involved 18 Italian preschools: 3-to-6-year-old children have been introduced to experiences of coding and robotics (BeeBot, Cubetto, Lego WeDo 2.0, i-Code). The study aimed at promoting social and discursive interaction among kids within mixed by age small group situations (4-5 children), for improving and increasing their knowledge co-construction. It was composed by different phases that interconnected teachers' training and school educational practices. Some initial results show that: a) educational robotics represented an effective tool for promoting discursive practices where linguistic and non-verbal dimensions complemented each other; b) within a specific educational planning, coding and robotics allowed teachers to organize learning contexts where children could act and improve several intelligences. This process was always developed within small group situations, where children could "mix and exchange" their individual intelligences.

Keywords: *small group situations, coding and robotics, preschool interactional practices, dialogic teachers' training*

1. The socio-constructivist approach

We can identify two main theoretical perspectives concerning children's development and learning processes (Pontecorvo 1989; Cole 1996; Monaco and Zucchermaglio 2021; Monaco and Ceol 2022): on the one hand we have the

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individualistic-cognitivist approach and on the other hand the socio-constructivist one. Piaget (1964) and Vygotskij (1934) are usually considered the main representatives of these two interpretations concerning the relationships between developmental factors and educational dimensions (Smith *et al.* 1997; Liverta Sempio 1998).

Because of Piagetian theory's influence, for several decades the studies on human thought and cognition were mainly based on individuals and their single minds, without seriously considering their social context, that means the environment where they live and that they contribute to build and transform.

In this perspective, social and contextual dimensions were usually considered not so relevant concerning the investigation of cognitive competences and skills. In some cases, they were conceptualized as "additional factors" that could just influence or facilitate "proper cognitive learning" (Edwards, Mercer 1987). Rogoff (1990), for example, stated that Piaget's main effort was to investigate how children learn to construct their knowledge and comprehend a "generic world", shared by the whole human species.

From the Eighties of the 20th Century, the Vygotskian approach started to make inroads and influenced psycho-pedagogical research about children's learning and development processes (Cole, 1996). According to this author, it was necessary to invert the relationship between social and individualistic dimensions, between mind and culture. Human development, in fact, can take place through significant social interactions among people and among them and their culture. Vygotskij (1934) said that the highest kind of learning is the one that "precedes development": in other words, what children "can do in collaboration today they will be able to do independently tomorrow".

This perspective introduced an epistemological revolution that was reinforced and enriched by Bruner's thought (1990; 1996b): this author proposes the idea of a "Cultural Psychology" that should consider individual's development such as a process that can be realized and implemented only in relation and within a specific cultural context. Bruner deeply studied Vygotskij's and Piaget's theories and, during a famous conference organized to celebrate their centenary (both were born in 1896), he said:

> "Piaget's genius was to recognize the fundamental role of logical operations in human mental activity. Vygotsky's was to recognize that individual intellectual power depended upon our capacity to appropriate human culture and history as tools of the mind" (Bruner 1996b, 22).

In fact, Rogoff (1990) argues that the differences between Piaget's and Vygotskij's theoretical approaches are linked to the differences among the phenomena they decided to investigate and analyse. Moreover, it is possible to identify some common dimensions concerning the two perspectives: for instance, the children's active nature, the constructivist concept of knowledge acquisition, the importance of the relationship between subject and object within learning processes, and the main interest in qualitative changes of the human mind (Liverta, Sempio 1998).

We think that it is very important to avoid any dogmatic acceptance of a specific model but, at the same time, we are convinced that it is necessary (and ethically clean) to explicitly refer to a precise theoretical-methodological perspective with which being in a critical and dialogical interaction.

According to us, the socio-constructivist framework is the one that allows to investigate and comprehend how children co-construct their knowledge, within and throughout *significant social interaction* with peers and adults, including *educational robotics*.

2. The small group methodology: a continuous challenging opportunity

In this perspective, we can consider significant social interaction as the more powerful "engine" of each learning and development process. For these reasons, the school becomes one of the most important contexts for children's cultural socialization (also for the youngest ones). The teachers should learn how to manage the "naturally social features" of this context for supporting and promoting children's knowledge co-construction.

Within the psycho-pedagogical world, authors often consider interaction among people as something useful from a socio-affective-relational point of view. It is still not assumed that social interaction should be seen as the most powerful condition for constructing "proper conceptual and cognitive" learning too. For these reasons, the numerousness of groups (sections, classes, etc.) is usually considered a kind of "barrier" for developmental/educational processes. On the other hand, the differences among pupils are often considered as negative interferences concerning their opportunity of learning and improving (Pascucci 1991).

In a socio-constructivist perspective, each child – who is always a "natural and active apprentice" (Rogoff 1990) – learns to move within his/her Zone of Proximal Development (Zo-ped: Vygotskij 1934) which is the psychological area he/she can reach if he/she is supported by the intervention of someone who is "more competent". Vygotskij considered the Zo-ped as "the tomorrow of

development" and for this reason all educational contexts, such as preschools, should allow children to recognize and practice all their competences and intelligences (Gardner 1983; 1999) throughout the interaction with Others.
Another important concept regards the "scaffolding" (Wood *et al.*, 1976): the scaffolder is someone who acts as a proper "support framework" that has to be gradually reduced and finally eliminated, since the child learns to be more autonomous and competent.

Both the ideas of Zo-ped and scaffolding can be activated and promoted within the child-adult relationships but also among peers: the small group situations are the most promising contexts concerning these processes.

From an operational point of view, the small group methodology represents a crucial tool for practicing these relationships between teaching and learning and for giving children the opportunity to experiment and face challenging situations of knowledge co-construction.

Educational contexts oriented to each member's Zo-ped should promote the "good conflict" (Pontecorvo 1993), which is the opposition concerning the themes of the discussion and not the relationships among the participants (Monaco and Zucchermaglio 2021). As Pontecorvo (1993) showed, the disagreement and the conflict "between ideas" – together with the argumentative sequences that moves from them – allow people to collectively elaborate more sophisticated thoughts, to better understand a specific phenomenon, to construct more complex decisions, etc. A high level of disagreement, of divergent positions and points of view, of diversified knowledge among children and among adults support the co-construction of much more refined explanations, argumentations, reasonings and comprehensions of phenomena and events (Pontecorvo *et al.* 1983; Dunbar 1993; Pontecorvo 1993; Monaco 2007; Asterhan and Babichenko 2015).

It is clear that the only possibility to reach a "significant social interaction" at preschool (3-to-6-year-old kids) is working with small groups of children (4-5 maximum). Since each class has 24-25 members with one or two teachers (depending on the moment of the day), how is it possible to work with 4-5 kids at time?

In order to solve this complex issue, that represents a proper challenge, our preschools adopt *the small group methodology* that the Provincial Federation of Preschools of Trento have been promoting and implementing since 2011: it requires a specific teachers' training and a deeply reflexive effort to be learnt and practiced (Monaco and Zucchermaglio 2021; Monaco and Ceol 2022). This methodology permits to divide the larger class into several small groups of children that will be stable for a certain time and mixed by age, gender and competences. The groups should be "not homogeneously well calibrated" (Pascucci and Zucchermaglio 1987; Zucchermaglio and Zanotti 1989; Pascucci 1996; Monaco 2007; 2017): they should

not be homogeneous and, at the same time, they should result quite balanced (e.g. avoiding to have a group where the discursive exchange is refined and one other where all the participants work hard to express their own opinion).

At the same time, we will have one group guided by the teacher (or more, depending on the adults' number) and other groups that will autonomously manage a specific experience. Both the guided and the autonomous proposals are planned by the team of teachers and are oriented by the learning process they are working on (e.g. collaboration, participation, doing observational research together, narrative co-construction, etc.).

Since 2011/2012, in fact, all the preschools associated with the Federation have been working on children's social learning process instead on specific themes or micro educational and individual objectives[4].

From a psycho-pedagogical perspective, choosing the small group methodology means to reach at least three kinds of advantages:

a) the small group, throughout a *significant social interaction* among few social actors, allows everybody – children and adults – to participate in different proposals in an aware and cognitively rich way;
b) the interaction within a small group supports and sustains *collaborative learning,* that is composed of a strict interrelation between consensual and oppositional dimensions (being in conflict in a constructive way is much more collaborative than always agreeing and cooperating);
c) the possibility to interact with Others in a "small situation" gives children greater opportunities of expression and participation, both on a verbal and non-verbal level.

As we stated elsewhere (Monaco and Ceol 2022), starting from infants/toddlers' centers up until the university system, a "good" learning context should always be founded on the possibility to propose diverse situations and opportunities, depending on teachers' educational intentionality. On the contrary, it often happens that children and students cannot easily access small group situations, despite their great educational power. Sometimes this inaccessibility is

[4] From a pedagogical and didactical point of view, this methodological choice implied the necessity to find some operational instruments that could concretely help the teachers to translate the learning process's dimensions into specific educational actions. This "help" came by the *process indicators*: they are children's behaviors (both *discursive* and *non-verbal*) that can be considered in a double perspective. On the one hand, the indicators are crucial criteria in order to plan concrete experiences aimed at promoting the learning process and, on the other hand, they are important tools in order to "assess" the development of the process itself. For instance, if participation is the chosen learning process, an indicator could be "the children ask questions to the peers" or "the children propose some alternative solutions to the group" or "the children make proposals through their actions" and so on.

linked to organizational reasons (e.g., many pupils with one or two teachers), some others it depends on specific "ideological" teachers' positionings.

Using the small group methodology, in fact, requires that educators and teachers drastically transform their point of view, concerning their implicit and explicit theories on development/learning processes, but also concerning their methodological and discursive competences. This way of working implies the activation of *continuous training processes* that allow adults to challenge "on field" all the ineludible problems and difficulties and to find inside them the "methodological keys" for transforming their educational-didactic interventions (Pontecorvo *et al.* 1991; Zucchermaglio 1999; Monaco and Zucchermaglio 2020).

3. Coding and educational robotics as instruments to promote children's social learning processes

Is it possible to introduce coding and robotics at preschool as additional tools for promoting children's social learning processes? In other words, which educational and methodological choices could we make to transform these instruments into useful "supporters" for teachers' cultural tool-kits (Bruner 1996)?

The starting point should be what Kranzberg (1986) stated almost 40 years ago concerning technologies: they are "neither good nor bad"; nor they are neutral. On the one hand the idea is that coding and robotics – such as any other tool, also the analogical ones – cannot create new social and educational practices "from nowhere". In fact, they always interact and "converse" with specific systems of practices that already exist within a community: these systems are characterized by a situated history and a very embedded tradition (Zucchermaglio 2000; Mancini and Ligorio 2007; Monaco *et al.* 2020; Mich *et al.* 2021). On the other hand, the idea that technologies "are not neutral" refers to the awareness that each tool has specific features and offers different opportunities that should contribute, throughout teachers' intervention, to sustain children's learning processes. For instance, as we will show in the following part of the paper, the BeeBot has functional and structural features that are very different from i-Code's or Lego WeDo 2.0's ones. The teachers should absolutely know and manage these differences to produce aware and effective pedagogical and didactical choices.

In other words, educational planning activities are the crucial "key" for transforming coding and robotics into proper "supporters" of children's knowledge co-construction. In fact, Digital Technologies – as well as robotics – can become useful and challenging methodological instruments only if two educational and training conditions are respected (Monaco and Ceol 2022):

a) since they are intended as "cultural tools" (Bruner 1996), coding and robotics have to become objective of training reflection with teachers, in a practice-based perspective (Little 2012);
b) the collective reflection on the innovative dimension of preschool teachers' professional role is essential in order to create the foundations of any "technological graft" at school.

From a cultural and ethical point of view, we think that this "training challenge" should contributes to construct adults' awareness about the importance that preschool supports what Prensky (2010) called "digital wisdom". The educational-pedagogical world is used to face a sort of dilemma that is based on a misleading conception: the proper question is not if the technologies should enter the school or if they should be avoided. We should wonder *how* we can give children all the cultural and cognitive instruments they need to transform their *digital dexterity* into a deep *digital wisdom* (Prensky 2012).

According to Prensky (2010), being "digital wise" implies the possibility to improve the natural competences through the available technologies. Moreover, it implies the necessity to continuously identify additional areas where human instruments – even though when they are refined – could be improved and increased by a digital "support".

Considering that today children are "digital natives" (*Ibidem*) and that it is useless to refuse this factual data, we think that preschools should work for making children aware of potentialities and risks of any technological tool. In this way they can become "digital wise persons" that means critical users.

A "digital wise person" is someone who is able to examine and evaluate the qualities and deficiencies of any digital instrument (both old and new ones) to find the balance that can transform them into "engines" of wisdom and complex learning. In fact, Prensky taught us that digital wise persons know that the skill of controlling and managing the Digital Technology, bending it to their own necessities, is a key competence in our era.

Here we have the connection with coding and robotics, because we know that digital wise persons are deeply interested also in the "programming dimension": machines must do all what human beings expect of them. Even though adults are not often aware of it, this conception is not so far from kids' culture, as we discovered in a research (Robobimbi: Monaco *et al*. 2020; Monaco and Ceol 2022) that investigated preschool children's representations of robots. In that situation, for example, Alice (a 4-year-old girl) told us that "robots make things because humans tell them what to do".

4. The Action-Research

The Action-Research we are going to present is grounded on the awareness that the relationships between children and Digital Technologies, including Educational Robotics, represent a crucial dimension of current human beings' everyday life. It is important that preschools (3-to-6-year-old) take Digital Technologies into consideration, promoting and supporting reflections, considerations and empirical investigation.

The research was found in a previous study, named Robobimbi (Monaco *et al.* 2020; Mich *et al.* 2022), that was centered on preschool children's representations of robots. On the one hand, it demonstrated that children's ideas are very complex and that robots' anthropomorphic shape is not the unique option, and on the other hand it showed that the concept of programming (crucial for robotics) is not so far from kids' representations.

4.1. The participants

The study involved 18 Italian preschools and 70 teachers that were dislocated into three main areas of the Autonomous Province of Trento: Valsugana/Primiero and Giudicarie esteriori[5]. The teachers were engaged in a process of training concerning the introduction of Educational Robotics as a specific tool for promoting and supporting children's social learning processes, such as collaboration, participation, narratives co-construction, collective observational research, meta-reflection, etc. (Monaco and Zucchermaglio 2021).

The research-training team has an interdisciplinary nature, since it is composed of two researchers/trainers belonging to a psycho-pedagogical background (Camilla Monaco and Tiziana Ceol) and two researchers/trainers who are experts in the ICT field (Ornella Mich and Alessandra Potrich[6]).

The team planned and realized two different versions of the training program:

[5] The pedagogical coordinators of these areas, between 2019 and 2024, have been dr. Daniela Dalcastagnè and dr. Elisa Barchetti for Valsugana/Primiero, dr. Lorenzo Santorum and dr. Luisa Fontanari for Giudicarie esteriori. The supporting and scaffolding action of the pedagogical coordinator is absolutely crucial in order to make efficient and really incisive whatever training program.

[6] Dr. Ornella Mich and dr. Alessandra Potrich are (or have been) researchers at FBK (Fondazione Bruno Kessler) in Trento. Since 2014/2015 a specific partnership has been created between the Provincial Federation of Preschools of Trento and FBK, with the aim of working in an inter-disciplinary perspective on the relationships between preschool children and Digital Technologies.

1) the first version engaged 11 preschools (in Primiero/Valsugana area[7]) and was planned through a co-design process that involved 6 teachers who had taken part in Robobimbi. These teachers, belonging to the preschools of Riva Sant'Alessandro, Povo and Tesero, planned and realized further learning experiences using the BeeBot with different small groups of children. These experiences were analyzed and discussed within the co-design group and later they were used to project a teachers' training program that was grounded on children's real competences and knowledge (Monaco *et al.* 2023; Monaco and Ceol 2022);
2) the second version involved 7 preschools (in Giudicarie esteriori area[8]) and it is still ongoing. It is a three-year process that interrelates the training process with the school experiences realized with children. This paper is centered on this part of research.

4.2. The main objectives

As regards the second version of teachers' training, the study aimed at:

a) planning and experimenting a *teachers' training program* with the purpose to promote and support *new professional competences about coding and educational robotics* (Monaco and Ceol 2022) by giving the participants the opportunity to try and use some specific robotic kits in order to enrich and transform their own educational actions with preschool children (Monaco and Zucchermaglio 2021);
b) promoting *social and discursive interaction among children within mixed-by-age and stable small group situations* (Vygotskij 1934; Bruner 1190; Cole 1996; Monaco and Pontecorvo 2009; Monaco and Zucchermaglio 2021), in order to improve and increase their *social learning processes* (e.g. participation, collaboration, collective observational research, narratives co-construction, etc.), throughout coding and robotics experiences.

4.3. The methodology

The Action-Research aimed at creating complex and effective interconnections between *teachers' training* – intended as a practice-based process – and *the educational school practices* with children. The leading idea was that on the one hand

[7] This area is composed of 10 preschools: Grigno, Ospedaletto, Pieve Tesino, Strigno, Tezze, Fiera di Primiero, Mezzano, San Martino di Castrozza, Tonadico and Transacqua.

[8] This area is composed of 7 preschools: Fiavè, Stenico, Santa Croce, San Lorenzo in Banale, Ponte Arche, Vigo Lomaso and Qaudra-Cavrasto.

it is possible to promote new teachers' competences concerning coding and robotics and that, on the other hand, these professional instruments can be used for planning challenging school experiences oriented to sustain children's social learning.

For these reasons, the study was based on two main methodological foundations:

1) a conception of teachers' training as a *dialogic process* centered on collective reflection about *real educational practices*. As Weigand (2010) suggests, we consider dialogue as a sequence of actions and reactions, throughout which people can *transform their own theories and perspectives*;
2) the *small group methodology* as the crucial choice not only concerning children's experiences but also concerning *adults' learning processes*. In this perspective, dialogue and social interaction were considered as the main instruments in order to change and improve teachers' professional tool-kits. In fact, this specific methodology was used not only for supporting teachers' learning about coding and robotics but also for scaffolding their planning practices concerning the educational proposal for their children.

In order to interconnect teachers' training and school educational practices, the research was structured into different *methodological contexts*:

a) the teachers' training program, intended in a dialogic sense and based on adults' practice with the robotics tools. This program included:
   I. large group situations (in order to promote collective reflections, for instance on theoretical-methodological issues, on specific experiences brought by the colleagues, etc.);
   II. small group situations among teachers *belonging to different schools* (e.g. in order to experiment with the different robotics kits and to discuss about their features and functions);
   III. small group situations among teachers *belonging to the same school* (e.g. in order to collectively construct some educational planning frameworks concerning the experiences to be proposed to children);
b) experiences at school with children, based also on the educational frameworks that teachers had co-constructed during the training;
c) collective reflection on school experiences, within the training context, based on teachers' documentations *(video, field and reflexive notes, etc.)*.

4.4. The training program

On the basis of the first version of the training program (2020/2021), the research/training team identified some specific features for designing the second version (from 2022/2023 to 2024/2025):

i. it was essential to participate in the training process as a *school team* (and not as single teachers);
ii. for each involved preschool the training was distributed on *3 school years*;
iii. each school year included 12,5/13 hours of training (*5 training meetings* from September to May);
iv. it was crucial the *Pedagogical Coordinator's support and scaffolding* action between a training meeting and the following one;
v. the social and dialogic interaction among teachers (mixed by school and by competences) within *small group situations* was considered the main "engine" of the training process. These groups were not casually composed: they were the result of a joined reflection between the trainers and the coordinator. The aim was to obtain small groups where people have different points of view and belong to different school contexts, in order to enrich the exchange and the discussion;
vi. learning by doing *together* as the favorite perspective to promote new knowledge, new competences and new professional tools (also with adults and not only with children). In this perspective, the teachers were never provided with instructions concerning the robotics kits and the research/training team never used direct teaching experiences. *Collective problem solving* was considered as the main training strategy, within a context oriented to peer learning processes;
vii. *video recording and field/reflexive notes* as the main methodological tools in order to analyze, within the training context, how everyday practices with children were evolving and improving.

4.4.1. The tools used within teachers' training

Unlike the first version of the training program (2020/2021), during the second one we decided to substitute Cubetto with i-Code, for two main reasons: on the one hand, it was a kit on whose realization three preschools took part in and, on the other hand, we had already supported several experiences in different educational contexts (Monaco, Ceol 2022).

A crucial methodological choice regarded "how to use" the different instruments: both with teachers (during the training) and with children (at school) we always used the approach of *one kit-one small group* (we and teachers never practiced individual uses of the tools!).

We are going to briefly describe some functional and structural features of each tool we used during teachers' training.

Figure 1. i-Code interface

I-Code is a PDST (Programmable Digital Storytelling) tool that creates a connection between the *physical programming cards* (that recall the puzzle mechanism) and the *multimodal technology* of a tablet and a specific App (see figure 1). Each card is associated to a specific command, represented both graphically and textually, and to a precise color that indicates the category of command (e.g. azure for movement commands, green for the start, red for the stop, etc.) Moreover, some cards can be associated with numerical parameters (that indicate the repetition of a specific command).

I-Code allows children, also in preschool, to really create their *multimodal narratives* from nowhere, by introducing every kind of "handmade" characters, scenarios, sounds, voices and so on.

In a Brunerian sense (Bruner 1990), we usually talk about "narrative co-construction" (instead of "storytelling") because this concept is much closer to the socio-constructivist idea of development and learning processes that we try to practice in our preschools. According to Bruner, in fact, the whole human experience is oriented to create narratives for understanding and attributing significant meanings to everyday life.

The world of "stories" has a very long and grounded tradition within educational contexts such as infants/toddlers' centers and preschools, but Digital Technologies can represent useful instruments for enriching and empowering the so called "art of storytelling". According to Rahiem (2021), in fact, Digital Storytelling (DST) can "blend the ancient art of storytelling with a range of contemporary tools to weave stories".

There is a further step of complexity that Digital Technology can confer on the "ancient art of storytelling": the combination of the DST with the concept of coding/programming (Mich *et al.* 2021). The *Programmable Digital Storytelling* tools (PDST) can be used to promote children's computational thinking (Macrides, Miliou, Angeli 2021) and, according to some recent studies, they can support the development of critical reasoning and the construction of collaborative and participating competences (Behnamnia *et al.* 2020; Dorouka, Papadakis, Kalogiannakis,2020; Fridberg, Thulin, Redfors 2018; Marsh *et al.* 2018). Moreover, in recent years some PDST tools (e.g., ScratchJr., Osmo or ScottieGo!) have been used for supporting the socio-constructivist educational approach (Amineh, Asl 2015; Bruner, 2020) where children learn to co-construct knowledge by working together and, also, by managing the conflict in a constructive way (Baranauskas, Posada 2017).

Figure 2. The BeeBot

BeeBot is a small bee robot that can memorize 40 commands and can move following the sequence of instructions chosen by its user (see figure 2). The buttons are located on the back of the BeeBot and allow it to go *Forward, Back, Left* (90° rotation) and *Right* (90° rotation). There is also the button *Pause* that stops the robot for one second and the button *Clear* that deletes all the commands previously memorized. By pressing the button *Go* the BeeBot starts moving and runs the sequence of commands that has been programmed. The robot has the possibility to record brief sounds and associate them with a specific command.

Finally, if two or more BeeBots meet each other they can interact through the light elements and the sound ones.

Unlike what usually happens in a preschool context, where BeeBot can be used within "coding programs" (mostly focusing on the main topological concepts), we decided to propose it as an instrument for creating authentic problems that children will try to solve in a collective and collaborative way.

For instance, a valuable dimension concerns a structural lack of this small robot: the BeeBot does not allow us to visualize the sequence of commands that users are producing. This feature becomes very interesting from an educational and pedagogical point of view: it could be challenging to identify with children, always in small group situations, how it can be possible to keep track of "what we did the BeeBot to do".

Figure 3. Lego WeDo 2.0 elements

Lego WeDo 2.0 combines the LEGO® bricks – that kids usually know and commonly use also at preschool – with a hub, an engine, two types of sensors (distance and tilt) and one quite simple software (see figure 3). Throughout this kit, children can combine the constructive part (linked to the bricks) with the main concepts of programming: they become able to build a robot and to face the challenge of saying to the robot itself "what to do and how". The software, in fact, allows them to create specific sequences of commands in order to make the robot move and "do things".

Within a small group, guided by an adult, children have the opportunity to ask questions, to define problems and to collectively search for their own solutions.

4.4.2. *Training program's structure*

From a methodological point of view, the training was structured considering the three years as a continuum where each meeting was interconnected with the following one.

The first training year

The first year was articulated in several steps, that sometimes were developed across different meetings:

a) an experience of "creative robotics" (Monaco, Ceol 2022) in order to elicit teachers' representations about robots and their possible uses in everyday life. Organized in small groups (mixed by schools and competences), they firstly elaborated a *collaborative project of a specific robot*, defining its features and functions, and then they realized it using only recycled materials. One more aim of this activity was starting to reflect (always together!) on robotics as a tool that can be educationally useful. This proposal allowed teachers to express their own "theories and perspectives" about robotics and to interconnect them with their colleagues' ones (see figure 4);
b) introduction and discussion (with the large group) of the concepts of sensors, actuators and computational thinking, by doing a connection with some competences that people use and construct during everyday activities;
c) presentation of the main results of Robobimbi research, in order to share what we learnt about children's "theories and perspectives" (Monaco *et al.* 2020);
d) introduction of the main principles of the Educational Robotics and the concept of "programming", followed by an unplugged experience (within small groups mixed by schools) with the analogical part of i-Code[9] (just the cards);

[9] In 2020, while the first version of the training was going on, dr. Tiziana Ceol and dr. Camilla Monaco, together with dr. Paolo Massa and dr. Ornella Mich of FBK, were involved in a challenging co-design process concerning this new technological tool – i-Code – that was conceived with the purpose of promoting the Programming Digital Storytelling experience from the age of 3. Three preschools belonging to the Federation (Fondo, Cloz-Brez and Tesero) were engaged in the experimentation of the mock-up and the first version of i-Code, moving as proper "robotics researchers" (Monaco, Ceol 2022).

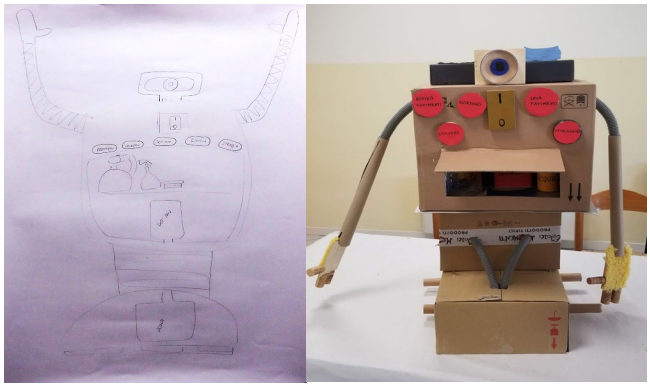

Figure 4. The collaborative project (on the left) and the robot (on the right)

e) presentation and discussion about some experiences realized in other preschools associated with the Federation (Fondo, Cloz-Brez and Tesero) by using i-Code within small groups of children. It was particularly valuable to share some data concerning other Areas in order to highlight how other colleagues did consider Digital Technologies as effective instruments to support and promote children's social learning processes;
f) small group situations among teachers in order to experiment i-Code – at an adult level – using both its physical and digital components. Teachers constructed collaborative multimodal narratives within the training and could ask for the trainers' supervision and scaffolding;
g) proposal of "training homework" concerning the i-Code adult experience: between two different training meetings, in each school teachers explored the kit in a collective way and kept track of doubts, questions and problems that had been emerging. The results of the "school homework" would have been discussed within the following training (in the large group) in order to construct collective reflections and possible future developments;
h) first attempts of experiences with children by using i-Code in small group situations, keeping in mind also the reflections and the collective reasonings produced within the training;
i) presentation and discussion, within the training large group, of some experiences realized at school with children, in order to share both advantages and difficulties/problematics;

j) a further experience – within small groups of teachers mixed by schools – concerning i-Code based on a more structured task: people had to insert within the activities some complex functions such as GO TO SCENE or REPEAT.

The second training year

The second year was dedicated on the one hand at consolidating teachers' learning concerning i-Code and its more complex functions and, on the other hand, to introduce and experiment with a new small robot: the BeeBot.

As well as the first year, also the second one was organized into several steps, that sometimes were developed across different meetings:

a) a new experience with i-Code (in small groups of teachers mixed by schools) in order to deeply practice some specific functions, such as the AUDIO card, GO TO SCENE card or the recording of the final video narrative;
b) presentation and discussion, within the training large group, of some experiences realized at school with children (using i-Code), in order to share both advantages and difficulties/problematics;
c) introduction of a new tool (BeeBot) without giving any kind of instruction or information. Within the stable small groups, teachers explored the BeeBot and tried to create a kind of "instruction booklet" containing the main functions they had discovered and understood. The results of these group works were discussed within the large group in order to construct collective reflections;
d) recalling of the main principles of Educational Robotics and in particular of the concepts of sensors, actuators and computational thinking;
e) presentation and discussion about some experiences realized in other preschools associated with the Federation (Povo and Tesero[10]) by using the BeeBot within small groups of children. It was particularly valuable to share some data concerning other Areas in order to highlight how other colleagues did consider Digital Technologies as effective instruments to support and promote children's social learning processes;
f) a further experience – within the same small groups – concerning the BeeBot, based on a more structured task and developed on a grid sheet (70x100 cm): the robot could not move only in a vertical or horizontal direction; it should cross at least two squares and it should make at least two reverse steps. Moreover, the BeeBot should produce circular movements around a specific object chosen and located by the teachers on the grid sheet. All these

[10] All these experiences belonged to the work of the co-design group that interconnected the results of Robobimbi research with the proposal that the expert teachers had planned and realized by using the BeeBot.

"constrictions" should be inserted into a micro narrative constructed by the group, considering also the experiences they were proposing in each school to children. The results of these group works were discussed within the large group in order to construct collective reflections;

g) presentation and discussion about some experiences realized by a school (Siror) who had took part into the first version of the training program;
h) introduction of a new tool (Lego WeDo 2.0) without giving any kind of instruction or information. Within the same small groups, teachers explored Lego WeDo 2.0 and tried to understand its main functional features. The results of these group works were discussed within the large group in order to construct collective reflections;
i) two further situations where the small groups experimented with Lego WeDo 2.0 in different ways: e.g. teachers constructed some robots by following the official instruction booklet and tried to "make them do something", in order to build more competence and awareness before proposing the kit to their children. Teachers also met some specific "robotics problems" concerning for instance the robot's direction (only backward and forward), the two types of sensors, the construction of an effective sequence of commands. These problems were discussed within the large group in order to construct collective reflections;
j) presentation and discussion about some experiences with Lego WeDo realized by a school (Ospedaletto) who had taken part in the first version of the training program;
k) an activity of collective "assessment" about the training program by using the Mentimeter platform: teachers answered some questions concerning both their training experience and the activities they planned and realized at school with children (Monaco, Ceol, in preparation).

The third year (still ongoing)

The last year of the training program is still ongoing: between September and October 2024 we have realized the first two meetings in order to:

a) recall all the experiences/learning constructed during the previous two years;
b) propose a "training homework" concerning Lego WeDo adult experience: between two different training meetings, in each school teachers collectively built a robot (following the official booklet), then they located one or more markers on the robot itself and finally programmed it in order to draw on a big sheet of paper. The results of the "school homework" would have been discussed within the following training (in the large group) in order to construct collective reflections and possible future developments;

c) propose an experience of educational planning within the training context: the small groups (composed by teachers belonging to the same school) started to decide how they would have used at least two robotics kits (i-Code, BeeBot and/or Lego WeDo 2.0) to promote the children's learning process they were working on.

Some days after the second meeting, each school shared the planned activities with the research/training team, who gave back some suggestions/notes/indications in order to improve them before their concrete actuation.

The third meeting is planned in January 2025: the involved preschools will have enough time to effectively implement (and document) those experiences with children that will be later analyzed and discussed within the training context (in the large group).

The aim of the last two meetings will be engaging the teachers into a more specific analysis of their discursive and interactional interventions: the purpose will be better understanding *how* Digital Technologies are concretely supporting the construction of children's learning processes. For example, if the teachers wanted to promote participation among children and were planning some experiences in this perspective, it would be necessary to take into consideration the possibility to use one or more robotics tools and, moreover, to have clear *which* specific purposes each instrument can support, *how* and *why*.

4.5. Initial results

Concerning the second research object, that was promoting social and discursive interaction among children through coding and robotics, we are starting to see that:

a) Educational Robotics represented an effective tool in order to promote discursive practices where linguistic and non-verbal dimensions complemented each other, allowing children to construct increasingly *rich and significant forms and levels of participation* (Goodwin 1994);
b) within a specific educational planning framework, coding and robotics allowed teachers to organize learning contexts where children could act and improve several intelligences (Gardner 1983; 1999): e.g. visual-spatial, linguistic-verbal, logical-mathematical, body-kinesthetic, etc. This process was always developed within small group situations, where children could "mix and exchange" their individual intelligences.

We are going to illustrate these initial results through an example (belonging to Ponte Arche preschool) where i-Code is used to promote social and discursive interaction within the small group of children.

4.5.1. "Then what did you say to your tablet?"

When this example was collected the teachers of Ponte Arche were attending the second year of training and i-Code was already considered by children as a "normal" tool included within their everyday educational life. The preschool was working on a specific learning process: *doing observational research together*.

This stable small group (mixed by age, gender and competences) is working on a Map (from the school to the park) they created some days before. It is a complex experience, characterized by some "trips" to the public park and by several methodological steps oriented to promote children's awareness concerning the relationship between the map and the real world. Children have, for instance, the possibility to take some pictures of the places they consider crucial on the road (which should be inserted into the map).

When i-Code enters the experience, the different parts of the big map are transformed into "homemade" scenarios and the children themselves become the characters of the multimodal narrative (see figure 5).

Figure 5. The small group of children that became the "character" in i-Code

The example belongs to a session of activity of 38 minutes[11] and starts when a specific problem comes out: kids are checking a sequence of cards they have

[11] The situation was watched also by some teachers, university professors and school directors coming from Florida, Texas and New Jersey, in order to observe how the methodology was applied.

previously created (and saved as a picture on teachers' mobile phone) but something is going wrong concerning the movement of the characters. The cards/commands that put the children "in trouble" are four: MOVE UP, MOVE DOWN, MOVE LEFT and MOVE RIGHT.

As we are going to show through the following interaction, the "mistakes" should be considered as crucial occasions for the co-construction of new knowledge, especially when the teacher is able to avoid giving any solution and to support children's collective reasoning. In this perspective, problems and mistakes are very important sources of social learning.

00:00	1.	Teach.:	vai! go!
	2.	(4.0)	*((L'ins. e i bambini guardano cosa accade sul tablet))* *((Theach. and children look at the tablet))*
	3.	Corrado:	ma perché ritorna [INDIETRO:? but why he comes [BACK:?
	4.	Teach.:	[ma perché ritorna INDIETRO:, *((battendo le mani))* [but why he comes BACK:, *((she claps her hands))*
	5.	Marco:	 forse perché va in su di qua! *((indicando a destra con il pollice della mano destra))* maybe because he goes that way! *((indicating toward the right direction with the thumb of the right hand))*
00:13	6.	Teach.:	ma cosa gli avete detto::? *((riferendosi al personaggio e indicando la stringa di comandi))* but what did you tell him::? *((referring to the character and indicating the cards sequence))*
	7.	Corrado:	VAI IN SU! MOVE UP!

Figure 6. Excerpt 1 (turns 1-7)

Figure 7. The collaborative map that became the scenario in i-Code

Children would like to make the characters (the pronoun “he” refers to the small group itself) go down and then go right, but they have just used the cards MOVE DOWN and MOVE UP (see figure 6). The small group should move from the school (the pink building on the top of the map) to the Municipality (see figure 7), but they have created a sequence of cards that produces a “down and up” movement. For this reason, Corrado (turn 3) asks why the characters “come back” and the teacher (turn 4) mirrors his question. At turn 5 the adult produces a “clarifying question” in order to support children’s collective reasoning: it would have been easier (and quicker) to give them the answer, but she chooses to let the group think.

After having elicited the confusion between UP and DOWN (see figure 7: turns 6→10), the teacher makes an action in order to problematize: she declares the “need” to find a shared agreement (turn 11). At the same time, she uses her proxemics to support interaction and dialogue among children, going back with her chest on the chair.

8.	Teach.:	e lui è andato in su! and he moved up!
9.	(1.5)	*((i bambini guardano l'ins.))* *((children look at the teach.))*
10.	Corrado:	ma lui è andato in giù! *((indicando il tablet))* but he moved down! *((indicating the tablet))*
11.	Teach.:	eh, qua bisogna capirsi dov'è su e giù *((muovendo la testa a destra e sinistra e indietreggiando con il busto rispetto al tavolo))* eh, we need to find an agreement about where up and down are *((moving her head from left to right and vice versa and going back with her chest on the chair))*
12.	Corrado:	 questo è il su. e questo è l'ingiù. *((indicando rispettivamente due tessere della stringa))* this is the up. and this is the down. *((indicating two different cards on the sequence))*
13.	Teach.:	*((allarga le braccia guardando Corrado, poi si riavvicina al tavolo con il busto))* *((she opens the arms looking at Corrado, then she comes back near the table with her chest))*

Figure 8. Excerpt 2 (turns 8-13)

	14.	Corrado:	[deve andare di qua, e poi deve andare di qua. *((muovendo il dito indice della mano sinistra sul tablet))* [he has to go here, then he has to go here. *((moving the index finger on the tablet))*
00:30	15.	Teach.:	 [*((apre la mano destra e la colloca di fronte a Corrado invitandolo ad attendere))* [*((she opens her right hand in front of Corrado to invite him to wait a moment))*
	16.	Teach.	quali altre tessere di movimento abbiamo? which other movement cards do we have?
[...]			*((Ins. e bambini esplorano le diverse tessere di movimento che sono sul tavolo: VAI SU, VAI GIÙ, VAI A DESTRA, VAI A SINISTRA, etc.))* *((Teach. and children explore the cards that are on the table: MOVE DOWN, MOVE UP, GO RIGHT, GO LEFT, etc.))*
00:36	17.	Teach.:	qual è quella che va di là? which is the one that goes there?
	18.	Corrado:	questa, *((collocando una tessera sotto la stringa))* this, *((putting a card under the sequence))*
	19.	Teach.:	allora voi che cosa avete detto al vostro tablet? *((si tira nuovamente indietro allontanandosi dal tavolo))* then what did you say to your tablet? *((she moves back again oh the chair))*
	20.	Marco:	di andare di là e da quella *((indicando verso sinistra))* to go there and on that direction *((indicating on the left))*
	21.	Teach.:	e lui *((intendendo il personaggio))* cosa ha fatto? and what did he *((intending the character))* do?
	22.	Marco:	è andato in su:, he moved up:,
	23.	Corrado:	e poi è andato in giù. *((muovendo l'indice in direzione orizzontale))* and then he moved down. *((moving the index finger in an horizontal way))*
	24.	Teach.:	quindi cosa cambiamo? *((indicando la stringa di tessere))* so what do we change? *((indicating the cards sequence))*
	25.	(3.5)	*((i bambini guardano le varie tessere che sono sul tavolo))* *((children look at the cards on the table))*
01:00	26.	Marco:	questo! *((indicando una tessera della sequenza))* this one! *((indicating a card on the sequence))*
00:57	27.	Teach.:	con cosa? with what?
	28.	Corrado:	no! glielo dobbiam mettere lo stesso! *((inserendo una nuova tessera nella stringa))* no! we need to put it as well! *((inserting a new card into the sequence))*

Figure 9. Excerpt 3 (turns 14-28)

Turn 16 represents another teacher's action that sustains children's active exploration to find a "good" solution for the problem (see figure 9): she indirectly invites them to go back to the different cards that are available. Immediately after, she produces a direct question: which is the one that goes there (intending "on the right")? The sequence of turns 18→28 represents the teacher's effort to elicit questions and problems that could/should be solved by the group in a collective way (e.g. "what did you say to your tablet?", "and what did he do?" or "so what do we change?").

[...]			*((i bambini fanno ripartire il personaggio e si conferma che qualcosa non torna))* *((children make the character move on the scenario and something is going wrong))*
01:03	29.	Marco:	 siamo andati in giù, e poi in su. *((muovendo l'indice sul tablet))* we moved down, and then we moved up. *((moving his finger on the tablet))*
	30.	Teach.:	ah! allora qual è quello sbagliato? so which is the wrong card?
	31.	Marco:	questo! *((indicando la tessera VAI IN GIÙ e allontanandola dalla stringa))* this one! *((indicating the MOVE DOWN card and moving it away from the sequence))*
	32.	Corrado:	no ma ci serve lo stesso! *((cercando di rimettere la tessera dov'era prima))* no but we need it as well! *((he tries to put the card when it was before))*

Figure 10. Excerpt 4 (turns 29-32)

After Marco's reconstruction (turn 29), the teacher continues to support children to use a problem-solving approach (see figure 10): watching again the i-Code project, letting children discover the "trouble" (turn 30) and then supporting them to find a solution. At turn 31, in fact, Marco discovers the "wrong card" which is the MOVE DOWN one, but his answer does not convince Corrado, who does not want to eliminate that card ("no but we need it as well!").

33.	Teach.:	ascolta Corrado, (0.2) prova ad ascoltare *((separando nuovamente le tessere))* listen Corrado, (0.2) try to listen *((she separates again the cards))*
34.	Corrado:	°lo stesso°. °as well°.
35.	Teach.:	questo va in giù, e questo va in giù. *((indicando le rispettive tessere))* è quello che vuoi tu? this moves down and this moves up. *((indicating the respective cards))* do you want this?
36.	Marco:	[*((riproduce con il dito sul tablet il movimento che vorrebbero far fare al personaggio))* [*((he reproduces with his finger on the tablet the movement they would like to produce))*
37.	Teach.:	[che vada in giù e poi vada in su? [that he moves down and then he moves up?
38.	Corrado:	 noi andiamo verso di qua, *((muovendo il dito sul tablet dall'alto verso il basso))* we are going in this direction, *((moving the finger on the tablet from up to down))*
39.	Marco:	*((riproduce nuovamente con il dito il percorso sul tablet))* *((he reproduces again the character's movement on the tablet using his finger))*
40.	Teach.:	*((guarda Marco))* *((she looks at Marco))*
41.	Marco:	di qua e poi così. perché va in giù (e poi di qua) *((continuando a muovere il dito sul tablet))* in that way and then in this one. because he moves down (and then in this way) *((continuing to move his finger on the tablet))*
42.	(3.0)	

Figure 11. Excerpt 5 (turns 33-42)

The turns sequence 33→41 (see figure 11) shows how the teacher tries to involve Corrado within a concrete reasoning concerning the concepts of "up" and "down" ("do you want this? that he moves down and then he moves up?"). Marco (turns 39 and 41) gives his conceptual contribution to the discussion: he moves his finger on the tablet in order to indicate the correct movements the characters should do.

	43.	Teach.:	Marta? che pensi? (0.2) dov'è sto su e sto giù? Marta? what do you think? (0.2) where is this *up* and this *down*?
	44.	(2.0)	
	45.	Teach.:	scusa Marta! se io ti dico *tirati su!*? come fai? sorry Marta! if I tell you *stand up!*? what do you do?
01:44	46.	Marta:	 *((si alza in piedi e sorride))* *((she stands up and smiles))*
	47.	Teach.:	e se io ti dico *vai giù*? and if I tell you *go down*?
	48.	Marta:	*((si risiede e sorride))* *((she sits down again and smiles))*
	49.	Teach.:	e se io ti dico::, per [esempio::, and if I tell you::, for [example::,
	50.	Corrado:	[ah quindi è andato indietro! *((muovendo la mano da sinistra verso destra e riferendosi al personaggio dentro i-Code))* [oh so he moved behind! *((moving his hand from left to right and referring to the character in i-Code))*
	51.	Teach.:	*((si copre il viso con le mani sorridendo))* *((she covers her face with the hand and smiles))*
01:56	52.	Corrado:	 quindi non ci serve que::sto! *((sorridendo e indicando la tessera VAI IN GIÙ))* so we do not need this one::! *((smiling and indicating the MOVE DOWN card))*

Figure 12. Excerpt 6 (turns 43-52)

In the last part of the excerpt (see figure 12), the teacher continues to promote a more central participation of each child, by using both discursive and non-verbal strategies. Marta, who has observed all the interactions between the adult and the other children, becomes the member who convinces Corrado about the difference between the MOVE DOWN card and the MOVE RIGHT one. Marta's body movements (turns 46 and 48), in fact, are the most effective way in order to help Corrado to understand this crucial difference. At turn 52 the boy realises that they "do not need this one".

4.5.2. Teachers' discursive and interactional positioning

This long example (52 turns in all: figures 6; 8-12) shows how i-Code can be used within a small group of preschool children to support their reasoning processes, without ever giving answers and solutions. The teacher's discursive and non-verbal positionings are not something "natural" or "spontaneous": they are the result of an hard and continuous training and auto-training process centered on the most effective strategies for promoting and supporting children's knowledge co-construction.

In fact, there are some specific teacher's discursive and interactional positionings that can promote and sustain children's collective reasonings, also through coding and robotics tools (Pontecorvo *et al*. 1983; Pascucci and Zucchermaglio 1987; Pontecorvo *et al*. 1991; Pascucci 1991; Orsolini and Pontecorvo 1992; Pontecorvo 2005; Monaco and Mancini 2020; Monaco and Zucchermaglio 2021; Monaco and Ceol 2022).

For example, it is important that teachers learn to:

a) use "mirroring" actions (recalling children's speech in order to facilitate its analysis: Lumbelli 1982; Pontecorvo 1999; Monaco and Zucchermaglio 2021);
b) manage silence (consenting and accepting pauses intended as "room to think");
c) elicit problems and questions to be collectively solved (e.g. "what did you say to the tablet?");
d) support children in order to find shared solutions and agreements (e.g. "we need to find an agreement…")
e) be able to use their proxemics in order to support interaction and dialogue among children;

f) involving each participant into the discussion by using specific and situated discursive and non-verbal strategies (e.g. involving Marta to use her body movements to help Corrado).

In the FPSM preschool system these adults' competences are continuously objects of collective reflection and training within a non-stop ongoing process (Monaco and Zucchermaglio 2021). What we are starting to see is that a tool such as i-Code, if it is inserted within a well-planned educational framework, can become an effective "helper" for children and adults, since it supports challenging situations of collective problem solving.

5. Conclusions and new perspectives

The initial results of this Action-Research are starting to show that the teachers' training process is gradually contributing to:

i. transform teachers' theories and perspectives (Weigand 2010) concerning the introduction of educational robotics in preschool everyday life (from skeptical positionings to more open-minded perspectives centered on a learning by doing experience: Monaco, Ceol, in preparation);
ii. modify and enrich teachers' discursive and dialogic competences, for promoting children's knowledge co-construction, also thanks to the physical and multimodal features of coding and robotic tools (i-Code, BeeBot and Lego WeDo 2.0) always within small group situations;
iii. sustain and support teachers' professional awareness concerning the importance of inserting these technological tools always within a well-planned educational framework aimed at promoting children's social learning processes (e.g. collaboration, participation, narratives co-construction, etc.).

The third training year is going to be mainly oriented to improve teachers' awareness concerning the possibility – and the importance at the same time – of *interconnecting different coding and robotics tools*. In this perspective, *peer learning* (among adults) will be the most powerful context for guiding and supporting teachers to construct new competences and to link them to older ones. At the end of this study, the research/training team will analyse all the results with the aim of projecting and experimenting with new versions of teachers' training programs concerning the introduction of coding and robotics within the preschool contexts. Concerning the training processes' evolution, one more objective will be the *involvement of some expert teachers* with an explicit training function towards less expert schools and colleagues.

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