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Co-constructing narratives through educational robotics in preschool small working groups

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The research involved three Italian preschools, where children were considered as proper "researchers" about a new Programming Digital Storytelling (i-Code). Educational robotics was not considered as an interesting issue by itself, but it was managed as a tool that could support the construction of collective reasonings in small group discussions. The preschool children were involved into two research steps: (1) testing and evaluating the prototype of i-Code; (2) exploring and using the first complete version of the kit. The initial results show that: (a) children competently construct collective reasoning also concerning the world of robotics and the narrative co-construction can be enriched by i-Code; (b) the narrative co-construction is much more effective when teachers play a modulation role inside the small groups.

Keywords: *preschool; small groups working; educational robotics; narrative co-construction; Programming Digital Storytelling (PDST)*

1. The theoretical framework

Psycho-pedagogical research, within all its disciplinary articulations, has always been characterized by two epistemological, methodological and conceptual polarities: from one hand the individualistic-cognitivist approach and from the other and the socio-constructivist one. According to the first perspective, the individual – with his skills, attitudes and abilities – is the main issue of interest; on the contrary, within the second approach, the focus is moved on the interaction and reciprocal influence between the individual and the external world (that means the other individuals, the environment, etc.).

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Children's development has been studied by considering cognition and learning within two different perspectives as well: development/learning processes have been considered as something strictly individualized or, quite the opposite, as something strongly characterized in a cultural and social meaning. Piaget and Vygotskij can be considered the main representatives of these two interpretations of children's learning and developmental processes (Smith *et al.* 1997; Liverta Sempio 1998).

From the twenties to the eighties of the 19th century, Piaget's theory played a crucial role within the studies related to Phycology of Development and Education. For several decades, in fact, the research on human thought and cognition was centred on individuals' mind, without really considering the social environment where people lived and interacted each other's. One of the evidences is given by the supposed necessity, elicited by many studies, to distinguish social development and social behaviours from whatever other kind of development and behaviour (Musatti 1986).

In this perspective, contextual dimensions were usually considered not so relevant concerning the investigation of cognitive competences and skills or, in some cases, they were conceptualized as "additional factors" that could influence or facilitate cognitive learning (Edwards and Mercer 1987).

Rogoff (1990) reminds us that Piaget's main effort was to study how young people learn to construct their knowledge and to comprehend a "generic world", shared by the whole human species.

However, starting from the eighties of the 19th century, a new perspective started to be much more present (Cole 1996): it referred to Vygotskij (1934) and tried to relocate the epistemological point of view concerning how individual and context, mind and culture reciprocally interact and mutually construct. According to a socio-constructivist approach, development dimensions and educational factors are strictly interrelated, since human development can take place only throughout significant social interactions (Pontecorvo 1999).

In the nineties of the 19th century, Bruner (1990; 1996a) proposed a perspective of "Cultural Psychology" that considers each human being's development as a process that can be realized only and exclusively within a specific culture. During a famous conference organized to celebrate Piaget's and Vygotskij's centenary (both were born in 1896), Bruner tried to go beyond the opposition between their different theories: he stated that both their perspectives were essential for comprehending how people grow up, develop themselves and construct their knowledge, by creating specific interpretations on themselves and their world:

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

According to Rogoff (1990), the differences between Piaget's and Vygotskij's theoretical points of views are linked to the differences among phenomena they decided to study and analyse. In fact, as Liverta Sempio (1998) states, it is possible to identify some points that are shared by the two approaches: for instance, the children's active nature, the constructivist concept of knowledge, the importance of the relationship between subject and object within learning process, the main interest about qualitative changes of human mind (more than about the quantitative ones).

Anyway, once we have clarified the opportunity to avoid whatever dogmatic acceptance of a certain epistemological model, it is very appropriate to refer to a specific theoretical-methodological perspective, trying to construct with it a critical and dialogical interaction.

In our case, the socio-constructivist theory referring to Vygotskij was the only effective approach for investigating and comprehending *how children co-construct their knowledge*, within and throughout significant social interaction with peers and with adults, also concerning *educational robotics*. In order to obtain a situation of "significant social interaction", it is fundamental to work with small groups of children (4-5 members per each group). However, since in a context such as preschool (attended by 3-to-6-year-old children) we have several kids per each class (24-25) with one or two teachers (depending on the moment of the day), how is it possible to systematically use the *small working groups*?

For answering to this real problematic issue, there is a specific methodology that we have been promoting and implementing in preschools since 2011: it requires an important training and a deeply reflexive effort to be learnt and practiced (Monaco and Zucchermaglio 2021).

1.1. The innovative methodology of small groups

How do children learn to know and to transform the world they are included in? It is a quite common feeling to consider direct teaching and individual tasks as the preferred conditions to promote learning construction, also in preschool. Despite there are several studies concerning knowledge acquisition as a process that is strongly characterized in a social sense (Vygotskij 1934; Cole 1996; Pontecorvo and Pontecorvo 1986; Pontecorvo 1989; 1999; Rogoff 1990), interaction among people

is still usually considered only from a socio-affective-relational point of view. It is still not so common to intend social interaction as the most powerful condition to construct "proper" cognitive and conceptual learning.

This vision has at least two levels of implications: on the one hand, the numerousness of groups (sections, classes, etc.) is considered a kind of "barrier" for developmental/educational processes; on the other, whatever type of diversity among pupils is evaluated as "not positive interference" that influences the group's opportunity of learning and improving (Pascucci 1991).

Vygotskij reversed this perspective by demonstrating that social interaction between children, and between them and teachers, represents the most efficient "engine" for development and learning, also from a cognitive point of view. That means that educational contexts, such as preschools, are important places of *cultural socialization* (Ochs 2002; Ochs and Schieffelin 1994): they help children to become competent members of their society by enriching their "tool-kit" (Bruner 1996) with several cultural tools, above all the language/discourse.

Throughout the interaction with other kids and with experienced adults, within well-planned educational frameworks, each child – who is a "natural and active apprentice" (Rogoff 1990) – learns to move inside her/his Zo-ped (Vygotskij), that is the psychological area she/he can reach whether she/he is supported by the intervention of someone who is "more competent" (Vygotskij 1934).

According to Vygotskij, Zo-ped is "the tomorrow of the development": the idea is that learning is good only when it "precedes development" and all the educational contexts should work to allow children to practice all their competences and intelligences (Gardner 1983; 1999).

From an operational point of view, how can the school (and the preschool or the infants/toddlers' centre as well) actualize this pedagogical overturning of the relationships between teaching and learning? Which methodological choices can guarantee to children the possibility to experiment with real and challenging situations of collaborative learning (Pontecorvo 1989; 1999; Monaco and Zucchermaglio 2021)?

According to Bruner (1996a), social interactions that children construct with the external world are the most important bases of their own development, if educators/teachers are able to assume with them a function of "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 and more autonomous and competent. Anyway, the concepts of Zo-ped and scaffolding are not specifically linked to the relationship child-adult: they can be activated and promoted also among peers. In fact, the people who are "more competent" can be also other children: the scaffolding can be structured

also among children, within small groups where it is possible to promote significant social interactions.

Educational contexts oriented to work within the Zone of proximal development of each member should also promote the "good conflict", that is the opposition concerning the things that people discuss and not the relationship among the participants.

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 and more complex decisions, etc. A high level of disagreement, of divergent positions and points of view, of diversified knowledge among children and among adults supports the co-construction of much more refined explanations, argumentations, reasonings, and comprehension of phenomena and events (Pontecorvo *et al.* 1983; Dunbar 1993; Pontecorvo 1993; Monaco 2007; Asterhan and Babichenko 2015).

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

a) the small group (4-5 members) permits to construct a *significant social interaction* among few social actors, allowing everybody – children and adults – to participate in different proposals in an aware and cognitively rich way;
b) the interaction within a small group support and sustain *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 that always agreeing and cooperating);
c) the possibility to interact with the Other in a "small situation" gives children greater opportunities of expression and participation, both in a verbal and non-verbal level.

Starting from the infants/toddlers' centres 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 linked to organizational reasons (e.g., many pupils with one or two teachers), some others it depends on "ideological" teachers' positionings.

Using the small group methodology, in fact, requires that educators and teachers drastically transform their point of view, not only concerning their implicit and explicit theories about development/learning processes, but also as regards their methodological and discursive competences. Working in this way implies the activation of *continuous training processes* that allow teachers to challenge "on field" all the ineludible problems and difficulties and to find inside them the

"methodological keys" for transforming their educational-didactic intervention (Pontecorvo *et al.* 1991; Zucchermaglio 1999; Monaco and Zucchermaglio 2020).

This methodology does not require the possibility to access supplementary spaces or to activate additional teachers: it permits the adult to interact with a small group of children at once, also in the most complex and numerous situations. One of the most important methodological requirements is that teachers learn to really trust children and their competences and learning potentialities. In this way, it is possible to reach a condition where – in the same room – there are both *small groups guided by an adult* (one group or more, depending on how many adults are present at the same time) and a certain number of *autonomous small groups*. These last manage – in a completely autonomous way – an interesting and challenging proposal specifically planned by teachers: there is a unique collaborative and participating task, intended in a brunerian meaning (Bruner 1996a).

It is important to establish a shifting system in order to allow each small group to develop both the guided activity/activities and the several proposals of autonomous activities. First, it is necessary to negotiate and define the whole methodological process with children, who have to be considered as active and aware actors. Teachers create many small groups (e.g. 5 groups in a classroom made of 25 members) that should be "not homogeneously well calibrated" (Pascucci and Zucchermaglio 1987; Zucchermaglio and Zanotti 1989; Pascucci 1996; Monaco 2007; 2017): they should be characterized by a certain dishomogeneity inside themselves (e.g. concerning age, gender, competences, etc.) and at the same time they should result quite balanced among them (e.g. avoiding that there is a group where the discursive exchange is very refined and one other where all the participants work hard to express their own opinion).

Moreover, there is a requirement that represents from one hand a great educational-didactic benefit and from the other hand an important methodological support: the groups are stable for a certain period (its duration depends on several dimensions, such as the frequency of the working groups' sessions, the features of the proposal, etc.). In that way, each small group can gradually construct an own interactional history that can sustain children's social learning processes.

It is not assumed that teachers are able to create "not homogeneously well calibrated" groups and to plan challenging educational proposals both for guided and autonomous small groups (Monaco and Mancini 2020). All these adult's competences should be object of specific training processes, intended as "places" where teachers can co-construct methodological foundations in order to experiment the innovation and to search for observational and assessment strategies that can be useful for collectively reflecting and re-planning new proposals (Pontecorvo 1979; GUS 1980; Zucchermaglio *et al.* 2013; Monaco 2017).

1.2. The educational robotics as an instrument to promote children's social learning processes

Concerning the introduction of digital technologies within educational context aimed at promoting and supporting children's social learning processes, the first assumption is that, as Kranzberg affirmed in 1986, this kind of instrument is "neither good nor bad; nor it is neutral". The idea is that technological tools – such as any other tool – do not create new social and educational practices "from nowhere", since they always interact with a system of practices that already exists and that has an own history and an embedded tradition (Zucchermaglio 2000; Mancini and Ligorio 2007; Monaco *et al.* 2020; Mich *et al.* 2021).

In other words, the educational planning, and the collective reflection about the innovative dimension of teachers' professional function, are the most important "cornerstone" of every technological/robotics proposal within preschools.

In this perspective, digital technologies – as much as robotics – can become interesting and significant methodological instruments only if two educational and formative conditions are respected:

a) since it is intended as a "cultural tool" (Bruner 1996a), robotics has to become objective of training reflection with teachers, in a practice-based perspective (Little 2012);
b) this reflexive training action gets much more effective and situated (Mercer 1992) whether it is founded on the awareness about what 3-to-6-year-old children think and know about robots.

For these reasons, the first step we moved some years ago, together with dr. Ornella Mich and dr. Alessandra Potrich (researchers of Fondazione Bruno Kessler[3] in Trento, Italy), was a specific research (Robobimbi: Monaco *et al.*, 2020) aimed at investigating preschool children's ideas and representations about robots[4].

That study showed from one hand that preschool children's representations about robots are quite complex and not much stereotyped, and from the other hand that they have quite clear the "mechanical" nature of robots, that are seen as instruments that "do things because humans tell them what they have to do" (as a 4-year-old girl affirmed within Robobimbi).

[3] Fondazione Bruno Kessler (FBK) is the top Research Institute in Italy, ranked 1st for scientific excellence within 3 different subject areas and for the economic and social impact according to the latest quality of research ANVUR evaluation (https://www.fbk.eu).

[4] Robobimbi research involved 12 preschools associated with the Provincial Federation of Preschools of Trento (FPSM), belonging to different Areas of the Province of Trento. We had in all 219 children and 25 teachers engaged into the research (Monaco *et al*. 2020). FPSM is an association of 134 autonomous preschools.

The secondary purpose of Robobimbi was the possibility to project and realize contexts of teachers' training for introducing educational robotics within preschools (Mich *et al*. 2022). In fact, we were convinced that the best training for the educators should be thought and planned starting from what kids themselves already know and think.

Two years ago, involving some teachers who had participated in Robobimbi, we started to design a specific training program for preschool teachers with the purpose to introduce educational robotics to promote and support children's social learning processes (e.g., collaboration, participation, narrative co-construction, etc.).

It was a practice-based training program[5], and we used tools such as BeeBot, Cubetto and Lego WeDo, in order to familiarize teachers and children with the idea of coding, programming and using these instruments to sustaining the possibility of learning to collaborate, to decide together, to participate and so on (Mich *et al.* 2022).

In a socio-constructivist framework, as we wrote in the first part of this paper, language and discourse are the most important tools that children have to acquire within their "tool-kit" (Bruner 1996a). In a perspective that considers the language as "social action" (Wittengstein 1953; Ochs 1988; Fasulo and Pontecorvo 1999/2022), the discursive interaction among children – within significant and challenging educational situations – is the most powerful "engine" for constructing complex and refined social learning.

We tried to support the teachers to find some possible answer to a precise question: *how can robotics support significant discursive interactions within a stable small group*?

For example, Ospedaletto preschool (one of those that took part in the robotics training) planned and realized an experience that interconnected the small group work with the Lego WeDo 2.0. Each small group present in the classroom (three in all) built a specific part of a robot, shown into the instruction booklet. For building that "piece" of robot, children had to: 1) refer to the instruction booklet and 2) try to understand and follow it, always in a collaborative way (of course, none was a conventional reader).

[5] The training program involved 11 preschools associated with FPSM (all the schools belonging to the Area of Valsugana and Primiero: Monaco, Ceol 2022). In September 2022, we introduced a new training program with 7 preschools associated with FPSM (all the schools belonging to the Area of Giudicarie esteriori), based also on the research experience made by Fondo, Cloz-Brez and Tesero.


When the three pieces of the robot had been built, children and teacher put them together and – always in the small group – discussed on a crucial issue: *how was it possible "to tell the robot what it had to do"*? Once each group reached the awareness about the fact that the robot "needs the computer for doing things", children started to do the first attempts for programming it by using the PC interface.


This brief example shows the concrete possibility to use a robotic tool, such as Lego WeDe 2.0, within significant educational activities. As well as it happens concerning whatever instrument, the most important dimension is given by the presence of a solid and well-planned educational framework (Monaco and Zucchermaglio 2021) that allows the teachers to manage spaces, timing, materials/artifacts, grouping strategies and adults' positioning for supporting children's social learning process. As regards the Lego WeDo 2.0 example, the preschool was working on the co-construction of narrative and this tool represented a new and interesting opportunity to attribute significant meanings to their interesting experience (Bruner 1990).

In 2020, while we were working with some schools (such as Ospedaletto) on robotics as an instrument to promote children's social learning processes, we were involved, together with dr. Paolo Massa and dr. Ornella Mich of FBK, in an interesting co-design process concerning a new technological tool – i-Code – that was conceived with the purpose of promoting the Programming Digital Storytelling experience from the age of 3.

In a brunerian sense (Bruner 1990), we prefer to talk about "narrative co-construction" (instead of "storytelling") because this concept is much closer to the socio-constructivist idea of development and learning processes. According to Bruner, in fact, the whole human experience is oriented to create narratives for understanding and attributing significant meanings to everyday life. This author affirms that human life and human mind are shaped by culture – and not by biology – and it is culture that gives meaning to action, by situating its underlying intentional states in an interpretive system (Bruner 1990).

Therefore, co-constructing narratives – also among preschool children – is much more than "making up or telling stories": it signifies finding and negotiating meanings to represent and confer "a structure" onto experiences (as we saw in Ospedaletto preschool's experience).

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

Perhaps one of the most interesting features of the DST is its multimodal nature (Garvis 2018): children can use, and interconnect each other's, several languages (e.g., words, pictures, photographs, drawings, sounds, music, voices, etc.) to construct *digital stories*. In this way their narratives, that are always the cultural product of complex social and discursive interactions among kids, become *multimodal stories* with the increased function of "giving meanings" (Bruner 1990) to their life.

There is a further step of complexity that digital technology can confer to the "ancient art of storytelling": the combination of the DST with the concept of coding/programming (Mich *et al.* 2021). Thompson and Tanomoto (2016) use the expression "storytelling programming environment" to indicate those instruments that adopt software commands to move the characters, to modify the scenarios, to record voices and sounds, etc. The *programmable digital storytelling* tools (PDST) can be used to promote children' computational thinking (Macrides, Miliou, and Angeli 2021) and, according to some recent studies, they can support the development of the critical reasoning and the construction of collaborative and participating competences (Behnamnia *et al.* 2020; Dorouka, Papadakis, and Kalogiannakis 2020; Fridberg, Thulin, and 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 and 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 and Posada 2017).

It is possible to find different typologies of PDST: some of them are based on a fully digital interface (e.g., ScratchJr), while others (e.g., Osmo or ScottieGo!) adopt a tangible interface where the programming is done by using physical blocks (Baranauskas and Posada 2017; Sullivan, Bers, and Pugnali 2017; Yu and Roque 2019; Mich *et al*. 2021). According to us, one of the most critical features of tools such as Osmo or ScottieGo! consists into the restricted possibilities to create narratives entirely defined and decided by children. The story, in fact, is already embedded in the game system: paraphrasing Goffman (1981), kids are just in the possibility to "animate a message" that has been structured by someone else. On the contrary, ScratchJr gives the users much larger opportunities in story co-construction but its totally digital nature could not facilitate young children's use (Sylla *et al*. 2015; Sapounidis *et al*. 2019).

Therefore, the participation in co-designing a new PDST tool (i-Code), invented by FBK and realized by Edutech[6], was for us a very interesting and challenging proposal. I-Code, in fact, weaves the physical blocks with the digital interface within a specific App. Moreover, it allows children to really create their narratives from nowhere, by introducing every kind of "handmade" characters, scenarios, sounds, voices and so on.

For these reasons, our participation in i-Code co-design process was immediately translated into a new methodological and research question: *how it would have been possible to involve preschool children as "proper researchers" on robotics?*

2. The research

The research aimed at promoting *social and discursive interaction* among preschool children within *small group situations*, for improving and enriching their social learning process (Monaco and Pontecorvo 2009; Monaco and Zucchermaglio 2021), also concerning the issue of *educational robotics* (D'Ambrosio *et al.* 2019; Mich *et al.* 2021; Monaco *et al.* 2020; Bers 2022).

As we already explained, our theoretical framework – joined by all the schools associated to FPSM – refers to the socio-constructivism of vygotskian approach (Vygotskij 1934; Bruner 1990; 1996a; Cole 1996; Pontecorvo 1999).

In this perspective, the „superior form of activity and thinking" (Vygotskij 1934) has to be promoted and supported by extra-familiar educational contexts (e.g., infant/toddlers' centres, preschools, etc.), because it is strictly associated to every

[6] Edutech is a company that studies, develops and provides technological solutions to support educational and collaborative processes for schools and academic institutions, companies and organizations (https://www.edutech.it/en). i-Code was born from an idea of FBK and its co-design process involved also the Autonomous Province of Trento and Coopselios Cooperative.

socio-relational and socio-cultural environment that children live in – since their birth – and that they contribute to transform in an active and participating way.

2.2. The participants and the methodology

The research involved three Italian preschools associated to FPSM[7] (Cloz-Brez, Fondo and Tesero): 3-to-6-year-old children were considered as "proper researchers" about the design process of i-Code.

The participants were in all 66 kids and 7 teachers (for a total of 14 small groups): 21 kids and 3 adults in Fondo school (1 classroom, 4 small groups), 35 kids and 2 adults in Cloz-Brez school (2 classrooms, 8 small groups) and 10 kids with 2 adults in Tesero school (half classroom, 2 small groups). The main purposes of the study were:

a) promoting *social and discursive interaction among children* within mixed-by-age and stable small group situations, in order to improve and increase their social learning processes, also concerning *robotics*;
b) *educational robotics*, that was not considered as an interesting issue by itself, was managed as a tool that could be used – within a well-planned pedagogical framework – with the purpose of supporting the construction of *collective reasonings* throughout small group discussions.

Discussion is considered as a specific discursive situation where children have to manage a "problem" (something to be solved) by searching for shared solutions. "Discussing" is something very different from "conversing" because it implies the co-constructing of collective reasonings (Pontecorvo *et al.* 1991), where the individual ideas and point of view have to reciprocally interconnect and sometimes to be in conflict (intended in a constructive meaning).

As regards the methodological framework, the research is based on the ethnographic observation of preschool contexts "from the inside" (Mantovani 2003; Zucchermaglio 2003; Zucchermaglio *et al.* 2013; Monaco and Zucchermaglio 2021), in order to understand how the social actors reciprocally construct their interactions for acquiring new knowledge. The interactional data were collected/constructed, by the participant teachers themselves, throughout several instruments, such as field notes, pictures, and video recordings. The data were transcribed by using a Conversational System (Jefferson 1985) or a Multimodal System (Goodwin 1994; Mondada 2006; Monaco and Pontecorvo 2010; Monaco and Zucchermaglio 2021).

[7] The preschools of Cloz-Brez and Fondo belong to the Area of Cles 1, coordinated by dr. Ilaria Mancini, while Tesero belongs to the Area of Val di Fiemme, coordinated by dr. Tiziana Ceol, who is both one of the researchers and a pedagogical coordinator. We want to say a very big "thanks" to all the children, to all the teachers and to dr. Ilaria Mancini for their competent participation.

2.3. The research steps

Teachers and children, always working in small group situations (mixed by age, gender and competences), were involved into two different research steps:

1) children could test and evaluate the mock-up (prototype) of i-Code in an analogical form, without any kind of technology (Fondo preschool: school year 2020/2021). They actually did unplugged experience of coding;
2) children could use the first complete version of the PDST tool, without receiving any kind of technical instructions by the teacher. Children explored i-Code by reasoning together and by discussing about its several components (Cloz-Brez and Tesero preschools: school years 2021/2022 and 2022/2023).

In both cases, the activities were proposed within guided small groups: the teacher played a crucial role of interaction modulator (Pontecorvo *et al.* 1991; Fasulo and Pontecorvo 1999/2022; Monaco and Zucchermaglio 2021). Her discursive interventions were oriented to support the ideas circulation and the collective reasoning construction (e.g. she "mirrored" to the group some individual relevant contributions, she introduced problematization and sustained the opposition between different points of view, etc.).

All the involved preschool children moved throughout their different experiences as the real researchers usually do: all the discoveries they shared and all the proposals they did were communicated to the adult research group that was working on the co-design process of i-Code. In other terms, kids did not "pretend to be researchers": they really led an experimental process that produced important reflections and suggestions concerning both physical and functional features of the new-born PDST tool.

Moreover, another important dimension of the three preschools' experience concerned the presence of two different levels of narrative co-construction. In fact, if we would want to paraphrase Bruner (1990), we could say that children could co-construct narratives by activating a "double landscape": from one hand the storytelling itself (the narratives they were going to create) and from the other hand the narratives that concerned their interactions and theirs attempts to attribute negotiated meaning to the tools they were using.

3. Initial results

3.1. Testing and evaluating the mock-up of i-Code

Before starting the experimentation activities with children, the teachers of Fondo preschool – guided and supported by us and by the pedagogical coordinator (dr. Ilaria Mancini) – wrote a specific educational project aimed at introducing the i-Code mock-up (several homemade blocks and some numeric parameters) as a new objective of collective research. The preschool, in fact, was working on a specific learning process: *doing observational research together* (Monaco and Zucchermaglio 2021). Therefore, the i-Code prototype was not a kind of "stranger" suddenly arrived at school: on the contrary, it was presented an interesting issue to be studied and analysed in a collective way.

In the participating classroom, there were 21 children with 3 teachers: because of the presence of a "special needs" girl – who has many competences as well – the classroom was working also with a supplementary teacher[8]. In the usual organization of the preschool, that classroom was divided into 4 stable small groups, respectively called, by children themselves, "Chicks", "Tigers", "Hearts" and "T-Rex". Across several weeks, each small group did participate in every proposal the teachers had planned "around i-Code". In particular, this step of the larger research was organized into four different typologies of proposals (each working session was entirely video recorded by teachers[9]):

a) the exploration of the handmade blocks in order to find some shared meanings;
b) the use of the homemade blocks to decide how a specific character (e.g. a fireman who has to extinguish a fire) should move on a grid (the tiles of the floor);
c) the reconstruction of the sequence/code corresponding to a specific "path" created by the teachers on the floor/grid by using a colored adhesive tape (which should be the right sequence to obtain that path?);
d) the "migration" of the experience from the floor/grid to a paper sheet/scenario realized by each small group (which sequence do we need to make the character moving from a specific point on the scenario to another one?).

[8] We do not like the expression "special needs child" because we think that every human being has "special needs" and, moreover, a good school should work for giving all children (and all adults) the opportunity to construct different form and levels of participation (Monaco and Pontecorvo 2009; Monaco and Zucchermaglio 2021; Fatigante 2021). We decided to use the concept of "special needs child" only to make the comprehension of the classroom situation easier, since this expression is commonly adopted.

[9] We collected the informed consent by each family in order to use the observational data (including photos and videos) for research or training purposes.

3.1.1. Collective exploration of the blocks

Each small group of children analysed the different blocks that composed the mock-up and constructed a first explanation of the subtended "code", by discussing among them and by searching for a temporary agreement (Figure 1). The result was the presence of four different hypotheses of blocks/code (one for each group) and in all the situations children declared the necessity "to test and verify" their specific ideas.

Figure 1. All the small groups working on the exploration of the blocks (in different moments of the week).

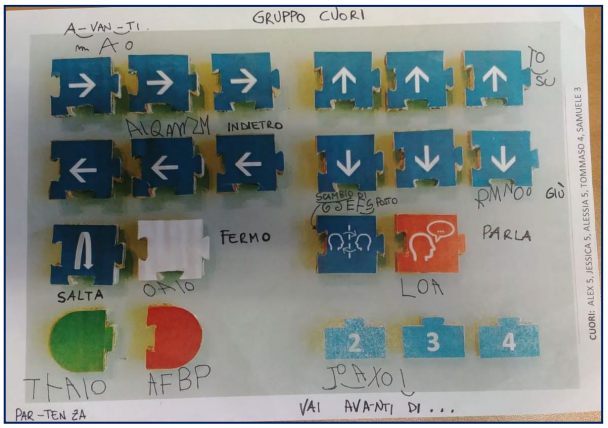


Figure 2. The blocks interpretation made by the Heart small group (children use also their "spontaneous written language", Ferreiro Teberosky 1979).

As we can see in Figure 2, each small group collectively hypothesized some specific meaning concerning every block (e.g. MOVE UP, MOVE DOWN, GO AHEAD, GO BACKWARDS, STOP, etc.).

As teachers wrote within their "reflexive notes" in the educational planning instrument[10],

> children immediately demonstrated a big passion for this experience. Most of them, when they saw the materials, associated the block with the idea of "giving some indications". According to each small group, the different blocks were useful to "let something move in several directions". It was very interesting that sometimes there was no correspondence between the verbal meanings that different children gave to the same block. For example, there was an interesting discussion between Isabella and Valerio about the block containing the symbol "↑": according to the girl, that block indicated the action "go ahead of 1 step", while the boy was convinced that it meant "go up 1 step". The only useful strategy they found out to solve this opposition was associating the movement of the hand to the hypothesized direction: in that way, the two kids were able to find an agreement and to arrive at a common and shared meaning that finally was "go up 1 step".

Only when all the groups were quite "convinced" about the meanings they attributed to the blocks of the mock-up (it required 3-4 working sessions for every group), teachers introduced the second proposal.

3.1.2. Using the blocks to make a character move on a floor/grid

Once the hypothetical meanings of the blocks had been defined, each small group started to test these materials by creating some initial sequences in order to make a character move on a grid that was represented by the tiles of the floor. Such as the first one, also this experience required several working sessions (2-3 per each group) and it was very interesting to notice that – such as they were used to do in other activities – children negotiated different roles during their interactions. These roles (e.g., programming, moving "as if" a child was the character, checking whether programming and movements were reciprocally coherent) were identified and played by children in a collaborative way, step by step, without any rigid or pre-defined participation framework[11].

[10] Teachers' work concerning the educational planning of significant activities, such as the construction of reflexive notes during and at the end of the experiences, is always a collective effort: the possibility to "think together" is one of the most important "ingredients" for a well-planned and well-acted educational context.

[11] This is one of the most important differences between the "cooperative learning" approach and the "collaborative learning" perspective (Pontecorvo 1999; Pontecorvo *et al.* 1991; Monaco and Zucchermaglio 2021): working in a collaborative way means learning to manage both the

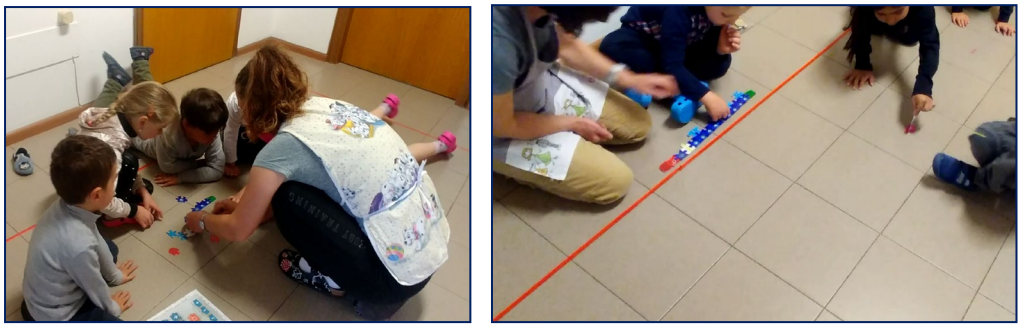


Figure 3. Children are creating sequences of blocks in order to move a character on the floor/grid.

Here we are going to present another excerpt from the "reflexive notes" written by teachers. It underlines some methodological choices that made easier children's work with i-Code mock-up:

> Reading the sequence, and coherently moving the character on the floor/grid, requires many competences that children should gradually construct and experiment several times. Moreover, it would be very important that each child played all the possible roles (e.g. the "sequence reader" and the "character mover"). We noticed that it was also very useful to find a way for leaving outlines on the floor/grid concerning the character's path (e.g., small pieces of adhesive tape). In that way, in fact, children felt much more comfortable with the necessity of understanding the connections between sequence and character's movement on the grid.

3.1.3.Reconstructing the sequence/code corresponding to a "path" on the floor/grid

Maybe this was the most challenging step of children's experimentation of the mock-up, because it required to invert the "normal" relationship between coding and character's movement.

consensual and the oppositional dimensions of social interaction. This learning implies the construction of several social, emotional and cognitive competences through which children can identify and assume different roles and diverse forms/levels of participation, without any rigid positioning attribution. In the collaborative meaning of learning – also with young children –, forms of participation, roles and collective tasks contribute to define a participation framework that has to be flexible and dynamic (Monaco and Pontecorvo 2009).

In this case, in fact, kids should identify the "right" sequence/code corresponding to a specific "path" created by the teachers on the floor/grid by using a colored adhesive tape. It was a quite complex proposal that would not have been managed by a single child: on the contrary, the small group – activating a collective reasoning scaffolded by the teacher (Wood *et al.* 1996) – searched for an efficient solution making several attempts. Of course, the main purpose was not reaching the "right answer", but thinking together and trying to find a solution to a very concrete problem: *which should be the right sequence to obtain that specific path* (Figure 4)?

Figure 4. Children are reconstructing the code/sequence that underlies the path on the floor/grid.

Also in this case, the teachers wrote some reflexive note that are very useful to better understand their educational and methodological choices:

> It was very useful, before creating the sequence, letting children view the character's movements on the path and repeat these movements some times. Concerning the numerical parameters, they were present and available form the first approaches to the mock-up. Anyway, in this part of the experience it was more frequent that one or two children per each group started to associate the numbers to the concept of movement repetition.

3.1.4.Migrating from the floor/grid to the paper/sheet scenario realized by children

The last proposal concerned the "migration" of the experiences from the floor/grid to a paper sheet that became the proper "scenario" of the first real narratives created by every small group.

Until that moment, the stories that connected the characters to the code/sequence had been not so rich and complex, because it had been necessary to construct a shared system of meanings around the tool. Once this cultural and technological socialization to the instrument was quite solid, children started to

negotiate some narratives and to “animate” them by using the mock-up and the homemade scenario (a drawing collectively made by the group and concerning the story they were creating).

Figure 5. Children are moving a character on a homemade grid/scenario within a narrative framework (e.g., in the photo on the left there is a machine that cuts the grass and has to escape some obstacles, such as trees, rocks, bushes, etc.).

The most interesting dimension of this part of the proposal was the necessity to check, always in a collective way, whether the instructions contained in the sequence were right. The migration from the floor to the paper introduced some challenging problems that children had to manage and solve. For example, at the beginning it was not clear how many steps the character could do without going outside the scenario.

Concerning this activity, teachers wrote:

> Some children, looking at the grid/scenario, were not able to immediately understand if the sequence they were creating did define a “right path” or if it was necessary to choose another starting point, in order to remain within the scenario itself. For example, in a small group at a certain moment a girl said “No, look here, if the machine starts from this point, then it goes down 3 steps and it goes outside. We have moved up the starting point!”. Moreover, at the beginning of the experience with the paper/grid, the sequence was created in a gradual way: children inserted some blocks, then they moved the character following the chosen commands and finally they came back to modify the sequence.

This recursive process that continuously moved from the sequence to the character and vice versa contributed also to enrich the narrative that the children were creating.

The research process led by the teachers of Fondo preschool – and guided by us and by their pedagogical coordinator – had a circular direction as well: from the planning framework to the experiences within the small groups, then to the collective reflection and again to a more aware and refined planning action.

3.2. Using the first complete version of i-Code

The second step of the larger research consisted into the experimentations of the first complete version of i-Code, that was the result also of the research activity of Fondo preschool (par. 3.1).

This step involved the preschools of Cloz-Brez (35 children with 2 teachers) and Tesero (10 children with 2 teachers). It was designed by the teachers supported by us and by their pedagogical coordinators (respectively dr. Ilaria Mancini e dr. Tiziana Ceol).

As we stated in the first part of the paper, i-Code is a robotic tool consisting of a set of tangible blocks and a tablet application. Each block is associated with a specific command, described with a graphical representation, a short textual description, and a colour that identifies the type of command (e.g. blue for movements, green for start, red for stop, etc.). Some blocks can be also associated with a numerical parameter (Figure 6).

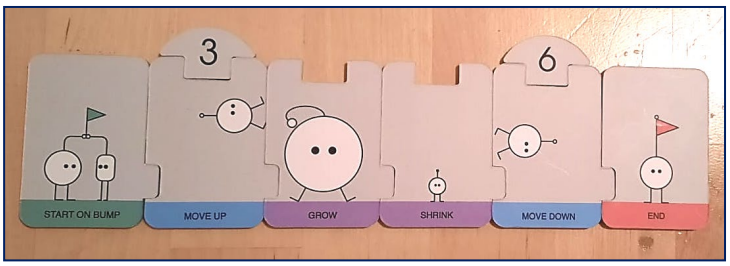


Figure 6. An example of a sequence made of blocks and numerical parameters.

The interface of the App is simple and immediate. The story creation process consists of:

1) choosing the scenario, that can be selected among the default examples[12] or can be imported by the users (by taking a picture of a drawing or everything else using the tablet's camera);
2) creating the characters of the narrative, choosing among those available in the App, or taking a picture of a drawing, a photo, a person, an object, etc. The users create the story by programming characters' movements and scenarios' changing. Moreover, they can also record audio messages.
3) creating appropriate blocks sequences and capturing them within the App by using the tablet's camera. When it has been correctly acquired, the sequence can be visualised in the App and it gives "life" to a specific character within the chosen scenario.

[12] Scenario and characters that are present within the App was created by Matteo Boato, an Italian artist who comes from Trento. He has been working with FPSM for many years.

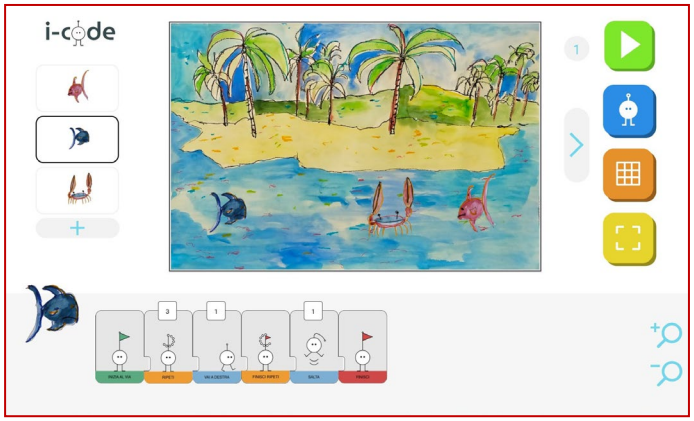


Figure 7. An example of an i-Code project, with the scenario, three characters and a blocks sequence.

Both the involved schools shared some methodological choices concerning this research step:

a) each stable small group had several work sessions (minimum 3-4) to explore i-Code;
b) at the beginning of this work children explored only the tangible blocks (without the tablet);

Figure 8. Small groups of children are discussing to find shared meanings around the different blocks.

c) the tablet – and the first connections between the blocks sequences and the digital components of i-Code (the App) – were introduced only after a long "familiarization period" with the blocks themselves and with the programming concept (the idea that the characters "made things because the blocks sequence, created by people, say them what to do");

Figure 9. A small group is learning to use the tablet for capturing the blocks sequence they have just created. After the capturing operation, children start to check if "in the tablet there are all the blocks" they chose for their sequence.

d) a specific discursive teacher's positioning within the small group was collectively identified (it was coherent with the socio-constructivist approach of the schools: see par. 1): she never gave answers or solutions and she promoted and sustained the construction of collective reasoning among children.

e) a specific discursive teacher's positioning within the small group was collectively identified (it was coherent with the socio-constructivist approach of the schools: see par. 1): she never gave answers or solutions and she promoted and sustained the construction of collective reasoning among children.

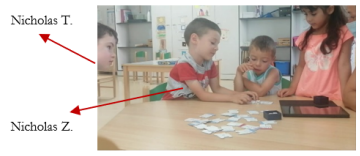
16:10	1.	Teach.:	what must we do to make Mr. Four-Eyes moving?	
	2.	Aya:	we have to take the blocks!	
	3.	Teach.:	great! you remember everything guys! (0.5) ((*she takes the box with all the blocks*)) here they are! (0.2) which his the first block we need to use?	
	4.	Leonardo:	the START block!	
	5.	Teach.:	the START block! very good!	
	6.	(2.0)	*((Children start to construct the sequence of blocks to make Mr. Four-Eyes moving within the scenario))*	

Figure 10. An excerpt[13] of small group interaction where the teacher sustains children's collective reasoning and discussion, by eliciting problems to be solved (e.g. "What must we do to make Mr. Four-Eyes move?").

[13] We used a multimodal transcription system (Monaco 2008; Monaco and Pontecorvo 2010; Monaco, Zucchermaglio 2021) created for analyzing social interactions among infant/toddler children.

We know, by several decades of educational Action and Research, that there are some specific teacher's discursive and interactional positionings that can promote and sustain the co-construction of knowledge among children (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). For example, it is important that teachers:

- use the "mirroring" actions (recalling children's speech in order to facilitate its analysis: Lumbelli 1982; Pontecorvo 1999);
- manage the silence (consenting and accepting pauses intended as "room to think");
- elicit problems and questions to be collectively solved;
- support children in order to find shared solutions and agreements.

These are only some of the discursive and interactional strategies belonging to expert teachers' "tool-kit" (Bruner 1996a). In the FPSM preschools system these competences are continuously objects of collective reflection and training within a non-stop ongoing process (Monaco and Zucchermaglio 2021).

3.3. The "double landscape" of narrative co-construction

A further dimension of the three preschools' experience concerned the presence of two different levels of narrative co-construction. Using the concept of "double landscape" introduced by Bruner (1990), and transferring it on other level, we can affirm that besides the proper storytelling activity (the narrative children are going to create) there was a *coexisting narrative process concerning participants' interactions* and their efforts to construct negotiated meaning around the tools they were using.

In this perspective, when a real problem appeared to children – or it was introduced by the teacher – the process of collective research for a shared solution itself was considered as a narrative co-construction.

We are going to present two brief examples of what we defined a "narrative double landscape" within the discursive situations of small group working.

Excerpt 1. An extract of the teacher's observational notes concerning the exploration of i-Code blocks

Within this example, during the blocks exploration, children have to face and solve a concrete problem: *which is the right direction of the sequence (horizontal or vertical)?*

As we can notice in the following excerpt, children discuss about the emergent issue and each of them tries to produce argumentations to sustain his/her point of view. At a certain moment, they also use their bodies to test the different hypotheses the group is constructing.

By adopting a narrative and socially connoted positioning, the teacher lets them discuss and accepts to close the small group session without a conclusive solution: she postpones the final and shared decision to the successive moment concerning the tablet introduction.

Since, according to Bruner, the narrative process consists of the collective research of shared meanings to attribute to human experience (Bruner 1990), this adult positioning can be considered as a deeply narrative choice.

Looking for shared meanings around i-Code blocks

Children agree about the idea that "on the blocks there are some characters who do something": they walk, jump, turn themselves.
The group discuss about some specific blocks (e.g., MOVE DOWN, MOVE UP, WAIT, MOVE RIGHT, MOVE LEFT, and so on) in order to find/construct a shared meaning.
It is very interesting when children are trying to understand (also by using their bodies) the meaning of the MOVE UP block. Immediately Thomas associated it with the MOVE DOWN block and decided to put them together on the floor.
Sofia, who has always been skeptical about the way of connecting the blocks each other's, tries to create a sequence developed in a perpendicular sense (instead of the correct horizontal one).

Sofia makes several attempts, trying to form two perpendicular lines, but Thomas always invites her to come back to the horizontal sequence.
I decide to ask them what is going on and Sofia answers: "if we put the block in this way [*intending horizontally*], the character falls down! It seems that he is flying!"
Now her schoolmates understand Sofia's doubts and start to lie down on the floor and to mime the action MOVE UP by staying in that position. They lift their feet upward and then put them on the wall.
At the end of this collective "research", children affirm that the sequence of blocks has to be built only in horizontal way: they agree that the perpendicular option is not functional.
Sofia is still not convinced but I prefer not to give the group any kind of solution: the five children will be able to verify their hypotheses when I will introduce also the tablet and the App.

Figure 11. An excerpt of the observational notes written by the teacher for reflecting on the educational experience[14].

[14] The three preschools involved into the larger research had participated in a specific training process concerning ethnographic observation (Mantovani 2003; Fatigante 2021; Monaco and Zucchermaglio 2021).

Excerpt 2. A co-construction of narratives mediated by i-Code

When children started to use the first version of i-Code (both blocks and App), they usually ran into concrete problems that required a collective effort to be faced and solved.

For example, there was a small group that asked to use i-Code to create a narrative concerning a recent visit to an animal farm made with all the class. Before going there, each small group had realized a *collaborative drawing*[15] that represented the animals that children had imagined to find within the farm.

Some days after the visit to the farm, one of the small groups asked the teacher to use i-Code to create a narrative, starting from their collective drawing about the "hypothetical farm" (that contained also a hypothetical lion).

First of all, the teacher started with them a conversation aimed at recalling the main meanings of their drawing. Then the children proposed to use the drawing itself as "scenario" within i-Code and the youngest member of the group (Nicholas) offered to draw the main character of the story they were creating: Mr. Four-Eyes (Figure 12)[16]. After a few minutes, Aya proposed to him to complete the drawing together.

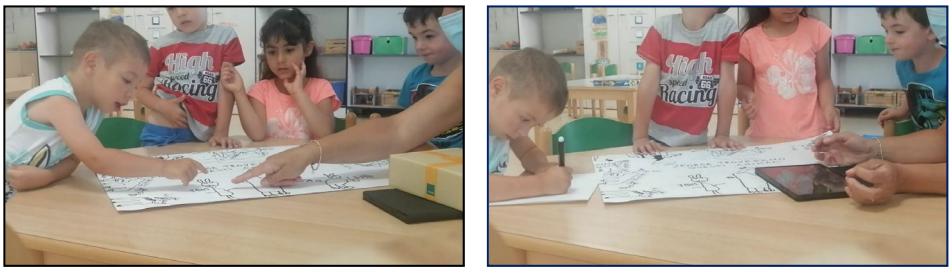


Figure 12. On the left, children and teacher are discussing about the collaborative drawing they had created some days before. On the right, Nicholas is drawing the character of the narrative.

While Nicholas and Aya were finishing to color Mr. Four-Eyes, the rest of the group decided to start to capture the scenario with the tablet. Children spent more than 7 minutes for this operation, because the drawing of the farm was very big (70x100

[15] A collective drawing is a product created by a small group in a collaborative way, by using a unique big sheet of paper, a pencil and a rubber that have to be shared and negotiated.

[16] The name of the character is linked to dr. Donato Quattrocchi (in English "Four-Eyes") who is the Safety Manager for all the preschools associated with FPSM. He is an expert that usually enters the schools and kindly interacts with children. Just to confirm, one more time, that the most fascinating and interesting world for children is the real one, the small group decided to attribute the Safety Manager's name to their main character.

cm) and the tablet was much smaller. The group made several attempts and the teacher acted as a proper scaffolder (Wood *et al.* 1976), without giving any solution and supporting their collective reasoning. Finally, children found out the answer: they put the drawing on the floor so they were able to capture it as the narrative scenario (Figure 13).

Figure 13. Children are searching for an effective solution to their actual problem: acquiring the big drawing as a i-Code scenario.

Then the group spent about 12 minutes creating the sequence of blocks, always discussing and negotiating about each step. When the sequence was ready, the teacher invited them to make "one more check" of the blocks they had used and then Aya tried to capture the sequence with the tablet. Since there are many blocks, this operation was quite complex, so the other children helped the girl to reach the goal.

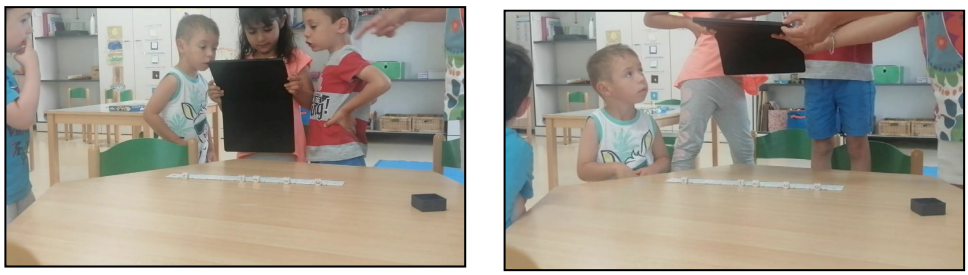


Figure 14. Children are trying to acquire the blocks sequence.

As shown by the two previous examples, the "double landscape" appears as a recursive process that continuously moves from children's discursive interactions to the operational attempts and comes back to new meanings negotiations.

4. Discussion and conclusions

The initial results show some interesting dimensions that would need deeper reflections and analysis.

a) The discussion is a situation where children competently construct collective reasoning, share a language and elaborate solutions to specific problems also concerning the world of robotics. Moreover, the co-construction of narratives can be enriched by using i-Code in a context of small group interaction. The discussion and storytelling processes are much more effective where teachers play a modulation role inside the small group (e.g., by promoting ideas circulation, by supporting oppositional situations, by introducing problematic issues, etc.).
b) Like any technological tool, i-Code does not automatically determine significant directions of educational action: it becomes a proper educational resource only when it is introduced within a specific and well-defined planning framework.
c) When there are the "right" educational planning conditions, children learn to use i-Code in a shared and negotiated way (also passing by conflict and opposition) and they also start to define – together – some functional features of the tool. In other terms, if teachers plan and propose significant and contextualized experiences, where real problems can be faced and solved in a collective way (e.g., *if we want the character to move 4 steps but we have only one block that gives that instruction, what can we do?*), children are absolutely able to move within their own Zo-ped.
d) This framework we chose completely avoids a one-tool-one-child approach: it considers the social interaction within stable small groups as the only effective context where every instrument (both analogical and technological ones) can be used for promoting and supporting children's learning processes (e.g., participation, collaboration, co-construction of narratives, etc.)
e) Throughout discursive interaction among children, and among them and the teacher, within the small group, the idea of «programming» is built by approaching the robotic tool, quite before the introduction of the tablet. This digital instrument, throughout the App, allows the children to verify (or falsify) the hypotheses they are producing about a specific sequence of blocks.
f) Even though i-Code has been considered as a tool that needs a specific educational framework to become significant and useful, its structural and functional features (physical blocks working like a puzzle and combined with a multimodal App; the possibility to introduce "homemade" scenarios, characters, voices, etc.) make it a potentially interesting instrument for promoting children's collective and multimodal narratives.

g) Children who took part in the research could start to co-construct narratives that, before concerning the use of a proper robotic tool as i-Code, did concern the construction of shared meanings about functional and structural features of an instrument that was still in progress. They gave us important feedback and suggestions that really influenced the production of i-Code and its several transitory versions.
h) Also concerning robotics, language/discourse – within a significant social context such as the small group working – was the main instrument in order to promote processes of cultural and linguistic socialization (Ochs and Schieffelin 1994).

In conclusion, it will be interesting to continue the research activity around robotics and 3-to-6-year-old children, above all by developing and enriching the circular relationship between *teachers' training* and their *concrete educational actions* within preschools. The studies we led till now were based on a specific idea of children, learning and education: we started with Robobimbi by investigating their complex thinking/discourses about robots, then we organized the first teachers' training programs on robotics and supported them to implement some experiences at school (Mich *et al.* 2022). Now we are experimenting with a more advanced version of training programs, founded on all the previous research and training steps, that will lead us to improve our learning and to promote more and more awareness about robotics both in preschool teachers and children.

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