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University of Pavia 19 - 21 June 2024

Lifelong Digital Learning and Education: promoting flexibility, inclusion, critical thinking and international exchange

Annamaria DE SANTIS, Elena CALDIROLA e Pietro CARRETTA

Conference PROCEEDINGS

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Preface

ISYDE 2024, the *Italian SYmposium on Digital Education,* has been jointly organized by the *Italian e-Learning Society* (SIe-L, https://www.sie-l.it/) and *Italian Society for Media Education Research* (SIREM, https://sirem.org/).

The 2024 edition focused on "Lifelong Digital Learning and Education: promoting flexibility, inclusion, critical thinking and international exchange" and aimed to promote innovative teaching and learning experiences enabled by technologies in the national and international scenario, able to transform educational paths into flexible and inclusive ecosystems.

Good teaching practices are the starting point for removing barriers and promoting inclusion, intercultural, and international exchange; favoring wellbeing and professional upskilling and reskilling throughout life through education and appropriate communication strategies; critically analyzing digital messages and environments.

The conference, which serves as a meeting point for sharing research, experiences, and technological applications, was held at the University of Pavia (Italy) from June 19 to 21, 2024.

Nearly 200 participants presented more than 60 contributions merged into eight Sections in the proceedings:

- Blended and Distance Learning (8)
- Teaching innovations, Communicating Science and emerging technologies in Education (10)
- Digital UpSkill and ReSkill for Adult Learners, Career Development and Training (5)
- Experiences in Education (11)
- Digital Citizenship and Media Literacy (4)
- Diversity, Equity, and Inclusion (6)
- AI in Education (13)
- Collaboration Projects and Networks (5).

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Towards the construction of an observational tool for interactions between children and Ozobots

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Abstract

The integration of robotics in early childhood education holds promise for transforming teaching methods into more exploratory and engaging experiences (Sjoberg & Brooks, 2023). This transformative approach can be realized by considering toy robots as didactic mediators (Damiano, 1993) operating within interactive contexts that feature enjoyable and adaptable environments (Bers, 2012), guided by adults and tailored to children's perspectives, utilizing various types of robots (Bozzi & Zecca, 2021; Belland et al., 2019; Angeli & Georgiou, 2023; Terroba et al., 2022).This project focuses on developing an observational tool to study how children aged 3-6 interact with Ozobots, aiming to understand the cognitive and social dynamics involved in robot play. Drawing from sociocultural and ecological perspectives on children's learning, we conducted observations in natural settings using a quasi-experimental research design. Video recordings were analyzed to identify specific actions and problem-solving approaches employed by children during interactions with Ozobots (Gaudiello & Zibetti, 2013; Gabriele et al., 2017). The analysis resulted in defining the grid categories using a bottom-up approach. Unlike traditional performance-focused assessments (Bakala et al., 2021), our analysis prioritizes understanding the cognitive processes underlying children's engagement with robotics. The goal is to create an observational tool that can enhance the design of educational activities and support teacher training, empowering educators to develop learning experiences that leverage children's cognitive abilities and motivations. This project bridges research and practice, seeking to enhance early childhood education through robotics by providing insights into effective pedagogical strategies and fostering meaningful learning experiences for young learners.

Keywords: Children Robot Interaction, Observational Tool, Robot-Mediated Activities, ECEC, Teacher Training.

1. Introduction

A great deal of research over the past two decades has been developed around the cognitive skills that develop in the interaction between humans and machines, and in particular educational robotics in the developmental age, and the cognitive benefits associated with this. Particularly interesting are the research developments around the concept of Computational Thinking (TC), linked to the experiences of robotics in early childhood, which due to its indeterminacy has expanded the possibility of exploration and definition. Recent research (Fessakis et al., 2013; Di Lieto et al., 2017; Castro et al., 2019) has identified new possibilities for disciplinary learning, cognitive and metacognitive development, particularly with regard to second-level, high-order thinking skills (Vygotskij et al., 1990), such as abstraction, generalisation, and the handling of frustration and error. Wing (2011) defines abstraction as the capacity to comprehend the fundamental characteristics or properties of an entity, thereby reducing its overall complexity. In a study conducted in 2010, Levy and Mioduser found that children (aged between 3 and 6 years) carry out playful, in-depth investigations of robot behaviour and that their constructions are planned and anticipatory, demonstrating the ability to simulate behaviour before executing programmes. The development of skills, understanding, knowledge and interactions with robots is supported by formal language, the development of different spatial perspectives and an understanding of the relationships between behaviour and rules.

Similarly to CT, the definition of 'Educational' Robotics (ER) is far from unambiguous. Indeed, the choice of definition establishes the theoretical approach that is taken when discussing and researching robotics in early childhood. Bozzi and Merisio (2021) provide a critical analysis of the primary research strands in this area: educational robotics has been defined as a tool for teaching and learning (Atmatzidou & Demetriadis, 2016) and for the development of cognitive skills (Ioannou & Makridou, 2018). It has also been described as a vehicle for rethinking largescale teaching, learning and education (Angel-Fernandez & Vincze, 2018). It has been characterised as a teaching practice (Komis et al.,2017) or, on the other and, as a 'mindtool based on constructivism and constructionism' (Mikroupoulos & Bellou, 2013). At last educational robotics is understood in some approaches as an area of research towards new environments and tools for teaching and learning (Ruzzenente et al., 2012) and intersection of different fields of knowledge (Scaradozzi et al., 2015).

One of ER's research trajectories considers the interrelatedness of robotics activities with other school activities. It argues that the thought processes involved in playing with robots promote the development of mental tools that are also useful in other domains (Angeli & Valanides, 2020). This is demonstrated in recent work by Bers (2018; 2020) and Botički and colleagues (2018) indicates that the promotion of CT at an early age improves children's analytical skills by introducing them to new tools for collaborative problem-solving and expression. Bers' (2010) work also demonstrates the importance of integrating technology into early childhood learning environments as a means of fostering positive interpersonal skills in the digital age.

These research trajectories acknowledge the necessity of interdisciplinary collaboration in the context of early childhood robotics education. This approach can facilitate meaningful learning experiences for children while offering teachers a playful and engaging method to integrate complex concepts through meaningful play (Bers et al., 2014).

The approach we adopt is predicated on the view that robotics can be conceived of as one of several potential expressive languages, or knowledge-building languages, that can be explored in educational contexts. From this perspective, the abilities displayed by children in their interactions with robots extend beyond the domain of computational thinking. These interactions demonstrate the manifestation of diverse and individualistic modes of reasoning, encompassing cognitive abilities, social competencies, communication and soft skills. The definition of ER that we endorse is that of a research area which 'aims to enhance people's learning experience through the creation, implementation, revision and validation of pedagogical activities, tools, and technologies, with an active role assigned to robots under the timely guidance of pedagogical methods' (Angel-Fernandez & Vincze, 2018).

Consequently, the development of programming skills is not the primary objective of educational activity; rather, it is a means of learning. In this regard, it can be seen to function as a conduit between subjects and objects in the production of knowledge (Damiano, 1993) a dispositif (Foucault, 2005; Massa, 1987). In its role as an educational and didactic mediator, the ER facilitates the enhancement of the cognitive, metacognitive and relational processes that children engage in, as these processes are integral to learning and cognitive development. Playing with robots is a way of playing to think, playing to create, and stimulates complex skills such as observing, describing, exploring, hypothesising, imagining experiments, (JoãoMonteiro et al, 2003), reasoning and the use of different expressive languages (Kazakoff & Bers, 2012), confronting oneself and others, thinking/discussing/deciding, feeling, thinking computationally, thinking metacognitively, and posing and solving problems algorithmically. Adopting the socio-constructionist approach to learning, robotic technologies are 'objects with whom to think' (Papert, 1980). According to this perspective, the integration of robotics into educational contexts changes the ethos of teaching from a competence-based approach to one that promotes exploration, discovery and play in learning (Sjoberg & Brooks, 2023), in which children's play strategies with robots reflect heuristic processes supported by peer and adult tutoring and scaffolding (Wood et al., 1976). At the educational level, this requires adopting the 'didattica laboratoriale' (workshop teaching) approach which is characterised by the implementation of activities that are designed with a didactic purpose and content, and which are conducted in a group setting. These activities are oriented towards operability, dialogue, research and planning.

Pupils engage in continuous reflection on their actions, evaluating the activities they undertake collectively and collaboratively. The workshop teaching, previously a domain reserved for specialized instruction, becomes a learning environment and a pedagogical approach that challenges the traditional transmissive 'classroom' teaching model. Laboratory teaching emphasizes active, multi-sensory, and reflective experiences, fostering creativity and the capacity to investigate.

Within the Italian institutional landscape, the interest in supporting and increasing the use of robotics in education is strongly determined by providing a stimulus to interrupt a transmissive didactic style by favouring, instead, critical and active thinking process (MIUR, Indicazioni Nazionali e Nuovi Scenari, 2018). Engagement with robotics provides an optimal learning environment, as it encourages problem-solving through experimentation, collaborative action and the utilisation of diverse forms of intelligence.

Within the field of ER, a variety of methodologies and robotic tools have been developed for use with different age groups undergoing developmental stages. In addition to code-line and block programming, there is a third programming principle that employs physical objects to represent and manipulate programming concepts, thereby facilitating a more accessible and intuitive process, particularly for the early childhood age group: tangible programming. A number of contributions can be found in the existing literature investigating the effects of using tangible programming. Belpaeme and colleagues (2018) emphasise the advantages of intuitiveness, collaborative learning and immediate feedback. Similarly, Horn and Bers (2019) identify tangible programming robots as effective mediators for fostering collaborative processes and valuable tools for supporting the development of abstract thinking and symbolic language skills. Moreover, the capacity to interact with robotic artefacts provides an opportunity to stimulate essential developmental competencies such as concentration and problem-solving, which also encompass fine motor and eye-hand coordination skills (Zecca and Bozzi, 2021). The tangible nature of robotic objects makes them particularly suited to facilitating learning among younger children, allowing them to actively construct knowledge within situated learning situations (Lave, Wenger, 2006), as well as learning-by-doing (Roussou, 2004). Tangibility, however, introduces a further level of complexity due to its impact on the relationship between algorithms and physicality. In addition to the difficulties involved in learning how to programme, tangible robots present children with the physical challenges of performing practical actions on which the outcome of the robot's movement depends. This introduces a further factor that must be taken into account when analysing interactions with robots.

The key factor emerging from Bers' work is the construction of fun and adaptive environments (Bers, 2012) in which children can play and explore skills and attitudes, guided by adults or peers, and tailored to children's perspectives (Zecca & Bozzi, 2021; Belland et al., 2019; Angeli & Georgiou, 2023; Terroba et al., 2022). The learning context incorporates bodily, imaginative and semiotic aspects on the basis of a multimodal approach to cognition (Ferrara et al., 2022). This necessitates that educators possess a diverse range of competencies. In order to establish these "interactive contexts", it is essential that teachers receive training, demonstrate observation skills, engage in reflective practice, and adopt a proactive approach. In the Italian educational context, this approach represents a means of repositioning workshop teaching as a central component of the curriculum. It offers an innovative and creative methodology through which knowledge and expertise are developed concurrently, thus providing a valuable contribution to the field of education. The implementation of didactic scenarios centred on robotics and educational electronics, logic and computational thinking, manual and digital artefacts, serious play and storytelling will facilitate the development of transferable skills within these spaces (Piano Nazionale Scuola Digitale, 2015).

Recent literature reviews (Tang et al., 2020; Bakala et al., 2021; Lockwood & Mooney, 2017) show how research interest in the field of ER tend to be oriented towards in-depth CT skills and competences or at least programming activities, hands-on exercises, even unplugged, thus oriented towards the development of programming skills and robotics competences. There is a paucity of research exploring the cognitive processes and learning outcomes associated with robotics in early childhood. Furthermore, there is a dearth of studies that have evaluated the impact of social interactions and shared knowledge in ER, and social construction of knowledge during play with robots (Bakala et al., 2021).

The objective of our research is to develop an observation and design tool for the purpose of studying the interactions of children (aged between 3 and 6 years) with Cubet and Ozobot. The intent is to provide teachers with a tool to facilitate understanding of the cognitive and social dynamics involved in playing with robots, with the aim of constructing a design based on the development of play and experiences. This will be achieved through the utilisation of an observation grid, which will facilitate the codification of behaviours and solutions sought and experienced by children. The objective is to gain insight into the cognitive and social dynamics associated with playing with robots.

2. Materials and Methods

The research started in 2018. The team consisted of Professor Luisa Zecca, the scientific supervisor, together with two researchers and two students, who were involved in various stages of the research development.

The first phase of the research focused on outlining the scientific background and research trajectory. consistent with the theoretical approach of considering robot play as a laboratory education experience, and in line with the aim of investigating the processes at work during robot play, the research developed a multifunctional tool for teachers. This tool was designed to observe children in action during play, investigate their interactions and support the design and evaluation of activities involving toy robots.

The research process was informed by a mixed-coding methodological approach, comprising top-down and bottom-up phases, and concluding with an intersubjective test to evaluate the tool. The field phase was conducted at the Scuola dell'Infanzia Bambini Bicocca and the Scuola dell'Infanzia Maria Bambina di Lissone. A total of 29 children participated in the study, comprising 25 children aged between 4 and 5 years old and four children aged 3 years old. The robots selected for the research were Cubetto and Ozobot due to their tangible programming process and the potential for creating a vast array of experiences with these toys.

Cubetto is a wooden robot measuring approximately 10x10x10 cm. It was designed in 2013 by Primo Toys for use with young children, allowing them to learn to program through hands-on play with a tangible interface. The robot is programmed through the use of coloured coding blocks, which are placed on a physical board according to the commands that the children wish to issue. Each block represents a discrete command, such as “move forward”, “turn left”, or “turn right”. The arrangement of these blocks in sequences enables children to program Cubetto to navigate the space.

Ozobot is a small programmable robot that was first introduced to the market in 2014 by Evollve Inc. It was designed and created for use in an educational setting and is intended for children between the ages of 4 and 13. The device offers a variety of programming options, including Color Programming (suited for younger children and used in this study) with a tangible interface, where users draw colored lines on a clear surface to create a program; as well as Application Programming and Block Visual Programming, which employs platforms like OzoBlockly (block-based programming).

The overarching research question was to identify the types of problems children encounter during play and the strategies they employ in addressing these challenges (heuristics). In order to gain an understanding of the concepts of “problem” and “heuristic” a review of the relevant literature was conducted following the question:

Q1 *What is meant by problems and heuristic processes in children's play with robots?*

This top-down phase enabled us to ascertain the scope of application of the two concepts. The concept of 'problem' that informs this study is defined as a situation in which there is a discrepancy between the current state and the desired future state (Robertson, 2017). In particular, this occurs when the objective is to achieve a goal through a specific action, but the method of achieving it is unclear. In instances where the desired outcome cannot be achieved through direct action, the mind is employed to devise a solution. This solution is typically presented as a series of strategic and planned actions, which are deliberately organised to reach a goal or solve a problem. This involves identifying potential courses of action that can bridge the gap between the current situation and the desired result, according to a specified criterion and method. In this study, the criterion in question is referred to as 'heuristics' (Aiello, 2001).

A number of categories of heuristics were derived from the literature review, with the work of Gaudiello and Zibetti (2013) and Gabriele and colleagues (2017) appearing to be particularly meaningful in classifying the strategies implemented by children when playing with robots:

1. A procedure-oriented heuristic is a solution-focused strategy that is task-oriented. It relies on changing parameters through trial and error to arrive at a solution to the problem through implicit reasoning.
2. Statement-oriented heuristics (or declarative-oriented) are problem-focused and knowledge-driven. They seek information about the rules of the task and only solve the problem once the task is fully understood. It involves applying individual actions to seek information about the rules of the task. The solution to the problem is only reached once the task has been fully understood.
3. Heuristics oriented towards metacognition are also focused on the problem, guided by awareness. They involve a combination of trial and error and logical reasoning, which is used to identify task limitations and to assess the individual's understanding. Metacognitive-oriented heuristics (problem-focused) are driven by awareness and involve the application of actions. The process entails a combination of trial and error and logical reasoning, which is utilised to ascertain the limits of the task and to evaluate the individual's comprehension. The debugging process encourages a reflective approach to programming, facilitating the gradual development of coding skills and the formulation of heuristics based on syntactic and semantic/logical knowledge.

The aforementioned definitions were instrumental in the construction of a grid for the interpretation of the observed play experiences in the bottom-up phase of the study.

The bottom-up phase entailed the identification and elaboration of specific categories for the labeling of articulations of thoughts and interactions during play with Cubetto first and then Ozobot. A quasi-experimental protocol was employed to refine the categories of problems and heuristics related to playing with robots. The aim was to construct a classification of problemsolving strategies employed by children during programming activities with the robot in question. The objective of this contribution is to present the refinement of the categories that emerged from playing with Cubetto and were adapted for the observation of interactions with Ozobots. A total of seven non-consecutive hours of video recordings were conducted of children aged between three and six engaged in playing with the robots in their natural environment, either independently or in social groups, the recordings were transcribed in their entirety, providing a comprehensive account of the problems encountered and the resolution strategies employed by the children. From the theoretical constructs of heuristics and problems, we found descriptors of behaviour that we looked for in the analyses of the videos, the ELAN 5.3 software was employed as a tool for the analysis, enabling annotations to be made by selecting the specific fractions of a second during which a particular behaviour occurred. The collected data were then subjected to qualitative analysis using a thematic approach, which resulted in the generation of behavioural descriptors (items). Subsequently, a grounded methodology was employed to group the descriptors according to similarity, with the objective of accurately describing a specific type of event while maintaining the possibility of referring to more than one situation. The items were identified through an intercoding process between two researchers who conducted a bottom-up analysis of the same game situations independently. The results demonstrated a compatibility level of 80% in the coding of the same behaviours. The items that exhibited compatibility with an inter-subjective interpretation process were selected. Ultimately, an observation grid was constructed based on the selected items, which was employed to code and inter-code the behaviours and to highlight the relationships between these and between strategies and problems/objectives. The grid is currently undergoing a testing phase to ensure its validity.

3. Results

In line with the objective of our study, which was to investigate complex problem-solving processes, the results of the investigation concentrated on the emergence of game heuristics (criteria guiding the subject in the choice of strategy) and problem-solving strategies. The bottom-up process resulted in the identification of specific types of problems and corresponding heuristics, which can be employed to describe the behavior observed in the game with both types of robot.

The analysis of the data obtained from the grid led us not only to classify different categories of problems and strategies (as discussed below), but also to distinguish between different levels of problems that emerged from the videos. All problems and related sub-problems were categorized according to the nature of the problem the subject was attempting to resolve. In order to facilitate the analysis of the data, a set of categories and descriptions have been defined. These categories are both general and specific, accurately describing a specific type of event while allowing for the possibility of referring to more than one situation, as can be observed in the table below (Table 1). The categories afforded the differentiation of a broad spectrum of issues encountered during the course of robotic programming. The differentiation was based on the initial identification of a general problem, defined as the goal (problem n°), and the subsequent emergence of several sub-problems of varying natures during the activity. The initial stage will entail comprehension of the movements the robot must undertake to achieve the desired outcome, which may be conceptualised as a 'movement problem'. Subsequently, the child will be required to select the appropriate codes that enable the robot to execute these movements, which may be conceptualised as a 'programming problem'. Finally, the child will need to understand how to act upon the code, which may be conceptualised as a 'tangibility problem'. Subsequently, the child must verify whether the constructed program is indeed the one that will bring the robot to the goal (verification problem).

Table 1 – Problem Type and Definition.

Problem Type	*Description*
Goal-setting problem	Possibility for children to propose the structuring of the problem (problem posing) in complete autonomy.
Movement mode problem	Problems related to understanding how the robot moves to perform the task/achieve the goal.
Programming problem	Problems strictly related to code construction, how to choose which codes to use, how to modify the program, how to complete the program.
Verification problem	Problems concerning the verification of the constructed program.
Direction problem	Problems concerning the direction in which the robot moves (left or right, forward or backward, choice when faced with a fork in the road).
Error detection problem	Problems in which the child has to detect an error that has been made.
Tangibility problems	Problems encountered in carrying out the physical actions necessary for the robot's operation (e.g. for Cubetto to fit the control blocks into the appropriate holes on the dashboard, for Ozobot to correctly manipulate the appropriate felt-tip pens to draw the lines of the appropriate thickness)

A variety of strategies are employed in response to the diverse challenges that children may encounter. These strategies, which are referred to as heuristics in accordance with the theoretical definition utilized, are behavioral descriptions that are precisely delineated with respect to a specific action, while allowing for the possibility of being applied to multiple situations, as evidenced in the following table (Table 2).

The observations revealed a variety of heuristics employed by the children during their interactions with the robots, thereby demonstrating the diversity of problem-solving strategies utilized. The data analysis defined the strategies related to solving the target problem by analysing each strategy used in solving sub-problems derived from the main problem. The wide range of heuristics that emerged highlights the children's ability to use varied and creative methods to solve the problems encountered. In certain instances, it was not possible to encapsulate the children's problem-solving strategies within a single definition. The analysis of the data revealed that problem-solving can occur through the utilisation of a complex strategy, which can be observed by breaking down the deployment of a multitude of strategies into micro-behaviours, adapted to the specific circumstances presented by the problem. It is essential that the observer breaks down the sequence of actions into micro-behaviours in order to gain an understanding of the general heuristics.

The purpose of utilising the observation grid is to facilitate the observation of interactions occurring throughout the entirety of the play sessions in question, employing a quasi-experimental protocol. The tool is currently being refined in a number of contexts, both in terms of its capacity to identify the processes that occur and its potential to support the adult observer in designing playful contexts for experimentation and learning.

Table 2 – Heuristic Type and Definition.

Heuristic Type	*Description*
Observational-intuitive strategy	Choices made through observation, guessing what to do to achieve the goal.
Decomposition strategy	Decomposition of a general problem into several parts or sub-problems.
Mental simulation	Adoption of a mental representation of the robot's movements.
Physical-body simulation	Problem solving through body movement.
Direct verification strategy	Verification of programming through robot movement.
Verbal simulation	Verbal explication of the movements required to achieve the goal.
Strategy of indifference to the problem	Various heuristics guiding reasoning in the presence of indifference to the problem.
Listening strategies	Solving the problem by listening to the instructions given by the guide.
Pattern imitation strategies	Achieving the goal by imitating the actions produced by another.
Asking for help	Strategy in which the child asks the guide or a companion for help in solving the problem.

3. Conclusion

It is widely acknowledged that an important yet challenging professional attitude is the ability to demonstrate one's own thoughts and expectations in a way that is transparent and conscious. This enables an objective observation of the children's thought processes and progress, rather than allowing preconceptions to influence this process. Such awareness allows educators to identify the multiple potential avenues and to avoid the assumption that their own line of thinking is the sole viable solution. The observational grid is an effective instrument for this purpose, as it directs the teacher's attention towards discerning the types of processes the children are currently engaged in. By directing the teacher's attention to discern the types of processes in which the children are currently engaged, the observation grid acts as a tool to support educational planning, because it is able to highlight the children's points of interest.

The majority of CT assessments focuses on students' abilities in relation to programming and the utilisation of computers. It is common practice to evaluate CT skills using traditional tests and performance assessments (Tang et al., 2020). In contrast to traditional performance-focused evaluations (Bakala, 2021), our analysis prioritises an understanding of the cognitive processes underlying children's behaviour when playing with robots. This is accomplished through a comparative analysis focused on the transversality of events and situations, as opposed to the level and capabilities achieved. This is done in order to make it a tool for observation, documentation and the design of teaching activities. In alignment with Papert's (1980) constructionist perspective, which views robotic technologies as "objects with whom to think", engaging with robots offers a chance to examine metacognitive reflection (awareness of one's own cognitive processes), "aloud" reflection, and collaborative intelligence (Martinez, 2006).

This study aims to make a contribution to the existing literature on preschool educational robotics. It offers an analysis of the cognitive processes and social dynamics involved, and provides a framework for future research that can further explore the interactions between children and robots in natural educational settings. The observation grid developed can be adopted and adapted in different educational contexts, thereby contributing to the standardisation of formative assessment tools. The study identified specific types of problems and related heuristics that children use during activities with robots. These categories serve as a framework for understanding the diverse problem-solving approaches that children use during play. The behavioural descriptions derived from this analysis are both general and specific. They provide a clear and accurate depiction of certain types of events while remaining flexible enough to apply to various situations that may arise. This dual nature of our descriptions ensures they are robust and versatile, facilitating their use in different educational contexts. The constructivist approach, when applied to the field of educational robotics, has the potential to foster the development of a number of key skills, including technical abilities, metacognitive capabilities and collaborative competencies. These skills are widely acknowledged as being essential for meaningful and lasting learning. The implementation of teacher training programmes based on the findings of this study has the potential to enhance the efficacy of educational robotics activities within educational settings.

The limitations of our study, which may provide avenues for future research, include the following:

- The sample size (29 children) and the type of robot (two tangible programming robots) may limit the generalisability of the results. Further studies could expand the participant base and include different types of robots to compare interaction dynamics.
- The complexity of the robotic interactions and the variety of observed behaviours may require further research to deepen the understanding of heuristics and problems.

The future direction of the observation grid is to refine and experiment with teachers with the objective of deliberately designing teaching activities in accordance with an understanding of the cognitive, motivational and engagement processes that underpin learning. Indeed the approach expressed in this study facilitates the integration of research and practice, providing meaningful and quality experiences for early childhood education and care through robotics. It enables the development of design strategies, observational postures, and documentation tools that support teachers' professional role and action in the educational contests.

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